EFFECT OF NONRESPONSE AND CALLBACKS ON THE ESTIMATION OF SURVEY NONRESPONSE BIAS

ANKET CEVAPLANMAMA VE TEKRAR ZİYARETLERİN CEVAPLANMAMA YANLILIĞI TAHMİNİNE ETKİSİ

H. Öztaş Ayhan*

ABSTRACT

This article aims to examine the components of nonresponse error in sample surveys. Response and nonresponse rate relations are examined. Number of callbacks for different nonresponse reasons have been examined. Computation of household and individual person nonresponse rates have also been covered. Methodology of subsampling from nonrespondent's is illustrated as a remedy to reduce the nonresponse bias. Components of nonresponse bias is determined and illustrated by numerical examples.

KEYWORDS: Callbacks, nonresponse bias, nonresponse error, nonsampling error, number of calls response rate, sources of nonresponse, unit nonresponse.

ÖZ

Bu makale, cevaplanmama hatası bileşenlerini incelemeyi amaçlamaktadır. Cevaplanma ve cevaplanmama oranı arasındaki ilişki incelenmektedir. Farklı cevaplanmama nedenlerine göre tekrar ziyaret ilişkileri bu çalışmada incelenmiştir. Hanehalkı ve bireysel anketlere dayanan farklı cevaplanmama oranları incelenmiştir. Cevaplanmayanlara dayanan alt örneklere bağlı olarak elde edilen cevaplanmama yanlılığının azaltılması metodolojisi önerilmiştir. Cevaplanmama yanlılığının bileşenlerinin metodolojik ve sayısal olarak belirlenmesi uygulaması gerçekleşmiştir.

KEYWORDS: Tekrar ziyaret, cevaplanmama yanlılığı, cevaplanmama hatası, örnekleme dışı hata, ziyaret sayısı, cevaplanma oranı, cevaplanmama kaynakları, ünite cevaplanmaması.

*Affiliated Faculty, Department of Statistics, Middle East Technical University, Ankara, Turkey.
oayhan@metu.edu.tr
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INTRODUCTION

The term *nonresponse* can be defined as failure to measure some of the units in the selected sample. Nonresponse affects estimates in two ways, which are by introducing a possible bias in the estimates and increasing sampling variance because of the reduced sample. The relationship between the bias and the size of nonresponse depends on the magnitude of nonresponse and the differences in the characteristics between respondents and nonrespondents. Empirical evidence has shown that the nonrespondents are often different from the respondents in many characteristics.

Nonresponse issues have been the concern of survey researchers for many years. Early studies of Hansen & Hurwitz (1946), Durbin (1954), Durbin & Stuart 1954a, Kish & Hess (1959) ,Hawkins (1975) and Bartholomew (1961) initiated the basic research in this area. Latest research in this area is covered in Bethlehem & Kersten (1985), Platek & Gray (1986), Bethlehem (1988), Groves (1989), Groves & Couper (1998), Groves et. al. (2001), KocakKoçak (2001), Lynn et al (2002), Ayhan (2004), Stoop (2005), Czaja & Blair (2005), Groves (2006) and Platek & Gray (1986). Bethlehem et al (2011).

The objective of improving response rates has the following WFS (1977) recommendations. For weighting of survey data, WFS guidelines recommend that, if the overall nonresponse is below 10 percent, it is most unlikely that, there will be any serious bias resulting from ignoring it, this also has been recommended by Kish (1992).

Following the introduction, this work continues by examining the types of nonresponse and their classification in the next section. Response and nonresponse rate relations are examined methodologically. An alternative methodology is also proposed. Computation of household and individual persons survey nonresponse rates followed by the components of nonresponse bias. Estimation of nonrespondents from subsampling methodology is illustrated. The survey nonresponse bias is illustrated with numerical examples which is based on original survey data. The work is finalized by the conclusions of this study.

TYPES AND CLASSIFICATION OF NONRESPONSE

In this section, types of nonresponse and classification of nonresponse is summarized below.

Types of Nonresponse

As a result of survey operations, generally three types of nonresponse may occur.

1. *Unit nonresponse*. Unit nonresponse refers to unavailability of response from the selected sample unit to the whole questionnaire. Unit nonresponse can be evaluated at two stages.

a) *Household survey nonresponse*. Household nonresponse is the first stage of not obtaining any answer from the household survey respondent.

b) *Individual survey nonresponse*. Individual nonresponse is the next stage of not obtaining any answer from the individual survey respondent.

Information for these two stages are obtained separately and later related nonresponse components are computed jointly, which is described in later sections.

2. *Partial nonresponse*. Partial nonresponse occurs when a respondent refuses to answer a group of questions or a complete questionnaire module.

3. *Item nonresponse*. Item nonresponse occurs when a respondent refuses to answer single question(s).

The partial nonresponse and item nonresponse is not evaluated under the present work.

Unit nonresponse can be defined as occurring at the initial meeting when all members of an eligible household refuse to participate in the survey or when no one can be contacted after repeated attempts. Many studies related to nonresponse have been conducted in the literature, so there seems to be a need to have an extensive review on the subject.

This study only focuses on the unit nonresponse in surveys. The term *nonresponse* is used instead of the term *unit nonresponse* in this paper. Information on the *types* and *classification* of nonresponse sources are covered in the following sections.

Classification of Nonresponse Sources

In surveys, nonresponse errors are examined and classified in different categories. According to Lindström (1983), studies of nonresponse errors in surveys and their effects can be divided into 6 main categories by type of problem as; *evaluation studies, presentation of nonresponse by variables, study of response rounds, comparison of data collection methods, assessment of compensatory methods,* and *analysis of nonresponse characteristics*.

Some methods generally accepted for handling the causes of nonresponse problem are described as follows. According to Kish (1995), the nonresponse reasons can be classified as *not at homes, refusals, incapacity or inability, not found,* and *lost schedules*. On the other hand, sources of nonresponse is classified by Cochran (1977) as *not at homes, noncoverage, unable to answer,* and *hard core*.

Moser & Kalton (1979) classified the non-response reasons as *unsuitable for interview, movers, refusals, away from home,* and *out at a time of call*. Unlike Kish and Cochran, Moser & Kalton have accepted a separate category for the *movers*.

The other categories point the same portion of nonresponse with different group names.

From the above classifications, it is clear that the reasons of nonresponse should be diverse. On the other hand, classification and analysis of nonresponse reasons should follow the same standard within a given survey. For the present work, the following classification is used for the reasons of nonresponse as; *not at home, away from home, refusal, incapacity, address not found, lost schedules,* and *living elsewhere*. Alternative approaches for nonresponse classifications are also mentioned by AAPOR (2002), Ayhan (1981 & 1998), and Lynn et al (2002). The concept of eligibility is also important in obtaining the denominator for response rates. DHS and AAPOR has different response rate formulaes by assuming different eligibility states for those of unknown eligibility.

THE PROPOSED METHODOLOGY

When we examine the nonresponse components in terms of reasons, it is possible to decompose it in the following manner. We can use the following form ($R_i = N_i / N$) of the rate and the size ($N_i = \sum_{j=1} N_{ij}$) to illustrate the mechanism, where $i = 1, 2$ and $j = 1, 2, ..., J$.

$$R_i = \frac{N_i}{N} = \frac{\sum_{j=1}^{J} N_{ij}}{N} = \frac{N_{i1} + N_{i2} + ... + N_{ij}}{N}$$

For the nonresponse stratum (where $i = 2$), the relation takes the following form;

$$R_2 = \frac{N_2}{N} = \frac{\sum_{j=1}^{J} N_{2j}}{N} = \frac{N_{21} + N_{22} + ... + N_{2J}}{N}$$

The unweighted nonresponse components will not represent the selection of the number of calls from the restricted choice set. Therefore, a weighted components will be proposed for the ideal estimator, in the following form.

$$R_i = \frac{N_i}{N} = \frac{\sum_{j=1}^{J} W_{ij} \; N_{ij}}{N} = \frac{W_{i1} N_{i1} + W_{i2} N_{i2} + ... + W_{iJ} \; N_{iJ}}{N}$$

where $W_{ij} = N_{ij} / N_i$ and $\sum_{j=1}^{J} W_{ij} = 1 \;\; \forall j$

For the nonresponse stratum (where $i = 2$), the relation takes the following form;

$$R_2 = \frac{N_2}{N} = \frac{\sum_{j=1}^{J} W_{2j}\ N_{2j}}{N} = \frac{W_{21}\ N_{21} + W_{22}\ N_{22} + \ldots + W_{2J}\ N_{2J}}{N}$$

Number of Calls

Number of calls can vary according to the mode of data collection. There are no established number of calls which will be ideal for most surveys. There are no gold standarts established for the number of recalls in sample surveys. WFS (1977) and Groves (1989) have proposed some lower bound values for the number of calls in personal (face to face) interview surveys. Number of total calls, is based on the *first visit* and *number of recalls* (call backs) for each case, which is illustrated in Table 1 and 2. You may achieve higher number of calls in telephone surveys in comparison to personal interview surveys, where the cost and timing of enumeration per sample unit will be lower. The number of total calls also differs for different nonresponse reasons.

Table 1: Relationship between the number of calls and nonresponse reasons.

Symbol	Nonresponse reasons (1)	Number of total calls (2)	
		Household survey	Personal interview survey
N_{21}	Not at home	1 + 3 = 4	1 + 2 = 3
N_{22}	On vacation	1 + 0 = 1	NA
N_{23}	Refusal	1 + 1 = 2	1 + 2 = 3
N_{24}	Incapacity	1 + 0 = 1	NA
N_{25}	Address not found	1 + 0 = 1	NA
N_{26}	Lost schedules	NA	NA

(1): Based on Kish (1995), (2): Based on WFS (1977) & Ayhan (1981), *NA*: Not Applicable

Table 2: Relationship between the nonresponse reasons, number of calls and its probability.

Symbol	Nonresponse reasons	Number of total calls		Weighted proportion of calls from the restricted choice sets
		Household survey	Personal interview survey	
N_{21}	Not at home	4	3	$\frac{1}{2}\frac{4}{9}+\frac{1}{2}\frac{3}{6}=\frac{17}{36}\cong\frac{1}{2}$
N_{22}	On vacation	1	0	$\frac{1}{2}\frac{1}{9}+0=\frac{1}{18}$
N_{23}	Refusal	2	3	$\frac{1}{2}\frac{2}{9}+\frac{1}{2}\frac{3}{6}=\frac{13}{36}\cong\frac{1}{3}$
N_{24}	Incapacity	1	0	$\frac{1}{2}\frac{1}{9}+0=\frac{1}{18}$
N_{25}	Address not found	1	0	$\frac{1}{2}\frac{1}{9}+0=\frac{1}{18}$
N_{26}	Lost schedules	0	0	0
N_{2}	Total	9	6	1

RESPONSE AND NONRESPONSE COMPONENTS

Assuming that, the population size of N can artificially be devided into response and nonresponse stratum. We can use the following form ($R_i = N_i/N$) of the rate and the size ($N_i = \sum_{j=1}^{J} N_{ij}$) to illustrate the mechanism, where $i = 1, 2$. Response rate ($R_1 = N_1/N$) is the ratio of responses to the total selected sample, and nonresponse rate ($R_2 = N_2/N$) is the ratio of nonresponses to the total selected sample. Here the following relations $N_1 + N_2 = N$, $R_1 + R_2 = 1$, $(1 - R_1) = R_2$ holds for these two strata.

The survey data will only be collected for the response strata. The response strata will have the mean μ_1 which is based on the N_1 observations. Where, the response stratum mean will be, $\mu_1 = N_1^{-1}\left[\sum_{j=1}^{N_1} X_{1j}\right]$. The unknown mean μ_2 of the nonresponse stratum which is based on the N_2 observations will be, $\mu_2 = N_2^{-1}\left[\sum_{j=1}^{N_2} X_{2j}\right]$. Where the population mean μ should be based on all selected sample elements, rather than enumerated, and should take the following form $\mu = N^{-1}\left[\sum_{j=1}^{N} X_j\right]$.

Response and Nonresponse Rate Estımatıon

Household response rate (*HRR*) is estimated as the ratio of (n_1/n) from the selected sample. Individual response rate (IRR) is calculated by the multiplication of household response rates and individual response component. Individual response component is calculated as respondent individuals (m_1) over, enumerated individuals (m). These calculations are given with the following formulas;

$$IndvSurvRR = \frac{n_1}{n}\frac{m_1}{m}$$

Household response rate, $HRR = n_1/n$

Individual response component, $IRC = m_1/m$

Individual response rate, $IRR = (HRR)(IRC) = (n_1/n)(m_1/m)$

Household nonresponse rate (*HNRR*) can be taken as the complement of the household response rate (*HRR*).

$$Household\,SurveyRR = \frac{n_2}{n}$$

$HNRR = 1 - HRR = [1 - (n_1/n)] = (n_2/n)$

Individual nonresponse rate (*INRR*) is calculated by the multiplication of *household nonresponse rate* and *individual nonresponse component*. Individual nonresponse component is calculated by taking *nonrespondent individuals* (m_2) over *enumerated individuals* (m).

$$IndvSurv\,NRR = \frac{n_2}{n}\frac{m_2}{m}$$

Individual nonresponse component, $INRC = m_2/m$

Individual nonresponse rate, $INRR = (HNRR)(INRC) = (n_2/n)(m_2/m)$

COMPONENTS OF NONRESPONSE BIAS

Moser and Kalton (1979) stated that, the bias of nonresponse occurs when the response stratum mean μ_1 is used instead of the total population mean μ. When we examine the situation in terms of expectations from all possible sample means, the source of nonresponse bias is based on the use of $Lim_{n\to\infty}E(\bar{x}_1)=\mu$ instead of $Lim_{n\to\infty}E(\bar{x})=\mu$, where $Lim_{n\to\infty}E(\bar{x}_1)\neq\mu$ but $Lim_{n\to\infty}E(\bar{x}_1)=\mu_1$.

By assuming the amount of nonresponse as constant for the survey then, we can illustrate the bias of using the response stratum mean $\bar{x}_1$, instead of the selected total sample mean $\bar{x}$. Here the population mean μ can be evaluated as the weighted mean of response and nonresponse strata. Following the illustration of Moser and Kalton (1979), the nonresponse bias due to the use of response stratum mean as the estimator will be,

$$B(\bar{x}_1)=\mu_1-\mu=\mu_1-(R_1\mu_1+R_2\mu_2)$$

$$=\mu_1(1-R_1)-R_2\mu_2=R_2(\mu_1-\mu_2)$$

The effect of bias is based on the amount of nonresponse rate and the difference between the response and nonresponse strata means.

ESTIMATION OF NONRESPONDENTS FROM SUBSAMPLING

The nonresponse bias of the stratum mean estimator is given as,

$$B(\bar{x}_1)=\mu_1-(R_1\mu_1+R_2\mu_2)$$

The design mean can be evaluated as,

$$\hat{\mu}=R_1\bar{x}_1+R_2\mu_2$$

Since μ_2 is not known, the sample estimator of this will be used, and weighted estimator will take the following form,

$$\bar{x}_w=\sum_{i=1}^{2}R_i x_i=R_1\bar{x}_1+R_2\bar{x}_2^*$$

where $\bar{x}_1=n_1^{-1}\left[\sum_{j=1}^{J}X_{1j}\right]$ and $\bar{x}_2=n_2^{-1}\left[\sum_{j=1}^{J}X_{2j}\right]$ is unknown. By taking a random subsample of size m_2, a new subsampling estimator of the nonresponse stratum mean will take the following form.

$$\bar{x}_2^*=m_2^{-1}\left[\sum_{j=1}^{J}X_{2j}\right]=\hat{\mu}_2 \text{ and } E(\bar{x}_2^*)=\mu_2 \qquad \text{where } m_2=f_b\,(n_2)$$

Here f_b is the subsampling rate from the nonresponse stratum and can be taken as a small fraction (i.e., $f_b=0.05$).

The expected value of the subsample estimator will be, $Lim_{n\to\infty} E(\bar{x}_2^*) = \mu_2$. On the other hand, the desired estimator of the sample mean is, $\bar{x} = n^{-1}\left[\sum_{j=1}^{J} X_j\right]$.

CALL SCHEDULING AND NUMBER OF CALLBACKS

A callback, or follow-up of nonrespondents was first proposed by Hansen and Hurwitz (1946). They suggested investigating nonresponse in mail surveys by taking a sample of nonrespondents and trying to obtain the required information by means of a face-to-face (personal) interview. This became known as the callback approach, where the aim is to obtain as high a response rate as possible.

The callback approach of Hansen and Hurwitz (1946) can also be applied in cases where the interviews in the first phase are carried out face-to-face instead of by mail. For the callback phase specially trained interviewers can be used to re-approach the nonrespondents. Of course, this substantially increases the survey costs.

During the early stages of data collection in surveys,number of callbacks have been a critical issue especially in personal interview (face to face) surveys. Among the reasons of nonresponse, callbacks have been generally associated with the "Not at Home Cases", more than others. For the recent applications for telephone surveys a *Call Grid* is used at the SRC to control the pattern of calls on *telephone sample cases* that are not easily contacted (Groves, 1989). The interviewers are told to place a call on the sample number to *fill up cells in the grid*, avoiding making more than the maximum number in any time period of the grid.

Early callback models have been proposed during the last century. during the last century. Deming (1953) has proposed a *double sampling approach*. The optimal fraction of nonrespondents to sample after the first call is conditional on whether one wants to follow the nonrespondent subsample for one more call, two more calls, three more calls, or what (Groves, 1989). To solve for the optimal subsampling fraction, a cost and error model is needed. Total survey cost; $C = C_1 n + C_2 f(n - r)$.

For the optimum calls with subsampling plan Groves (1989) provides a numerical example which is based on Deming (1953) model. The model is based on *first visit* plus *six recalls* (callbacks). The number of callbacks (# 6) worked out on the basis of (0.6) second phase sampling fraction. While Deming's plan permits the subsampling of remaining nonrespondents after the first call, other schemes have investigated the optimal number of calls without a subsampling plan. For example, Birnbaum and Sirken (1950) determine what call rule should be used to obtain a set probability that the bias of nonresponse would not exceed a certain level. They accomplish this for a binomial variable, since such a measure gives them limits on the bias ($0 \leq P_{NR} \leq 1$).

Hartley (1946) and Politz and Simmons (1949) were the first to describe a *one–call survey design* that weighted completed interviews by the chances of finding the sample person at home. Bartholomew (1961) proposes first visit and only one recall as an alternative method. Kish and Hess (1959) also proposes alternative nonresponse evaluation for continuous panel surveys. The basic idea is to estimate these probabilities on the basis of one visit to the respondents, thereby avoiding making expensive callback visits. This technique can be used to adjust survey results obtained after a maximum of three visits for a bias due to being not-at-home. That is, the technique focuses on correcting a nonresponse bias due to not-at-home persons (Bethlehem et al., 2011).

One of the important study is given by Edwards (1953) which provides outcomes on the basis of 8 number of calls for the British Market Research Board newspaper readership. The findings are detailed on Table 3 below.

Table 3: Distribution of interviews obtained at successive calls.

Number of effective interviews if a limit had been laid down of	Total		Men		Women	
	No.	Percent	No.	Percent	No.	Percent
1 call	1243	40	367	27	876	50
2 calls	2389	77	962	71	1427	81
3 calls	2880	93	1227	90	1653	94
4 calls	3023	97	1313	97	1710	97
5 calls	3089	99	1348	99	1741	99
6 calls	3109		1357		1752	
7 calls	3116		1359		1757	100
8 calls	3117	100	1360	100		

Source: Edwards (1953)

The findings has shown that, if interviewing had been confined to one call, only 40 percent of the final sample would have been obtained and only

27 percent of the final interviews with men. It is relevant to note that, in this survey, interviewers did not know the sex of informants in advance, so the low percentage of successful first call on men is not surprising. Still, a sample based on first calls alone would have been entirely unrepresentative with regard to sex and many other factors.

Some recalling is standard practice. The Government Social Survey insists on a minimum of four calls (i.e. three re-calls) and encourages further calls if there is hope of an interview; other organizations take three calls as their maximum (Moser and Kalton, 1979). Practitioners, on the whole, do not like too much re-calling on account of its costliness.

Callback is common in most survey modes, though cost often constrains the extent of callbacks. Repeated callbacks can be expensive, which creates a trade-off between boosting the response rate and keeping survey expenses within budget. Survey organizations differ considerably in how many callbacks they do, with five being a common number for phone interviews (Weisberg 2005).

Ayhan (1981) has examined the case of not at home for the personal interview (face to face) survey, the minimum total number of calls (*first visit + number of recalls*) for the household survey is recommended by the WFS surveys is 1 + 3 = 4 total calls. On the other hand, the total number of calls (*first visit + number of recalls*) for the individual survey is recommended by the WFS surveys is 1 + 2 = 3 total calls (WFS, 1975).

Callbacks are made at different times of the day and days of the week to increase the chances of contacting the household. Groves *et al* (2004) show a summary of five separate surveys in which only 40–60% of those were interviewed on the first call. In other words, callbacks can double the contact rate. An additional 10–20% were interviewed on the second call, another 10% on the third call, and about 5% on the fourth, with fewer on each of the following calls.

Some survey designs have specific rules for the calling patterns of households. Some telephone surveys use software in computer-assisted interviewing systems to enforce such rules. For example, surveys may specify that the interviwer make four call attempts over a number of days in order to make first contact with a household, and then obtain a final proposition within four additional calls (Dillman *et al* 2002).

Groves and Cooper (1998) have reported that, the National Survey of Health and Stress, 1990-1991 was based on the face to face interview survey. They have reported 4 call schedules, where for each visit the percentage of calls were reported as 49, 70, 80, & 90 percent, respectively.

Czaja and Blair (2005) have stated that, in general for a random digit dialing telephone survey, it is efficient to make the first call during the day because doing so facilitates eliminating businesses and other nonhousehold numbers. After that, weekday evenings and weekends are recommended when people are most likely to be at home. It is important that callbacks be spread over different days.

Although higher response rates may be achieved by increasing the number of call attempts to cell phone respondents, the personal nature of the cell phone suggests the need for caution with this strategy, due in part to the anti-harassment issues. AAPOR (2016) proposed that, in order to reduce the potential for overburdening (and likely harrassing) the cell phone respondent pool, it is recommended that the total number of call attempts be limited to a modest number, perhaps in the range of six to 10, as compared to the grater number of attempts often used when surveying landline telephone numbers. The length of the field period should be taken into consideration when deciding what will be the maximum number of call attempts in a cell phone survey.

ILLUSTRATION OF SURVEY NONRESPONSE BIAS

By using the World Fertility Survey for *high quality data collection standards* in fertility surveys, Ayhan (1981) examined the number of callbacks and their sample outcomes for the Turkish Fertility Survey. The survey design is based on a household schedule and individual persons survey, where the details of the sample outcome is provided in the following Tables 4,5, 6 and 7.

Table 4: The breakdown of reasons of nonresponse for the household survey

Reasons of Nonresponse	Count	Percent
Number of selected households	6163	100.0
Number responded households	5142	83.4
Number of nonrespondent households;	1021	16.6
Nobody at home	571	9.3
Away from home	42	0.7
Lives elsewhere	156	2.5
Refusals	72	1.2
In capacity (ill)	5	0.1
Adress not found	175	2.8

Source: Ayhan (1981)

Table 5: The breakdown of sample outcomes for the individual survey

Sample Outcomes	Counts	Percent
Number Responded Households (DUs)	5142	
Eligible Individual Existed	4769	
Eligibles Responded the Individual Survey	4431	92.91
Nonrespondents	338	7.09

Source: Ayhan (1981)

Number of eligible individuals within the household survey was 4769 women. Among these, 4431 (92.91 %) eligible women were interviewed for the individual survey.

Table 6: Number of calls for the individual survey by urban-rural breakdown

Number of Calls	Urban		Rural		Total	
	Count	Percent	Count	Percent	Count	Percent
1	2465	93.34	1727	96.48	4192	94.61
2	153	5.79	54	3.02	207	4.67
3 +	23	0.87	9	0.50	32	0.72
Total	2641	100.00	1790	100.00	4431	100.00

Sources: Ayhan (1981), & WFS (1975)

As a final out outcome, the individual survey response rate will be the product of household survey RR and individual survey RR;

$$IndvSurvRR = \frac{5142}{6163}\frac{4431}{4769} = 0.834 \times 0.929 = 0.7748$$

The individual survey nonresponse rate will be the product of household survey NRR and individual survey NRR;

$$IndvSurv\,NRR = \frac{1021}{6163}\frac{338}{4769} = 0.166 \times 0.0709 = 0.01177$$

Table 7: Cumulative number of calls for the total sample

Call number	Cumulative counts	Cumulative percent	Count details
1	4192	94.61	4192
2	4399	99.28	4192 + 207
3+	4431	100.00	4399 + 32
Selected eligibles	4769	92.91	4769
Total nonresponse	338	7.09	338

Source: Ayhan (1981)

$Household\ Survey\ NRR = \frac{n_2}{n} = \frac{1021}{6163} = 0.1657$ can be taken as fixed for the first stage.

Then, nonresponse bias for various call numbers for individual nonresponse components (INR_C) are;

$$INR\_C(1) = \frac{557}{4192+577} = \frac{557}{4769}$$

$$INR\_C(2) = \frac{370}{4399+370} = \frac{370}{4769}$$

$$INR\_C(3+) = \frac{338}{4431+338} = \frac{338}{4769}$$

Finally, the *individual nonresponse rate* for each call stage will be;

$$INRR(1) = \frac{1021}{6163} \times \frac{577}{4769} = 0.166 \times 0.121 = 0.020$$

$$INRR(2) = \frac{1021}{6163} \times \frac{370}{4769} = 0.166 \times 0.078 = 0.013$$

$$INR(3+) = \frac{1021}{6163} \times \frac{338}{4769} = 0.166 \times 0.071 = 0.012$$

Nonresponse bias for the individual survey nonresponse will be;

B(1, 3+) = INRR (1) – INRR (3+) = 0.020 – 0.012 = **0.008**

B(2, 3+) = INRR (2) – INRR (3+) = 0.013 – 0.012 = **0.001**

The estimated nonresponse bias values are found to be very low for the this survey. For the evaluation, the maximum call stage (3+) value was taken as the base for comparison.

CONCLUSIONS

Response and nonresponse rate relations are examined by their corresponding components. The relationship between the nonresponse reasons and number of calls on the nonresponse amounts are also investigated in this paper.

The case of not at home for the personal interview (face to face) survey, the minimum total number of calls for the household survey is recommended by the WFS surveys is 1 + 3 = 4 total calls. On the other hand, the total number of calls (*first visit + number of recalls*) for the individual survey is recommended by the WFS surveys is 1 + 2 = 3 total calls.

For an alternative data collection mode, of reducing the potential for overburdening the cell phone respondent pool, it is recommended that the total number of call attempts be limited to a modest number, perhaps in the range of six to ten calls.

When we evaluate the nonresponse amount as fixed for a given survey, then the size of nonresponse bias is based on the survey nonresponse rate and the difference between the response and nonresponse strata means. Alternatively, nonresponse can also be evaluated as a random variable, leading to alternative bias components.

Estimation of new responses are based on nonresponse stratum values which are obtained from subsampling of nonrespondents. By this means, nonresponse stratum has now new response values, which is based on the subsample. Numerical illustration of the individual survey nonresponse bias have been shown for several number of callbacks for a given survey. The amount of estimated nonresponse bias values are found to be reasonably low for the reported survey.

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