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A GENERAL VIEW OF NONRESPONSE BIAS IN SOME SAMPLE SURVEYS OF THE SWEDISH POPULATION

AV HÅKAN L LINDSTRÖM

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ABSTRACT

In the introduction, the similarity of a number of studies of nonresponse errors in some surveys of individuals is demonstrated. This similarity renders a rare opportunity to examine if there are any characteristics of the nonrespondents that are common for all the studied surveys. Section 2 gives a review of the different reasons for nonresponse and of differences between the various categories of nonrespondents. Theoretical models for nonresponse analysis are briefly presented in Section 3 and the measures of nonresponse bias used in this report are presented in Section 4. Section 5 compares the distributions of the nonrespondents on domains of study in three simultaneous studies. This comparison demonstrates the absence of any uniform overall nonresponse distribution on sociodemographic variables. Section 6, that constitutes the main part of this report, summarizes and presents the findings of a number of Swedish studies of nonresponse bias and makes some comparisons with bias studies of the other countries. In Section 7 the common traits of nonresponse in samples from the same population are discussed and some observations on the size and direction of the estimated nonresponse biases are made.

Key-words: nonresponse bias, sample surveys.

CONTENTS

1 THE COMMON CHARACTERISTICS OF SOME STUDIES OF NONRESPONSE BIAS

For obvious reasons it is hard to obtain good estimates of nonresponse errors in sample surveys. Even ambitious follow-up studies fail to win the cooperation of all the nonrespondents. Nor can measurement errors be separated from nonresponse errors when survey data for the respondents are compared with data for initial nonrespondents who were persuaded to cooperate. Comparisons with estimates or counts from other data sources are seldom conclusive because of differencies in definitions and timeliness, different coverage and measurement errors etc.

In Sweden, a number of studies of surveys of individuals have been performed that come as close as practically possible to giving unbiased estimates of nonresponse bias. The existence of personal identity numbers in the sampling frame - the register of the total population - has made it possible to match data from other population registers to all units in the sample - respondents and nonrespondents alike. The number of matching studies, however, is limited as they cannot be done without the permission of a particular authority and are, when allowed, governed by strict regulations.

The surveys under study have several things in common. The sampling unit is the individual. The sampling frame and the sampling population are roughly the same for all of the studied surveys. In all cases the sampling population is the adult population of Sweden although some differences in age limits do occur. Uniformity in data collection standards is furthermore guaranteed in that Statistics Sweden is responsible for the data collection for all of the surveys. The nonresponse rates of the surveys usually varied between 0.07 and 0.20.

In all the studies except one, the nonresponse bias is estimated through matching. Coverage errors are negligible, but measurement errors cannot be totally disregarded. However, the variables under study are fairly simple and factual. Variables of this type have often a low frequency of measurement errors. Since recording in the population register preceded the sample survey and in no way was influenced by the sampling and data collection precedure, differential measurement errors are not expected, especially not when recording is done by a government official. The risk is greater when an individual reports himself as in a census.

In the absence of knowledge about the nonresponse bias - which is the normal case - even a small nonresponse must be feared to have a disturbing or even a devastating effect on the the mean square errors of the estimates. Since it will not be possible to estimate the nonre-

sponse bias in most cases, it is very important to find out if there are any general characteristics of the nonrespondents in surveys of the same population. To shed some light on this problem is the main aim of this report. A number of studies of nonresponse bias are reported in a uniform way i Section 5 and 6 according to the principles accounted for in Sections 2 - 4. As the reported studies refer to the same population and can be analyzed in a uniform way, they offer an unique opportunity to search for some kind of regularity in the appearances and effects of nonresponse. Comparisons and general conclusions are given in Section 7 and some explanations suggested for the observed nonresponse effects.

The benefit derived from comparing the Swedish studies with studies of nonresponse bias in other countries is a bit uncertain. There are reasons not to postulate similar effects of nonresponse in two countries if, for example, population composition, survey climate and the ways of organizing and performing data collection are different. However, when comparable or otherwise illustrative studies from other countries have been found their results have been reported and compared with the Swedish studies.

The studies reported constitute most of the studies of nonresponse effects performed on data collected by Statistics Sweden, in which the nonresponse error could be fairly well separated from other sources of error. Lindström (1983), who reports the same studies in more detail and together with a number of less conclusive studies, presents evidence and draws conclusions about the effects of nonresponse in Sweden only but without attempting to make international comparisons.

2 BIAS FOR DIFFERENT GROUPS OF NONRESPONDENTS

Whether or not an individual will be a respondent in a survey depends on several interacting factors. A trained staff of interviewers and a resourceful data collection procedure for following up nonrespondents is essential for a high response rate. The attitudes of the individual to survey participation may depend on both the subject of the survey and certain aspects of the individuals life style. Different reasons for nonresponse may result in different types of nonresponse bias.

A detailed discussion of the sources of nonresponse and how their impact can be reduced is given by Platek (1977), who also demonstrates differences between those who refused and those who were not available in the Canadian Labor Force Survey. Refusers had a higher unemployment rate and belonged to households of larger average size than the other nonrespondents. The observation that separate groups of the nonre-

spondents can have different and even contrasting characteristics is also verified by Smith (1983), who studied the 1980 US General Social Survey and gives supporting evidence from other reports.

A recent Swedish study has shown that public assistance recipients are heavily overepresented among not-at-homes. 23 percent of all not-at-homes were recipients of public assistance, whereas only three per cent of both all other nonrespondents and respondents were receiving public assistance. The survey had a total nonresponse rate of 17.7 and a not-at-home rate of 2.2 percent.

Thomsen and Siring (1980) discuss nonresponse sources in much the same way as Platek and separate them according to whether they are directly or indirectly controllable. In an example they show that as the mean number of children per woman increases, the number of follow-up calls necessary to reach a women decreases. This demonstrates that women with children are more available for interviewing than other women. Another example shows that refusers have higher income than respondents, but that the other nonrespondents have lower income than respondents.

The study of subgroups of the nonrespondents is valuable in every survey because the results can either be used to reduce the bias or to estimate it. On the other hand, comparing the categories of nonresponse by reason in a number of surveys is somewhat dubious because of the survey specific nature of nonresponse. Most of all, it is the survey's response goals and data collection methods that determines if an individual will be a respondent or a nonrespondent.

Smith (1983) gives a representative description of how the length of the data collection period and the strategy of callbacks will decide the level and distribution of the nonresponse ultimately obtained in a survey. After two callbacks there were 32.5 percent respondents, 9.9 per cent refusers, 50.2 percent not-at-home and 7.3 percent others. The distribution changed after the concluding efforts to 76.0 per cent respondents, 16.3 percent refusers, 3.4 percent not-at-home and 4.2 percent others.

The surveys reviewed in Section 6 of this report differ in their choice of data collection method, length of data collection period and final nonresponse rate, as will be demonstrated. It cannot be proven if the not-at-homes in one survey belong to the same group as the not-at-homes in the other surveys or not. Breaking down the nonrespondents in subgroups by reason for nonresponse would not contribute much to explaining the general nonresponse effects, which is the main objective of this study. In the following section, nonresponse is dicussed as a whole without looking at nonresponse divided up according to reason.

3 STATISTICAL MODELS OF NONRESPONSE

This analysis of nonresponse effects follows the traditional approach, as used in Hansen and Hurwitz (1946), of dividing the sample into two groups, one belonging to a theoretical response stratum and the rest belonging to an equally theoretical nonresponse stratum. This model is still in common use as the mathematics for calculating estimators, variances and bias is straightforward, the reasoning easily understood and no supplementary information needed. Furthermore it provides unbiased estimates if subsampling among the initial nonrespondents is successful. It is used, for example, by Dunkelberg and Day (1973) and Kalsbeek and Lessler (1977) in studying nonresponse bias and by Kalton (1981) as a theoretical basis for comparing adjustment methods.

Although this model is widely used, there seems to be an equally common understanding that the stratum model is unrealistic and that more flexible models assuming a response probability $0 < q_i \leq 1$ attached to each sampling unit can be more fruitful and should be used if such probabilities can be calculated. In that case unbiased estimation can be done. Probabilistic approaches are used both in survey error models, as demonstrated by Lessler (1983), and in estimation, as described by Cassel, Särndal and Wretman (1983). Usually either response rates in subgroups or some measure of the difficulty to get each interview are used as response probabilities. However, this type of analysis could not be applied here since no information on response probabilities was available.

4 MEASURES OF NONRESPONSE EFFECTS

The nonresponse studies presented here have in common:

- the same sampling frame which has neglectable coverage errors
- sample designs with simple random samples or with sampling designs with approximately the same precision.
- information on almost the complete sample from population registers
- data with few measurement errors or measurement errors that don't depend on the objects being nonrespondents in the particular survey

That the surveys are so similarly constructed means that they can be uniformly analyzed via a fairly simple error model where the mean of a population can be written :

$$\bar{X} = W_r \bar{X}_r + W_{nr} \bar{X}_{nr} \qquad (1)$$

$\bar{X}$ has its conventional meaning as an average and W stands for relative stratum size. r indicates response stratum and nr the nonresponse stratum. So W_r is the relative size of the response stratum and $\bar{X}_r$ its average etc. .

The primary goal of the analysis is to find out how much an estimate is affected by nonresponse. It is measured by:

$\bar{B} = \bar{X}_r - \bar{X}$ or its unbiased estimate. (2)

P is substituted for $\bar{X}$ when the variable is dichotomous and small letters for capitals when reference is made to a sample. The estimates of nonresponse bias are then $\bar{x}_r - \bar{x}$ or $p_r - p$ when the variable under study is dichotomous. Sometimes the relative bias $(\bar{B}/\bar{X})$ is used.

The corresponding difference between the response and nonresponse stratum can easily be calculated by using the identity:

$$\bar{B} = \bar{X}_r - \bar{X} = \bar{X}_r - W_r \bar{X}_r - W_{nr} \bar{X}_{nr} = W_{nr} (\bar{X}_r - \bar{X}_{nr}) \qquad (3)$$

If response errors are present in the register that is matched to the sample, the error model should be slightly modified. If the observed value Y_i of each object has a measurement error expressed as a deviation from its true value X_i and with expectation M_i, the expectation of a difference is separated into nonresponse bias and measurement bias as:

$$\bar{Y}_r - \bar{Y} = W_{nr}((\bar{X}_r - \bar{X}_{nr}) + (\bar{M}_r - \bar{M}_{nr})) \qquad (4)$$

For surveys using simple random sampling and neglible sampling fraction,

the approximate variance of the of the difference $\bar{b} = \bar{x}_r - \bar{x}$ is:

$$\mathrm{Var}(\bar{b}) = W_{nr}^2 \left(\frac{S_r^2}{n\, W_r} + \frac{S_{nr}^2}{n\, W_{nr}} \right) \qquad (5)$$

where S_r^2 and S_{nr}^2 are the unit variances of response and nonresponse strata respectively. The result is valid when n is so large that the random variation of n_r and n_{nr} can be ignored and follows then immediately from formula (3).

Since the samples concerned can be accepted as close approximations of simple random samples and are fairly large, the test variable $Б/(\text{var}(Б))^{\frac{1}{2}}$ can be regarded as a standard normal deviate. Under the hypothesis of equal percentages among respondents and nonrespondents, which is the most frequent case in this report, both S_r^2 and S_{nr}^2 will be equal to $P(1 - P) \frac{N}{N - 1}$

A difference found significant by a two-sided test at the five percent level is indicated by * in the tables below.

5 NONRESPONSE AND SOCIODEMOGRAPHIC VARIABLES

Statistics Sweden uses samples of individuals and households drawn from a population register containing information on age, sex, marital status, place of residence etc. There is also a procedure for linking spouse to spouse and children to their parents. Most surveys use this information to some extent for both stratification and nonresponse adjustment.

When a survey has been performed, it is standard procedure to calculate and present nonresponse rates with regard to classifications of variables and the distribution of the nonrespondents on the following categories: refuser, not-at-home, ill-at-home, and cared-for-by-some-institution. The last two cathegories usually amount to less then one percent of the net sample together.

A detailed comparison of nonresponse distributions between the surveys is not possible without certain efforts. Those responsible for the surveys have various interests and have not adopted a common classification system. It is still possible to reject the hypothesis that there exists a nonresponse distribution common all surveys by using a rather limited material. This is illustrated in Table 1 through a comparison of nonresponse rates in the same domains of study in three regular surveys.

When the nonresponse rates in the domains of study in the three surveys were compared they showed the typical mixture of similarities and dissimilarities in their nonresponse distributions that always appears when several surveys are compared. In the Survey of Living Conditions (SLC) and Party Preference Survey (PPS) there was no significant difference in nonresponse rate between men and women, but men were significantly more often nonrespondents in the Labor Force Survey (LFS). On the other hand, nonresponse rates increased with age in both the SLC and the PPS but not

in the LFS among individuals above the age of 24. The main conclusions would have been the same if some other recent year had been chosen for comparison.

Table 1. Non-response rates in domains of study in three surveys

Domain of study	Labor Force Survey 1984 (LFS)	Survey of Living Conditions 1984 (SLC)	Party Preference Survey Nov. 1984 (PPS)
Men	0.072	0.162	0.150
Women	0.059	0.173	0.138
Age			
16-24	0.049	0.121	0.100
25-34	0.070	0.148	0.133
35-64	0.069	0.182	0.153
65-74	0.070	0.202	0.281
Total sample	0.065	0.167	0.144
Refusals	0.033	0.137	0.077
Sample size	264 300	7 990	8 940

The differences in the designs of the surveys were large. Both the LFS and the PPS collect their data through a 15-minute telephone interview, LFS within one week and PPS within two and a half. The LFS allows proxy interviews and might possibly have a different distribution of nonrespondents in the absence of proxy interviewing. The non-proxy response rate were 0.805 among men and 0.879 among women. In the SLC, data were collected via face-to-face interviews within three months. At this length of the data collection period the not-at-home rate was reduced to only two per cent. Differences in design and topic are believed to explain much of the differences in the nonresponse distributions.

The same mixture of occasional similarities but a lack of persistent common distribution can be seen in an extensive study by Statistics Sweden on nonresponse distributions in a number of regular surveys of individuals and households. The study, presented in 1974, could not offer any final explanations for the differences. Similar observations are reported by Smith (1983) when reviewing a number of US surveys.

One exception is "place of residence by population density" which has been repeatedly seen to have a positive correlation to the nonresponse rate. Such correlations were, for example, reported by Madow (1983), Smith (1983) and Steeh (1981). The table below shows representative Swedish data drawn from the SLC. The data covers five consecutive years when the surveys were carried out in a uniform way.

Table 2. Nonresponse rates in the SLC 1980 - 84 by region

Region:	1980	1981	1982	1983	1984
Stockholm region	0.174	0.171	0.167	0.207	0.219
Göteborg and Malmö regions	0.192	0.179	0.165	0.205	0.225
Other major cities	0.136	0.118	0.116	0.160	0.142
Medium sized communities adjacant to major ones	0.116	0.131	0.113	0.124	0.148
Medium sized communities not adjacant to major ones	0.117	0.118	0.095	0.119	0.132
Sparsely populated areas	0.112	0.075	0.107	0.091	0.118
All regions	0.144	0.136	0.130	0.160	0.167
Sample size	7 130	7 620	7 870	7 470	8 670

The same pattern is present in all five years. Sparsely populated areas have substantially lower nonresponse rates than the major cities; the other regions have an intermediate nonresponse level. Observations with this kind of regularity in periodical surveys are numerous and the rule rather than the exception. They offer support for the idea that nonresponse effects are the same in controlled repetitions of a survey and that estimators of changes over time could be less sensitive to nonresponse bias than level estimators.

6 ESTIMATES OF NONRESPONSE BIAS IN SAMPLE SURVEYS

6.1 INTRODUCTION

The main concern of the studies accounted for in this report is the nonresponse bias in estimates of percentages and means in the entire population and in major domains of study. All the variables studied are related to the living conditions of individuals, e.g., finances, state of health, employment, political activity, and family composition. The studies have been performed in the period 1973 - 1981.

Each of the subsequent sections of this chapter presents estimates of nonresponse bias in one or a few related variables. The material is presented in as uniform fashion as possible to facilitate overviews and comparisons. Each survey and the methodological study that yielded the nonresponse bias estimates are described in a concise fashion. The bias was estimated according to the formulas of Section 4. The sources of error that could possibly influence the estimated results are also presented making it possible to determine the quality of the results.

The original reports used various measures to discribe nonresponse effects and it was necessary in a number of cases to recalculate the estimates. Since the basic data, were not available, the information that was available in the reports determined the numerical precision, the possibility of significance testing, and the breakdown of the sample on domains of study.

6.2 EMPLOYMENT

Since 1970, the Swedish Labor Force Survey (LFS) has reported on employment every month using a sample size of around 20 000 individuals. In 1976 a new stratification was introduced, in which simultaneously weighting in strata and post-strata replaced imputation for nonresponse. It now became imperative to evaluate the nonresponse bias of the new design. This was done by matching the sample to the 1975 Census of Population and Housing that had an employment variable very much like the LFS. The overall employment rate fell from 68 to 66 percent when estimated with the census employment varable instead of the survey employment variable. The original study is mainly concerned with the effects of nonresponse on the stratified and weighted sample of 1976. However, some unweighted results from the 1975 LFS could be extracted, since a major part of the 1976 sample also participated in 1975. The survey uses a rotating sample and exchanges one panel out of eight each quarter.

The sample analyzed consisted of 43 998 individuals was self-weighting, and had a nonresponse rate of 0.074. It consisted of the mutually exclusive, equal-sized samples of LFS in September, October, and November of 1975. The census was performed during the period 20-26 October. In the data taken from the Census register there were only nine cases without employment information. The existence of response errors in the census must not be overlooked. If these errors are of systematically different size in response and nonresponse strata in the LFS, they will influence the observed difference as expressed by formula (4).

The nonresponse was also be studied in several domains of study. The number of observations was large enough so even moderately sized differences in the domains of study proved significant. In the 1975 study the sample was broken down by sex and age (twelve age groups). The results are presented in Table 3 (men) and Table 4 (women).

Table 3. Employment rates among men in the 1975 LFS.

Age	Respondents p_r	Net sample p	Difference $p_r - p$	Nonresponse rate
16-19	48.5	48.2	0.3	0.045
20-24	74.0	73.0	1.0*	0.076
25-29	91.6	90.1	1.5*	0.088
30-34	95.3	93.7	1.6*	0.087
35-39	95.0	93.5	1.5*	0.076
40-44	95.5	94.5	1.0*	0.090
45-49	93.5	91.2	2.3*	0.078
50-54	91.8	90.8	1.0*	0.074
55-59	87.1	86.4	0.7*	0.084
60-64	71.4	70.9	0.5	0.079
65-69	21.8	21.4	0.4	0.076
70-74	8.1	7.9	0.2	0.057
16-74	76.6	75.5	1.1*	0.077

The differences are significant for all men and for men in each of the age classes in the interval 20-59. For all cases the respondents had a higher employment rate than all the sample. The oldest and youngest age classes had both lower employment rates and a smaller nonresponse bias than the employment mean and nonresponse bias for the material as a whole. The greatest difference, which appears in the age class 45-49, is about twice the average difference.

Table 4. Employment rates among women in the 1975 LFS.

Age	Respondents p_r	Net sample p	Difference $p_r - p$	Nonresponse rate
16-19	49.1	48.9	0.2	0.055
20-24	67.4	66.4	1.0*	0.075
25-29	65.6	65.5	1.1*	0.067
30-34	67.7	66.9	0.8*	0.065
35-39	72.1	71.6	0.5	0.058
40-44	75.8	75.3	0.5	0.066
45-49	76.9	76.6	0.3	0.074
50-54	70.1	69.4	0.7*	0.077
55-59	60.6	60.0	0.6	0.090
60-64	36.6	37.3	- 0.7*	0.083
65-69	8.3	8.6	- 0.3	0.068
70-74	2.1	2.2	- 0.1	0.063
16-74	55.9	55.6	0.3*	0.071

The nonresponse biases are smaller among women then among men and show no uniform pattern. The bias among all women is small but significant, thanks to the large sample size. Significant differences are also established in the ages 20-34, 50-54 and 60-64. The last-mentioned age group was the only one where the respondents had significantly lower employment rate than the net sample.

Differences of somewhat smaller size were found when 1976 weighted data were broken down by sex and county, sex, and marital status and age. The same sampling units were now classified as respondents or nonrespondents according to their participation in the LFS in 1976. The weighting was done in strata and post-strata by age, sex and county and seems to have eliminated slightly less then half the bias.

6.3 CASES OF ILLNESS

The Swedish Social Security System includes compensation for loss of income due to illness. Cases of reported and compensated illness and the illness's duration are registered centrally. Data from these registers were used to supplement the systematic samples from the population aged 16-74 sampled in the Surveys of Living Conditions (SLC) in 1975 and 1976. The sample sizes were 8 799 persons in 1975 and 8 704 in 1976,

with nonresponse rates of 0.196 and 0.217, respectively. Most of the nonre- spondents were refusers. In 0.5 percent of the sample, bad health was the reason given for nonresponse. The register had no information on people without sickness compensation, so it was not possible limit the the analyze to the group entitled to compensation (consisting of 4.7 million people in a population of 5.9 million in the age groups concerned). Results had to be calculated either for the total population or for those with at least one case of reported illness.

The results for 1975 and 1976 are not fully comparable since new legislation lowered the pensionable age from 67 to 65 in 1976 and thus transformed a number of employed persons with protracted illnesses into old-age pensioners.

Nonresponse biases have been studied for three variables :

* having been ill or not (table 6)
* the number of cases of illness (table 7)
* the number of sickdays (table 8)

The results were calculated after the sample had been divided into sex and age groups. Both positive and negative differences were observed in age groups and no consistent pattern was found. Extremely high differences were found only in the average number of sickdays among women just below pensionable age. Only the results for all men and all women are presented here.

Table 6 Per cent with at least one recovered and compensated case of illness within the year among all persons aged 16-74.

Sex Year	Respondents p_r	Net sample p	Difference $p_r - p$	Nonresponse rate
Men				
1975	50.1	50.2	- 0.1	0.201
1976	53.4	52.2	1.2*	0.220
Women				
1975	44.3	44.7	- 0.4	0.191
1976	46.8	47.4	- 0.6	0.215

The percentage of the sample with at least one recovered illness during the year is calculated for the whole sample. Testing produced a significant difference only for men in 1976.

Table 7 Average number of recovered and compensated illnesses per year among those who had at least one such illness.

Sex Year	Respondents $\bar{x}_r$	Net sample $\bar{x}$	Difference $\bar{x}_r - \bar{x}$	Nonresponse rate
Men				
1975	2.6	2.6	0.0	0.203
1976	2.5	2.6	- 0.1	0.203
Women				
1975	2.4	2.4	0.0	0.201
1976	2.6	2.5	0.1	0.213

The nonresponse effects in the average number of illnesses among those who had at least one case of illness could not be tested since no variances were calculated. The measured differences in 1976 were, at any rate so small that they may even represent rounding errors.

Table 8 Average number of compensated sickdays a year among those who had at least one recovered and compensated illness.

Sex Year	Respondents $\bar{x}_r$	Net sample $\bar{x}$	Difference $\bar{x}_r - \bar{x}$	Nonresponse rate
Men				
1975	41.0	42.5	- 1.5	0.203
1976	35.4	38.6	- 3.2	0.203
Women				
1975	33.1	34.1	- 1.0	0.201
1976	35.3	37.5	- 2.2	0.213

The differences of table 8 between the respondent's estimate and the estimate for the sample as a whole for the average number of sickdays in 1975 and 1976 may be significant although they were rather small. Variances were not calculated for the average number of sickdays but a backwards calculation (at the disputable hypothesis of identical distributions in response and nonresponse strata) demonstrates that the differences shown in table 8 are significant as long as the unit standard deviations are not larger than 71.6, 154.1, 44.9 and 98.0 respectively. Significances are then obtainable even if the variables "number of sickdays" have distributions still more skewed than the negative exponential whose standard deviation is equal to its average.

As repeated studies of the nonresponse bias of the same variables and for identically defined domains of study are rare, these studies are interesting, especially as the design is the same both years and the nonresponse rates in 1975 and 1976 are practically identical. The differences between 1975 and 1976 in average number of sickdays for both sexes and in the per cent of men with cases of illness warns against uncritical belief that nonresponse bias always will be the same in one survey.

6.4 INCOME AND PROPERTY

Nonresponse effects on income data were studied in the Level of Living Survey (LLS). The net sample of 6 593 individuals was drawn with approximately equal probabilities from the age groups 15-75. The nonresponse rate was 0.148. The survey was performed in 1974 and used face to face interviews as its data collection method. Most of the nonrespondents were refusers. Income data were collected from taxation registers, and as far as the study refers merely to taxed income there were no measurement errors. Coverage errors were limited. Income information was missing only for 24 members of the net sample.

The percentage of the population who had a specific kind of income or property is presented in table 9 and the averages for the groups in table 10. The mean value for all persons could have been calculated as well, but was considered of minor interest since it would be distorted by both the percentage of persons without income/property and the nonresponse rate within this group.

Table 9 Percentage with income of various kinds or with property in 1974 among all persons aged 15-75.

Income source:	Respondents p_r	Net sample p	Difference $p_r - p$
employment	78.1	78.1	.0
capital	18.8	19.5	- .7*
other property	8.7	8.9	- .2
casual work	.9	1.0	- .1
farm property	3.5	3.4	.1
business	3.1	3.3	- .2*
Total income	81.1	81.5	- .4
Assessed income	80.9	81.3	- .4
Property	4.5	4.7	- .2*

Assessed income is total income minus legal deductions.

There was an obvious tendency to underestimate the proportion of income earners. All three values in table 9 that were significant - for capital and business income and property - had a negative bias. The only postive difference was not significant and appears for farm property. For the main income source - employment - there was no difference at all. The averages for the various income sources were calculated and are presented in table 10.

Table 10. Average income in SEK (thousands) of persons with the specific kind of income and average property among those with property in 1974.

Income source:	Respondents $\bar{x}_r$	Net sample $\bar{x}$	Difference $\bar{x}_r - \bar{x}$
employment	25.2	25.2	.0
capital	1.9	2.0	- .1
other property	1.4	1.5	- .1
casual work	3.6	4.8	-1.2
farm property	10.7	10.1	.6*
business	18.2	21.0	-2.8*
Total income	26.1	26.3	- .2
Assessed income	24.0	24.1	- .1
Property	208.8	214.3	-5.5

Significant differences were found only in income earned from farm property and from business. There was no differerence in the average income from employment. When the variances in the response and nonresponse strata were compared, significant differences were found in all cases except for income from employment and income from capital and for assessed income and property. With the exception of income from farm property, the variances were higher in the nonresponse group. Whether the differences were due to a few outliers or to entirely different population structures was not reported. In the 1981-83 SLCs, however, where the subject and data collection methods were similar to those of the LLS, a high nonresponse rate appeared among those who had the highest income. The non-response rates among those who earned more than 200 000 SEK a year were 4.9, 2.6 and 8.4 percent, respectively, higher than in all the net sample.

Nonresponse bias in estimates of farmers income and property was also studied in a mail survey in 1981. Although the nonresponse rate was as high as 0.29 among the 1643 farmers sampled, the effects on estimates of income, assets and debts were less then 0.5 percent of the net sample estimate and nonsignificant.

6.5 VOTING

Voter preference for political parties has been studied in the Party Preference Survey (PPS) since 1970, with an interruption in 1983 and 1984. The sample is systematic, uses three panels and reaches 9 000 eligible voters every survey occasion. The data is collected through telephone interviewing.

The prediction power of some estimators is improved by using the varying voting frequencies in population groups to reduce response bias. Special methodological studies are performed at each general election. During the two weeks before election day a survey on the voter's party preference and socio-demographic characteristics is performed. The sample was drawn from the population register carries information on who is entitled to vote, so coverage errors are negligible. Whether a sampled person actually voted or not was established by consulting the official voting records, so response errors cannot be expected to have any substantial effect on either the respondents voting rates or on the nonrespondents.

The methodological study was performed in 1973 and repeated in 1976 and 1979 but not in 1982. The results of the three eqvivalent studies is summarized in table 11.

Table 11. Voting rates (per cent) in the PPS.

Year	Respondents p_r	Net sample p	Difference $p_r - p$	Nonresponse rate
1973	94.0	91.2	2.8*	0.15
1976	95.5	92.3	3.2*	0.18
1979	93.5	91.2	2.3*	0.17

Sample sizes were 3 000, 3 100 and 3 000.

The voting rate is substantially higher among the respondents. The nonresponse effects in the variable "voting" are also highly significant.

They are among the largest biases observed in the Swedish studies presented in this report and of very similar size on all three occasions. The differences in nonresponse bias between the years are still significantly larger then zero except for between 1973 and 1976.

The results are very close to those reported by Thomsen and Siring (1980) in an extensive Norwegian study. In 1969 they found 71 percent participation in the general elections among the nonrespondents and 88 percent in the sample as a whole. This difference is exactly the same size as that which can be calculated between respondents and nonrespondents in the 1973 Swedish PPS. When the Norwegian sample was broken down on age groups the bias was consistently positive.

6.6 HOUSEHOLD SIZE

Even if household size is regarded to the most part as a classification variable, it is also decisive for the individuals' standard of living. Varying nonresponse rates among people belonging to households of different sizes points to the possible risk of nonresponse bias in variables correlated to household size like expenditure and housing.

In the 1981 Survey on Women and Children the sample consisted of 4966 women. The sample was stratified by age and a simple random sample was drawn within each stratum. Face-to-face interviewing was done and the overall nonresponse rate was 0.13. The subject of the survey was the interaction between family life and employment and a check of the distribution of nonresponse and family type was clearly important. The nonresponse effect on the variable "women with children under 18 at home" was calculated within strata. The information was drawn from the population register and the results are presented in table 12.

Table 12 Per cent of women with children under 18 at home.

AGE OF WOMAN	Respondents p_r	Net sample p	Difference $p_r - p$	Nonresponse rate
20 - 24	26	25	1	0.13
25 - 29	60	58	2*	0.12
30 - 34	83	81	2*	0.13
35 - 39	87	84	3*	0.14
40 - 44	74	71	3*	0.18

In all ages the respondents more frequently had children at home and the biases were significantly larger then zero in the four oldest agegroups. The difference between those who responded and those who did not was ascribed to women without children under 18 having less motivation to participate in a survey dealing with the interaction between employment, education and family life. Women without children were also thought to be less available because they belonged to smaller households. The observations were similar to those reported by Thomsen and Siring (1980) who showed a lower average number of live births among the nonresponding women in the 1977 Norwegian Fertility Survey.

The correlation between full household size and nonresponse is not so easy to study. Registers do not provide information on the household as a whole. Comparisons with the census are not reliable because there are also measurement errors in censuses. In addition, there are differences between household definitions of the surveys and of the censuses and the results may not refer to the same occasion. Only in the 1969 Family Expenditure Survey (FES) could a complete study be performed on the sizes of the nonresponding households. The nonresponding households were almost all refusers.

The 1969 FES used a two-stage sample. 4086 households were sampled with probabilities proportional to the number of family members. The unweighted overall non-response rate was 0.24. In table 13 probability weighted estimates of the distribution of both the population and the response stratum are given. Variances were not calculated for either the percentages or the nonresponse rates. This study is the only one in this report where the results refer to households and not to individuals. However, the nonresponse rates of the rows of table 13 can be read as representative for individuals belonging to a household of given size.

Table 13 Distribution of housholds by number of members. Per cent.

Number of members	Respondents p_r	All sample p	Difference $p_r - p$	Nonresponse rate
1	25.8	29.0	- 3.2	0.36
2	29.7	30.5	- 0.8	0.29
3	18.6	18.0	0.6	0.26
4	17.0	14.8	2.2	0.17
5	6.3	5.3	1.0	0.15
6 or more	2.6	2.4	0.2	0.18

Measurement errors among respondents are assumed to be small since interviewing was done in their homes and contact with all family members was essential. Answers from the nonrespondents cannot be regarded as equally reliable since they were acquired through follow-up study in which contact with only one family member was accepted and interviews at home were not requested. Response errors must be suspected to have had an impact on the estimated biases of table 13.

Nonresponse rates have a strong negative correlation with household size. When the respondents distribution is calculated there is an important negative bias for one-person households but overestimation of the percentage of households with three or more members. Nonresponse rates that decrease as the number of adults in the household increase is also reported by Smith (1983) and lower average household size among the nonrespondents by Platek (1977). In Great Britain both the General Household Survey and the Family Expenditure Survey had high nonresponse rate among people living alone and low nonresponse rate among families with dependent children (Knight 1986). Household size is one of the very few variables were several conclusive studies have been performed and were the nonresponse effects are generally the same.

7 CONCLUSIONS

The approach of response/nonresponse stratum offers a simple model for analyzing the results of one survey at a time but it was enough to look at the differences in nonresponse rates between surveys to see that there is no nonresponse stratum common to all surveys and in which all estimates of nonresponse bias are valid. However there may be an interior core of people who never are at home or who would be nonrespondents no matter how a survey was designed. If such a core exists, it is at any rate too small to have any substantial influence on most variables. In the LFS, where eight interviews during two years are requested of each sampled person, only 3 to 4 per cent of the sample were nonrespondents on all eight sampling occasions. About the same rate of hard-core noninterviewable persons was indicated by Bergman-Rapp-Hanve (1978). The rest of the nonrespondents in each survey, who do not belong to that core, thus are many enough to be a possible source of different nonresponse effects in different surveys. It is the same whether they are considered as representing a conditional nonresponse stratum of each particular survey or as belonging to a random group established through the workings of nonresponse probabilities. Consequently, there is no reason to believe that the findings in one survey can be generalized to other surveys with high precision. Only very general conclusions on common characteristics of the nonrespondents can be drawn from the review of nonresponse studies in section 6.

Theoretically nonresponse bias can be disasterous even at low rates of nonresponse if the nonrespondents often have extreme values. From this point of view the results are reassuring. In several but not all cases, the estimates studied had significant biases. Still the significant differences were often of limited size as all the samples were large. When percentages were estimated, the bias seldom exceeded three percentage points. It was unusual to find a relative bias larger then one tenth of the all sample estimate. When the nonresponse bias was reported for several domains of study, a persistent pattern was sometimes present, as in "employment among men" (table 3) and "children at home" (table 12), but there are also examples of the opposite, as in "employment among women" (table 4). Other studies who report a high frequency of nonresponse biases of moderate, although sometimes significant, or negligible size are Dunkelberg and Day (1973), O'Neil (1979), Rizvi (1983) and Smith (1983).

Although the nonresponse biases were of limited size, the differences between respondents and nonrespondents were sometimes large which can be demonstrated by application of formula 3 on the estimated biases. In the cases of significant bias it was sometimes suspected but not proven that the biases depended more on outliers then on pervading differences in distribution between respondents and nonrespondents.

Although no examples of very large biases were found, it would obviously be unwise to conclude that there are no such cases. It should be kept in mind that the reported results refer to the population and some major domains of study and that the variables under study were not very sensitive ones. It should also be remembered that the surveys studied were well-managed and had nonresponse rates of moderate size. If one analyzes small domains of study, if the variables are correlated to the reasons for nonresponding or if they discribe socially unaccepted behaviour, the outcome could be quite different.

No relationship could be established between the size of the nonresponse rate and the size of the bias, even though the nonresponse rates varied from 0.07 to 0.29. The bias was no larger in the "illness variables" of the SLC at a nonresponse rate of 0.20 (tables 6 and 7) than in employment of the LFS at a nonresponse rate of 0.07 and was negligible in income among farmers at the nonresponse rate of 0.29. Several of the largest biases were found at the intermediate levels of nonresponse rate in "voting" (table 11) and in "children at home" (table 12). When relative biases were calculated, small values were found at all levels of nonresponse rate. The lack of relationship is explained if several variables are only weakly or not at all correlated to the reasons for nonresponse. Bergman-Rapp-Hanve (1978) made that conclusion in a follow-

up study on a small sample of regular refusers from the 1977 LFS and the SLC that was performed by especially qualified interviewers. The persuaded former nonrespondents of their study were heterogeneous both in reasons for refusal, in personal characteristics and in living conditions. Together with the general information on how well the data collection was performed the character of each variable of the survey may be a better indication on the danger of nonresponse bias than the nonresponse rate.

One pervading characteristic of the nonresponse biases studied was that the respondents' estimates tended to overestimate social participation. The respondents had higher employment rates, fewer sickdays and higher voting rates and were more often members of a family than the nonrespondents. O'Neil (1979) suggests that the non-respondents include a group of people who are unaccustomed to the idea of research and feel uncomfortable when they are contacted in a survey. Such a group could easily be thought to be an important contributor to the biases reported above[1]. Unfortunately there was no direct observation in the Swedish data to support his idea. Income was an exception, since respondents had lover income in average, although the differences were significant in only one third of the tests.

Comparisons with nonresponse studies in other countries were possible in a few cases. There were two apparant consistencies. In all reported cases nonresponse rates decreased with the family size and increased with the degree of urbanisation of the area where the sampled person was living.

Our present knowledge of nonresponse is useful primarily in evaluating the size of the nonresponse bias, in drawing attention to variables and domains of study where nonresponse is especially disturbing, in pointing out how data collection should be improved, and in developing ideas on how the effects should be countered in estimation. It is important to make further register studies since they will provide us with more reliable information on nonresponse bias then any other type of studies.

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[1] The results are also consistent with the hypothesis that nonresponse always contains a group of dropouts, as such people often are hard to find and if found are hard to interview. Maybe surveys would do better to exclude such groups by definition when the topic of the survey has little to do with the circumstances under which they live. When information on this group is desired, it has to be obtained in other ways, for example, through proxy interviewing.

More research is needed before response probabilities can be developed to reduce or eliminate nonresponse bias in estimation. Experiments, that use the degree of availability or the degree of persuasion needed for an interview to estimate response probabilities, have not always been sucessful, as for example the staunch refusers sometimes have turned out to be different from the never-at-home group. Use of supplementary information from the sampling frame has sometimes successfully reduced the nonresponse bias in a few variables, but seems seldom to operate satisfactory on the majority of the variables in a survey.

If nonresponse probabilities are to be a powerful tool in statistical estimation, nonresponse must be studied through experiments, interviewing on the reasons for participating in a survey, and coordinated analysis of nonresponse in a number of surveys. This is especially important if nonresponse is to be understood generally and not only survey by survey.

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