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Summary

In this paper we compare *coverage bias* with *nonresponse bias* in a telephone election survey. The sample was drawn from a register of individuals in Switzerland, which included basic socio-demographic characteristics. Telephone numbers were subsequently matched using three steps: An automatic match by the Federal Statistical Office using listed numbers, a match by the survey agency using commercial sources, and numbers delivered by respondents following a postcard request. In addition, we analyse *coverage and nonresponse bias in associations between variables* for the matched sample as well as respondents only and *reasons for nonresponse*.

In the automatically matched sample the probability of being matched ranged between 70.5% (the divorced) and 93.3% (those aged 73 or over). Coverage bias can be slightly improved by investing in more matching efforts. Nonresponse bias has small effects on top of coverage bias, with the exception of older people, for whom telephone numbers were more easily matched, but who were much less likely to respond. Bias in associations from undercoverage and nonresponse depend on the variables analysed. Reasons given for nonresponse by different person-groups follow expected patterns.

Coverage and nonresponse errors in an individual register frame based Swiss telephone election study

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1 Introduction

In Switzerland, the telephone was long considered the best mode for high quality, cost-effective surveys. At the end of the last century almost every household possessed a landline with a number listed in the public telephone book (KIG 2001). Most surveys were conducted over the telephone and survey firms built up centralized CATI infrastructure and valuable knowledge and experience for conducting high quality telephone data collection. Since the start of the 2000's however, as in other countries, Swiss telephone surveys have been challenged by a growing problem of under-coverage resulting from two developments (Ernst Staehli 2012): one, a dramatic increase in the proportion of "mobile only"[1] households; and two, the fact that since 1998 it has no longer been obligatory to register telephone numbers in the public directory.

This coverage problem is compounded by the fact that people with registered landline telephone numbers differ from those without on a number of variables, for example with respect to age (Busse and Fuchs 2012, Lipps and Kissau 2012), municipality size, or civil status (Lipps and Kissau 2012). As a consequence, general population surveys that continue to rely on telephone data collection alone – and particularly those that use samples drawn from the public telephone book – have severe representativity problems, which pose a persistent threat of bias to key survey estimates. Indeed, Brick (2011) considers undercoverage as "more insidious than nonresponse [with] the potential for bias with substantial undercoverage … in many ways more similar to the potential for bias in volunteer samples" (p.885).

[1] Mobile numbers are registered even less often, as they do not need to be registered by law as fixed lines used to be.

Fortunately, since 2010, the Swiss Centre of Expertise in the Social Sciences (FORS) has been allowed, under a strict legal agreement, to use samples drawn by the Swiss Federal Statistical Office (SFSO) from its recently harmonized frame of individuals residing in Switzerland, based on population registers maintained by the municipalities and cantons in Switzerland, as well as additional registers for special populations such as asylum seekers or diplomats. This sampling base (Stichprobenrahmen für Personen und Haushalte (SRPH)) is available for use by FORS' core surveys[2]. This register guarantees almost complete population coverage. However there is evidence that higher coverage may come at the price of higher nonresponse bias because of the inclusion of individuals who are less likely to participate (Peytchev et al. 2010). Undercoverage and nonresponse result in zero probability of inclusion for some in the population and unknown probability of inclusion for others in the population. If members of the target population who are omitted or less likely to be interviewed are systematically different, this makes estimators not only of means and variances, but also of associations such as regression coefficients biased (Peytchev et al. 2011).

A sample drawn from the individual register frame offers several obvious advantages for FORS surveys. On top of an almost zero coverage error; sampled individuals can be addressed personally with an advance letter, which may help increase participation; and it eliminates the need for household screening to identify a target individual, which may exacerbate existing coverage problems due to underreporting of household members (Tourangeau et al. 2012) and nonresponse (Lipps and Pollien 2011). Furthermore, the frame provides basic demographic information about non-participating sample members.

However, for surveys which draw samples from this register but still use the telephone as the principal data collection mode, the coverage challenge remains. The problem is that the SRPH does not include telephone numbers, which means that these need to be separately identified and matched to samples drawn from the register. The SFSO is able to automatically match samples against their own register of telephone numbers 'CASTEM'[3], which they used for sampling purposes prior to the SRPH. CASTEM includes both publicly listed and unlisted fixed-line telephone numbers, but the latter numbers are not available to FORS due to data protection reasons. Because the automatic matching procedure used by the SFSO does not succeed in matching numbers to all sample members (and only publicly-listed numbers are available to FORS) raises the question of

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[2] The Swiss Election Survey (Selects), the Swiss Household Panel (SHP), the Swiss parts of the European Social Survey (ESS), the Survey of Health, Aging and Retirement in Europe (SHARE), and the survey Measures and Sociological Observations of Attitudes in Switzerland (MOSAiCH) that includes the Swiss part of the International Social Survey Programme (ISSP).

[3] "**Ca**dre de **s**ondage pour le **t**irage d'**é**chantillons de **m**énages", see http://www.bfs.admin.ch/bfs/portal/de/index/news/00/08.html (in German).

how to obtain numbers for the remainder of the sample, and of whether different solutions have implications for survey errors and costs.

For CATI surveys, and face-to-face surveys for which contact attempts are also made by telephone, the guiding principle in efforts to address this challenge has been to try to improve coverage by searching for numbers not listed in the public register. Lipps and Kissau (2012) describe how telephone numbers can be successively matched to a cantonal (Lucerne) register-based sample in different steps. In their study, similar to the Selects study analysed in this paper, the following three consecutive steps were taken to match telephone numbers to names. Firstly, an automatic matching procedure was carried out by the SFSO to find numbers in CASTEM. Then, an additional matching procedure was carried out by the survey agency using publicly available commercial software, followed by a “manual” matching procedure using alternative sources (for example internet searches, asking other household members, etc.). Finally, a postcard was sent to remaining sample members without numbers asking them to provide their telephone contact details.

Lipps and Kissau (2012) analysed the cumulative effects of each additional matching procedure with respect to bias on the available frame variables and found that each additional step, and especially the postcard request, made it possible to obtain numbers for sample members with different characteristics, thereby reducing bias on frame variables. In addition, they examined reasons for not responding to the survey given by different socio-demographic groups.

In the present study, we extend Lipps’ and Kissau’s research in a number of respects. We investigate non-coverage and nonresponse errors separately and in more detail in a national probability sample taken from the new SRPH, and drawn for a national telephone election survey of Swiss citizens (Selects). To separate errors of non-coverage and nonresponse is important, not only because both can work in different directions (Peytchev et al. 2011) but also to provide information on where to invest scarce resources in future surveys (op. cit.). There are few studies that examine the relation between non-coverage and nonresponse error in telephone surveys. Among these, Rao et al. (2005) compared an RDD study in the U.S. with a large, high response-rate survey which included non-telephone households. They find that the younger age groups, men, and those with a lower education are under-represented. As for comparing non-coverage with nonresponse, they find as a general rule that if more than 50% of a person-group in the RDD study are not represented (such as adults under the age of 30 years), most of the overall differences is due to non-coverage of non-telephone households. However, if more than 50% of a person-group in the RDD study are represented, then most of the overall error is due to nonresponse. This latter finding held in their study for most socio-demographic characteristics.

This paper is organized as follows: The first part deals with the extent of errors of coverage and nonresponse based on an analysis of socio-demographic variables available on the sampling frame. Then, we examine the success of different methods to reduce coverage errors in the second part of our analysis. Finally, we analyse bias in associations due to under-coverage and nonresponse, before analysing reasons given by nonrespondents for not taking part.

2 Data and Methods

The Swiss Election Studies - Selects[4] - is a research project run by FORS and funded by the Swiss National Science Foundation (Selects 2012a,b). The project started in 1995 and is conducted every four years at the time of the Swiss federal elections.

Two samples intended to represent Swiss residents eligible to vote in Swiss federal elections, i.e., all Swiss citizens aged 18 years and older on election day, are studied here. The samples were drawn by the SFSO from the SRPH. The first was used for a "Rolling Cross-Section" (RCS) survey (Johnston and Brady 2002) which was conducted during the 41 days preceding the elections (September 9 to October 22, 2011) in the German and French speaking regions of Switzerland. The RCS used a simple random sample design and comprised about 100 (random) interviews per day, with a gross sample of 19,834. Each number was kept open for two weeks using a specific contact scheme to equalize the probability of contacting each individual. The second sample was used for the "Post-Election Survey" (PES). The PES used a random sample with disproportionate stratification by cantons, with small cantons overrepresented so that each canton had at least 100 respondents. The actual gross sample in the Selects post-election study was of 17,276. To have more similarity with the RCS sample, we chose not to include the additional oversampling in three cantons and excluded the additional addresses with phone numbers added from a separate sample during fieldwork. The gross sample size considered in this paper was thus 8,438 individuals. The PES is the core of the Selects study and the fieldwork lasted from October 24 to November 25, 2011, starting on the day after the federal election. Both surveys were conducted using

[4] More on the Selects study can be found in Lutz (2012) (in German – available also in French and Italian).

Computer Assisted Telephone Interviewing (CATI) by DemoSCOPE Research & Marketing, Adligenswil, Switzerland.

From the RCS sample, 13,866 (69.9%) had a listed CASTEM telephone number matched by the SFSO; compared to 5,838 individuals (69.2%) from the PES sample. In the second step 2,998 (15.1%) additional telephone numbers from the RCS sample and 1,306 (15.5%) from the PES sample could be matched by means of other searches for telephone numbers by the survey agency, using commercial sources such as getstone.ch, based on the Swisscom directory, and AZ Direct, a marketing directory, or through manual searches using Swisscom directory-based websites like local.ch[5]. A postcard asking for a phone number was sent to the still unmatched PES members before the beginning of the survey fieldwork. Of the 1,294 addressed, 128 (response rate 9.9%) returned the postcard with a telephone number. Altogether, in the RCS, 16,864 (85.0%) individuals could be assigned a telephone number; in the PES, 7,272 (86.2%) individuals.[6] The results of the number matching procedures are shown in Table 1. Information about whether a sample member was successfully matched to a number in CASTEM, which is not listed publicly (and so not available to FORS) is only available for the RCS sample.

Importantly, the usability of the phone numbers that are acquired by the various procedures does not seem to differ significantly. To assess usability, we examined the response rates for the subsamples and found them to be mostly similar. There are however two exceptions: in the case of numbers coming from AZ Direct, the fact that it is a telemarketing directory makes us believe that these people are more likely to be solicited often by telephone and thus less willing to respond to a survey. For response cards, people have already de facto accepted to do the survey when they communicate their phone number and the response rate is thus much higher than in any other category. Regarding the other sources, the response rate for CASTEM and getstone phone numbers is almost identical, while it is only slightly lower for manual search. A more detailed study of call data could give us a more insight into whether there are significant differences in “wrong numbers”, technical problems, or other issues, but regarding the most important characteristic – the response rate – our data shows no significant quality problems with the additional matching procedures.

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[5] The high number of phone numbers found using additional search is in part due to the relatively conservative matching done by the SFSO, as explained to one of the authors during the preparation of the Selects study (6.5.2011). Indeed, to avoid delivering erroneous phone numbers, only exact matches are kept.

[6] This matching rate must be compared with an average matching rate which is currently of 76% in surveys conducted by the SFSO that include unlisted landlines (Joye 2012). Note that the SFSO surveys generally include residents with a foreign nationality.

Table 1: Sources used to match telephone numbers to the population register samples. Data: Selects 2011

Source of telephone number	**RCS**	**PES**
Total sample size	19,834 (100%)	8,438 (100%)
SFSO CASTEM (listed numbers delivered)	13,866 (69.9%)	5,838 (69.2%)
SFSO CASTEM (unlisted and not delivered)	2,374 (12.0%)	not available
Telephone number matched by other methods	2,998 (15.1%)[7]	1,306 (15.5%)
Telephone number delivered by postcard	-	128 (1.5%)
No telephone number available	2.970 (15.0%)	1,166 (13.8%)
Final sample of numbers available for fieldwork[8]	11,618	6,225

3 Coverage and nonresponse bias on frame variables

In this section, we compare different subsamples of the combined PES and RCS gross sample.[9] The aim is to identify the extent to which frame variable bias is due to coverage or nonresponse error at different stages. We compare individuals for which a telephone number was matched with those for which no number was found, those with unlisted numbers with those with listed numbers, and – for those where numbers were successfully matched – non-responding with responding people. To assess the extent and nature of coverage error, we examine discrepancies in frame variable between the following subsamples

- the gross sample and the different subsamples resulting from different methods of obtaining telephone numbers, and the subsample without fixed line telephone numbers.
- for those who were matched to numbers in the CASTEM register: people without a listed number and those with a listed telephone number.

To assess the extent of nonresponse error, we examine discrepancies in frame variables between the non-respondents and the respondents, among sample members for whom a number was available, and who were eligible to participate in the survey.
We use the following frame variables with respective categories:

- Age groups: 18-30 years (base category), 31-44 years, 45-58 years, 59-72 years, 73+ years

[7] Of which 1,170 (39%) were matched with CASTEM but were not listed and therefore not delivered by the SFSO.
[8] Excluding ineligibles, addresses that weren't activated, and those who refused before fieldwork started.
[9] The survey dummy distinguishing the PES and the RCS used later in the multivariate analyses turns out to be insignificant.

- Size of municipality (derived from municipality codes), representing the degree of urbanization: more than 100,000 inhabitants (base category), 20-100,000 inhabitants, 10-20,000 inhabitants, 5-10,000 inhabitants, 2-5,000 inhabitants, less than 2,000 inhabitants
- Civil status: married (base category), single, divorced, widowed
- Gender (base category women)

In Table 2 we show frequency distributions for each of the above variables for the different subsamples described and for the gross sample. In addition, we list column specific chi^2 contributions[10] which are indicators of the relative contribution of a subsample to differences observed in the distribution of a variable (like age group) from all samples combined (for example, column chi^2 = 411.5 for "Automatch" indicates the relative contribution of the automatically matched sample members (N=19,704) to the difference of the age-group distribution of the gross sample (N=28,272).[11]

With each successive matching procedure, each age group is increasingly better represented. The strongest discrepancy between the gross sample and the different subsamples holds for individuals without a matched telephone number. Here young people are strongly over-(+16% points), and older people under-represented. If only telephone numbers listed in CASTEM were used, undercoverage of adults up to their mid-40s would amount to 3-4% points, overcoverage of people from 59 years onwards to 2-3% points. The not listed sample members are surprisingly similar in age to those who returned a postcard.

Nonresponse bias is weaker than bias from undercoverage: the discrepancy between non-respondents and respondents is only significant for older people. Older respondents (73+ years old) are underrepresented, other age groups overrepresented. This example shows that for the youngest and the oldest age groups coverage bias and nonresponse bias go in different directions. Here, nonresponse bias thus balances out the coverage bias.

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[10] The column chi^2 is the sum of all cell-chi^2 contributions from the considered frame variable categories, such as from the age groups.

[11] Sample sizes must be taken into account, for example, although the age group distribution of people sending back a postcard is different from that of all other groups combined, the column chi^2 =26.2 for "Postcard" is relatively small, because of the small number of people in this group.

Table 2: Distribution of frame variables for different samples

Column percentages	Gross Sample	Auto-match	Other methods	Post-card	No tel. numb.	Unlist. (RCS)	Listed (RCS)	Non-res-pondents	Res-pondents
18-30	20.6	16.8	22.5	30.5	36.6	30.0	16.8	15.3	17.1
31-44	22.1	19.3	26.8	32.0	30.0	32.1	19.5	19.9	21.6
45-58	25.6	26.7	27.1	23.4	19.0	22.0	26.6	26.9	27.7
59-72	19.6	22.3	16.3	11.7	9.8	10.9	22.3	21.1	23.6
73+	12.2	14.9	7.4	2.3	4.7	5.1	14.7	16.8	9.9
Column chi^2 contrib.		411.5*	159.3*	26.2*	1088.2*	532.7*	91.2*	58.0*	106.1*
single	31.2	26.7	31.8	45.3	51.7	41.3	26.6	25.8	25.5
married	52.0	56.5	52.4	32.8	31.0	41.2	56.3	56.5	59.8
widowed	6.8	7.9	5.6	.8	3.0	3.2	7.8	8.9	5.3
divorced	10.0	8.9	10.3	21.1	14.4	14.3	9.3	8.8	9.1
Column chi^2 contrib.		263.7*	10.7*	128.0*	1078.9	297.0*	50.9	24.0	43.8
Women	52.4	53.2	52.1	53.1	49.0	52.1	53.5	53.6	52.4
Men	47.6	46.8	47.9	46.9	51.0	47.9	46.6	46.4	47.6
Column chi^2 contrib.		4.6*	.1*	.0*	18.8	1.3	.2	.7	1.3
>100K inhabitants	10.0	9.4	10.9	16.4	15.0	11.6	9.3	9.8	9.3
20-100K inhabitants	11.4	11.0	12.1	13.3	13.2	14.2	11.5	10.9	11.9
10-20K inhabitants	16.7	16.6	17.0	16.4	17.7	17.0	17.0	16.9	16.0
5-10K inhabitants	17.2	17.5	16.3	21.9	15.3	17.4	17.5	17.2	17.9
2-5K inhabitants	23.8	24.6	22.0	15.6	20.1	22.3	23.9	23.9	24.0
<2K inhabitants	20.9	20.9	21.8	16.4	18.7	17.4	20.8	21.3	20.9
Column chi^2 contrib.		13.1*	12.6*	12.2*	50.8*	14.5*	1.2	2.8	5.1
N analyses sample	28,272	19,704 28,272	4,304 28,272	128 28,272	2,137 28,272	2,374 16,240	13,866 16,240	11,535 17,843[12]	6,308 17,843

*Notes: * = significant on 1% level. Data: Selects 2011*

In terms of marital status, the findings run in parallel to those of age, most likely because marital status is correlated with age. Single people suffer from undercoverage – more than the 18-30 years old - both in terms of being less likely to be automatically matched to lists of telephone numbers (though this can be improved with additional matching efforts) and of being listed. Similar findings apply for people who are divorced, while the opposite holds for married or widowed people. As for response, married people tend to participate more often, whereas widowed people are more difficult to contact or refuse more often. However, also here, effects from coverage error appear to be stronger than effects from nonresponse errors.

[12] Excluding all people without a valid telephone number and not eligible cases.

The sample is not biased by coverage or nonresponse error related to gender to a significant degree. One exception is that men are less likely to have a fixed telephone line than women.

The representation of different sized municipalities appears to be biased by coverage and nonresponse to a small extent only: like younger and single people, large cities are underrepresented in the subsample for whom numbers were automatically matched, or among those with listed numbers. This discrepancy can however be corrected to a certain extent through additional matching procedures. Nonresponse errors are small and do not follow a stable pattern according to municipality size.

To conclude, coverage errors are more severe than nonresponse errors with regards to all the frame variables analysed. Of the sample members who remain not covered by the matching procedures used here, the people without a fixed telephone differ most from the gross sample, followed by those with telephone numbers that are not publicly listed. There is a weak tendency that nonresponse bias among older members of the sample mitigates bias from under-coverage.

4 Effects of telephone number matching efforts on coverage bias: multivariate analysis

To analyse the effects of additional efforts to reduce coverage bias on the frame variables simultaneously, we estimate a series of multivariate logit models comparing samples that result from the different matching procedures with the "no number available" (NN) sample.[13] The NN group is first compared with the automatically matched (AM) group, second with the combined AM and matched by other methods (OM) group, and third with the combined AM, OM, and the returned postcard (RC) group. Thus, the total sample analysed is the sum of the AM, OM, RC, and NN groups, of which all four groups are only used in the last model (AM+OM+RC versus NN). We control for the survey sample analysed (PES=1 vs. PES=0). Statistical differences on frame variable coefficients across the models will show:

1. the degree to which specific frame variable categories are affected by coverage errors

[13] The advantage of using the NN group as the reference category is that this group contains the same individuals in each model.

2. if bias is observed, subsequent models reveal whether the bias increases or decreases with the additional sample groups included

If the group of people sampled for whom telephone numbers were obtained (AM+OM+RC) were unbiased, its socio-demographic distribution would be the same for all person groups. This would then signal the absence of coverage errors.

In addition to the predicted probabilities (Mood 2010) of a sample member being matched to a telephone number, we list the results of significance tests.

Table 3: Predicted probabilities and test of differences vs. predicted probabilities of the reference category.

Logit regression coefficients [Predicted Probabilities of matching telephone (holding the other variables at their mean)]	**Model 1 Automatic match (AM) vs. no number (NN)**	**Model 2 + Other methods (AM +OM) vs. NN**	**Model 3 + Return card (AM+OM+RC) vs. NN**
RCS survey (reference)	.825	.852	.852
PES survey	.830	.855	.858
18-30 years old (reference)	.729	.778	.779
31-44 years old	.749*	.796*	.797*
45-58 years old	.865**	.886**	.887**
59-72 years old	.911**	.921**	.921**
73+ years old	.933**	.938**	.938**
Married (reference)	.876	.897	.897
Single	.798**	.825**	.826**
Widowed	.840**	.869**	.869**
Divorced	.705**	.751**	.753**
>100K inhabitants (reference)	.732	.776	.778
20-100K inhabitants	.798**	.832**	.833**
10-20K inhabitants	.818**	.846**	.847**
5-10K inhabitants	.845**	.869**	.870**
2-5K inhabitants	.854**	.875**	.875**
<2K inhabitants	.855**	.877**	.877**
Women (reference)	.835	.860	.860
Men	.818**	.846**	.846**
McFadden Pseudo R^2	.102	.086	.085
N [sample members]	23,840	28,144	28,272

*Notes: ** (*) = significantly different on 1 (5) % level vs. reference (first) category. Data: Selects 2011. Chi^2(model1=model2)=378), chi^2(model2=model3)=122*

The models are each significant and the differences in model chi-squares show that the (combined sets of) coefficients of the three models are mutually different from each other. Adding subsamples reduces the pseudo R^2, both slightly increases and equalizes the predicted probabilities, and therefore lowers the bias to a certain degree. In terms of age, we see that especially those who were underrepresented in the AM sample (for example, the 18-30 years old; 72.9%) had a comparatively higher probability of being matched to numbers in subsequent procedures (e.g. including the OM sample increases the 18-30 year old group to 77.8%). This is also confirmed by some significant differences between the coefficients when adding the subsample matched by other methods (e.g. for people aged 45 and over, for widowed or divorced people, and for those living in smaller municipalities), and the subsample that used the return cards (for people over 44 years old, the single or the divorced, and those living in small villages). Adding the RC subsample brings about a number of statistical differences between the coefficients relative to the size of the sample, underlining how different this group is from the others. In addition, all three socio-demographic variables are different, which indicates that the coverage bias decreases from model 1 to model 2 and model 3 with regard to age, sex, civil status and municipality size.

To conclude, although the final telephone sample (AM+OM+RC) is still different from the NN sample in terms of the frame variables included, we achieve a 5% points (between 70 and 75%) increase in matching probability for the worst represented groups in the AM sample (the very young, the divorced, and those living in big towns) by adding the OM and RC subsamples. For those already well represented in the AM sample however, such as those 73+ years old, the increase in matching probability with the addition of each procedure is small (from 93.3 to 93.8%).

5 Bias in associations

In this section, we examine coverage and nonresponse bias in associations between variables. Measures of associations and their significance levels are of central interest when doing deductive statistics and their analysis is the core business of social scientists testing hypotheses. For this reason, it makes sense to assess whether errors observed in point estimates affect conclusions drawn from analyses of the relation between variables. To date, few studies have examined this aspect of the impact of coverage and nonresponse bias (Peytchev et al. 2011). To look at bias in associations in the Selects data, we again conduct multivariate logit models, comparing coefficients from different samples and their relationship with the dependent variable. We assess coverage bias by comparing measures of associations for the gross sample (which provide the “true” measures) with those of the AM+OM+RC sample, and nonresponse bias by comparing measures of associations of the AM+OM+RC sample as a whole with those of the respondents. We model predicted probabilities of two subgroups with different coverage and nonresponse properties as examples (see Table 4), using the other three frame variables as covariates:

- those who are married (married people have both high coverage and high response rates),
- those aged 73 years and older (coverage of older individuals is high but response rates are low)

The resulting predicted probabilities by sample and frame variable characteristic can be found in Table 4.

Table 4: Predicted probabilities of being married or being 73+ years old and test of differences.

Logit regression coefficients [Predicted Probabilities (holding the respective other variables at their mean)]	Model 0 Gross sample (‘true’coeff.)		Model 1 Automatic match (AM)		Model 2 + Other matched (AM +OM)		Model 3 + Return card (AM +OM+ RC)		Model 4 Respondents	
	marr.	73+	marr.	73+	marr.	73+	marr.	73+	marr.	73+
RCS survey reference	.493	.081	.544	.106	.535	.095	.534	.094	.581	.067
PES survey	.501	.081	.554	.114	.550	.097	.545	.096	.600	.061
Married reference		.121		.141		.128		.128		.095
Single		.021		.029		.025		.025**		.014
Widowed		.648		.659		.652		.651*		.529
Divorced		.081		.094		.086		.086		.066
18-30 years old reference	.101		.086		.094		.094		.096	
31-44 years old	.587		.642		.637		.634**		.668	
45-58 years old	.671		.707		.703		.702**		.742	
59-72 years old	.689		.714		.710		.710**		.739	
73+ years old	.531		.557		.545		.545**		.626*	
>100K inhabitants reference	.336	.130	.375	.193	.370	.163	.369	.162	.382	.127
20-100K inhabitants	.456	.100	.511	.143	.506	.121	.505	.120	.541	.091
10-20K inhabitants	.494	.088	.542	123	.533	.107	.531	.106	.548	.084
5-10K inhabitants	.512	.073	.564	.100	.556	.086	.553	.085**	.629*	.059
2-5K inhabitants	.537	.070	.573	.095	.573	.083	.572	.083**	.638*	.055
<2K inhabitants	.547	.065	.599	.081	.587	.076	.585	.075**	.639	.042*
Women reference	.469	.076	.506	.103	.504	.089	.503	.088	.539	.052
Men	.524	.086	.593	.114	.578	.103	.577**	.103**	.640*	.083**
McFadden Pseudo R^2	.165	.202	.172	.187	.171	.192	.171	.192	.193	.164
N [sample members]	28,272		19,396		23,700		23,828		6,308	

*Notes: ** (*) = significantly different on 1 (5) % level: coefficients model 3 vs. model 0, coefficients model 4 vs. model 3. Data: Selects 2011.*

Compared with the “true” probabilities of being married predicted by the frame variable categories in the gross sample (model 0), the samples tend to be less biased (overestimating the probability of being married, except among 18-30 year olds) the larger they are. There are significant differences between the predicted probabilities of the final telephone sample (AM+OM+RC; model 3) and the gross sample (indicating a coverage bias) for the variables age and sex. The probability of being married is overestimated for people aged 31 years and older, and for women and men. Comparing the final respondents (model 4) with the total sample of telephone numbers surveyed (AM+OM+RC; model 3) to assess bias due to nonresponse, the predicted probability of being married is overestimated for older people (73+ years), for those living in small towns between 2,000 and 10,000 inhabitants, and for both sexes.

Turning to the predicted probabilities of being 73+ years old (figures in brackets), we find values that are higher than the gross sample (coverage bias) for single and widowed people, those living in municipalities below 10,000 inhabitants, and for both sexes. Nonresponse bias in the predicted probabilities of being 73+ years old occurs only for very small municipalities (<2,000 inhabitants) and for sex.

To conclude, with respect to the predicted probabilities of being married, the coverage bias improves with additional matching efforts. However, nonresponse bias compounds coverage bias, as both errors go in the same direction resulting in an overestimation of predicted probabilities. Regarding predicted probabilities of being 73+ years old, the picture is more mixed. Probabilities are generally overestimated as a result of coverage bias, but there appears to be an underestimation due to nonresponse bias. The true value (from the gross sample) most often lies between that based on the final telephone sample and that based on the final responding sample. These examples show that more research should be conducted to improve our understanding about the effects of coverage bias and nonresponse bias on estimated measures of associations between variables.

In the next section we analyse the different reasons nonrespondents gave for not participating and their relation to the available frame variables to gain additional insight into the mechanisms behind the nonresponse bias observed.

6 Socio-demographic characteristics of sample members by response status

In this section we explore the reasons given by different sample members for not participating. We make a distinction on the basis of the final response status 'no contact' and several reasons for noncooperation. We use the combined PES and RCS sample excluding those without telephone numbers and other ineligibles[14]. In addition, we present the final response statuses for the samples matched to telephone numbers by each of the different methods. We distinguish sample members with respect to eight final statuses:

1. sample members who responded to the survey
2. sample members with a still pending appointment (continuous "call back later" until end of fieldwork)
3. sample members who state age or health problems
4. sample members who state language problems
5. sample members who could not be contacted
6. sample members who mentioned no interest as a reason for refusal
7. sample members who mentioned no time as a reason for refusal
8. sample members who refused before fieldwork started after receiving the advance letter

In the tables that follow we list the column percentages and chi^2 contributions for each category of final response status group by the frame variables.[15] These tables give hints of which socio-demographic group is more likely to have which final status.

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[14] Not reachable during time of fieldwork (holidays, business trip, etc.), deceased, without Swiss nationality, wrong address, fax, modem, no or erroneous telephone number. Among numbers that were matched by other means (OM) the proportion of ineligibles are twice as high as among the automatically matched numbers (AM).

[15] All cells have expected frequencies of more than 10. As for the column chi^2 we refer to our descriptions to Table 2.

Table 5: Distribution of frame variables for different final statuses. Data: Selects 2011.

Column percentages	Partici-pant	Pending apptmt	Age or health	Langu-age	No contact	No interest	Before Field	No time	Non-resp.
N	6,308	389	1,109	266	2,190	5,321	409	1,851	11,535
18-30	17.2	24.4	2.5	5.6	21.7	12.4	13.9	23.8	16.9
31-44	21.6	21.9	3.8	29.3	25.6	19.9	20.8	21.2	20.6
45-58	27.7	29.6	6.3	39.9	29.8	28.9	24.9	28.0	26.5
59-72	23.6	17.7	14.8	20.3	16.8	25.4	22.5	17.8	20.6
73+	9.9	6.4	72.6	4.9	6.2	13.5	17.9	9.1	15.4
Column chi^2 contrib.	106.1	38.7	3101.0	60.5	206.0	82.0	5.4	122.5	
single	25.5	30.3	12.0	8.7	39.9	20.9	29.1	32.0	27.4
married	59.8	60.2	47.2	78.2	43.2	63.2	51.8	55.8	55.1
widowed	5.5	2.8	34.7	6.8	5.4	7.1	10.5	4.1	8.3
divorced	9.1	6.7	6.1	6.4	11.6	8.8	8.6	8.1	9.2
Column chi^2 contrib.	43.8	17.8	1163.0	51.6	285.1	78.5	8.6	63.6	
Women	52.4	43.4	65.0	62.8	50.4	53.6	58.7	50.1	53.5
Men	47.6	56.6	35.0	37.2	49.6	46.2	41.3	49.9	46.5
Column chi^2 contrib.	1.3	14.8	62.5	9.9	6.9	.4	5.0	6.8	

Regarding final status by age, we find patterns that have often been observed in other studies (for example, Lipps and Kissau 2012, Lipps 2012): fewer than average pending appointments, fewer time reasons, fewer non-contacts and many more age- or health-related refusals among older age groups. In addition we find more non-contacts, pending appointments, or time reasons among the younger members of the sample, and fewer no interest reasons given for refusals.

For civil status, we find similar patterns to those related to age. There is a higher occurrence of health problems among the widowed, and more individuals not reached among the singles. With the exception that women state more age, health or language problems than men, final outcome status did not vary significantly by gender. Similarly, municipality size is not correlated with different final statuses.

Next we analyse final statuses by the stage at which a telephone number was matched to the sample member. Because only eight individuals who sent a return card did not participate[16] (compare similar findings in Lipps and Kissau 2012), we only compare the

[16] 1 pending appointment, 1 age or health reason, 3 no contacts, 2 no interests, and 1 time problem.

two groups for whom telephone numbers were either automatically matched or matched by other means.

Table 6: Distribution of matching stages for different final statuses. Data: Selects 2011.

Column percentages	Partici-pant	Pend. apptmt	Age or health	Langu-age	No contact	No interest	Before Field	No time
Automatch (AM)	84.4	85.2	89.2	81.3	82.5	84.4	80.7	82.6
Other methods (OM)	15.6	14.8	10.8	18.7	17.5	15.6	19.3	17.4
Column chi^2 contrib.	.3	.3	20.4	1.7	4.9	.2	3.2	3.4
N	6,152	386	1,107	262	2,175	5,302	342	1,843

Age or health problems are stated more often by sample members from the automatically matched group, presumably due to their higher age (see Table 2). Apart from this, the differences between the groups are relatively small. To conclude, we find the expected final status distributions by frame variable groups and by matching stage.

7 Summary and Conclusion

In the present study we analyse which socio-demographic groups are over- or underrepresented in a telephone election survey where the sample was drawn from an individual register in Switzerland. The primary aim is to compare *coverage bias* on sampling frame variables across different subsamples resulting from different procedures for matching names and addresses from the sampling register with different sources of telephone numbers. These include numbers that are publicly *listed* in the regular telephone book (and thus generally available for telephone surveys) and those who are not (thus only available for telephone surveys conducted by the Swiss Federal Statistical Office (SFSO). Linked to this question is the effect of coverage errors on *associations* between variables, which we also examine. The secondary aim is to analyse *nonresponse bias*: given a sample that suffers from coverage bias, we were interested whether there are socio-demographic differences (conditional on coverage) and, again, whether any observed bias also impacts on *associations* between variables. We finally investigate the final response status of different person groups and telephone number sources to better understand the reasons for nonresponse across different subgroups.

Our starting point is a sample of adult Swiss citizens[17] which was randomly drawn from the recently harmonized frame of individuals in Switzerland (SRPH) by the SFSO. While

[17] A similar procedure using a cantonal register that included foreign people (Lipps and Kissau 2012) shows that additional telephone sources are particularly useful when national minorities are also sampled.

the SRPH includes basic socio-demographic variables, no phone numbers are included. These must be identified using other information sources. In the survey considered here, three steps were taken:

- automatic match (AM) of names and addresses from the “CASTEM” telephone register maintained by the SFSO, which includes publicly listed and unlisted telephone numbers, the latter of which are unavailable for FORS surveys
- matching using other methods (OM), specifically commercial telephone directories and external sources, including information from other providers of telephone directories and internet research
- sending return cards (RC) to those whose telephone number could not be found using the two steps above

Our comparison category is the person group for whom no telephone number could be found (no number matched (NN)).

We address our research focus with bivariate comparisons of differences between the samples obtained as a result of matching telephone numbers from the different sources with respect to the socio-demographic variables available in the sampling register: age, size of municipality, civil status, and gender. Note that nationality, although included in the register, is not relevant here, as the election study focuses solely on people of Swiss nationality.

We find that in the automatically-matched sample while the two younger age groups are underrepresented, the two older age groups are overrepresented. This bias can be somewhat reduced by using additional efforts to obtain telephone numbers from additional sources. The same applies to the initial under-representation of larger towns (and over-representation of small villages), and the underrepresentation of the single and the divorced (and over-representation of the married and widowed). These results are confirmed by the results of a series of multivariate models: the predicted probability that a telephone number could be matched increases especially for the most underrepresented groups, when additional telephone number sources are included, although the overall effects are rather small: starting from a predicted probability of obtaining a telephone number match of 70.5% for the divorced (lowest matching probability) and 93.3% for those aged 73 or over (highest matching probability) using the AM information source only, these figures increase to 75.3% and 93.8%, respectively, by including all three information sources (AM+OM+RC). Because the RC sample includes very few people, and because it was included *after* the OM sample, it is difficult to assess which measure proves more useful. A changed order – such as sending a postcard before checking other sources - could have been much more successful for the postcard action. We also examined coverage bias in associations, using predicted probabilities of being married and being 73+ years old as examples. Generally we find that the predicted probabilities both of being married and of being 73+ years old are largely overestimated in the AM sample (exception: predicted probability of being married for 18-30 age group). Although this overestimation decreases somewhat with additional efforts to obtain telephone numbers, the final telephone sample is far from being representative.

We were particularly interested in the characteristics of listed versus unlisted sample members in the SFSO telephone sampling frame CASTEM. The main results suggest that while the two younger age groups have a smaller likelihood of having listed telephone numbers, the opposite is true for the two older age groups. These findings point to a double undercoverage problem due to a smaller likelihood of fixed-line telephone possession and – for those who do have a fixed line - a smaller likelihood of the number being listed. Similar findings hold for single individuals and those living in larger towns.

Concerning our second research topic – nonresponse bias – we find that based on the covered sample, unlike coverage bias, old and widowed people tend to be more likely not to respond. Other variables are concerned by nonresponse bias to a smaller extent. Turning to nonresponse bias in associations due to nonresponse, we find that with respect to the predicted probability of being married for almost all person groups (exception: 18-30 age group) coverage and nonresponse work in the same direction. We find that the largely overestimated probability in the final telephone sample generally becomes even higher when only respondents are analysed. As for the predicted probability of being 73+ years old, nonresponse bias goes in the opposite direction and is even stronger than coverage bias so that, in the end, all probabilities are lower than in the respondent sample. These examples show that the relationships between coverage and nonresponse bias in variable distributions and associations are far from simple and point to the need for more thorough analyses.

We also looked at differences in the final response status (and reasons for refusal) of the survey sample by socio-demographic group. We find expected patterns: older and widowed people are less likely to try to postpone the interview (appointments), are more easily contactable and mention fewer time-related reasons for refusal. However, they state many more health- or age-related reasons. Younger and single people are more frequently not contacted, and state fewer “no interest” reasons. Generally, older people are less likely to participate. Language problems are more frequently stated by people in the middle age groups. Compared with the AM group, individuals belonging to the OM group are less likely to state age or health-related reasons for not participating in the survey. This knowledge may be used to anticipate nonresponse of specific socio-demographic groups. To mitigate nonresponse, fieldwork could be tailored, for example, by matching interviewers with particular characteristics or skilled to particular sample subgroups (Groves and Couper 1998, Lipps 2012).

To conclude, sample improvements are especially evident if additional efforts are undertaken to retrieve telephone numbers not automatically matched from the public directory, as was done in the present survey. The most important reason is the improved socio-demographic representation of the population. We cannot confirm the good experiences with approaching people to ask for a telephone number by postcard reported by the SFSO (von Erlach and Zweers 2012) based on our multivariate analysis, although the bivariate analysis suggested this. The number of people who sent back a postcard with a telephone number was simply too small. In addition, it is possible that those who sent a return card back are more representative of the “easier” sample members due to self-selection resulting from sending the card back.

Comparing coverage error with nonresponse error, we find that in our survey there is a tendency that the first outweighs the second, and more so with respect to bias than with respect to associations. This is true although, in relative terms, the problem of losing sample members due to undercoverage is much smaller than – conditional on being covered – that of losing sample members due to nonresponse. That coverage problems are more severe suggests that the differences between people with a fixed-line telephone are and those without are greater than those between people who agree to participate and those who cannot be contacted or who refuse to participate in a telephone election study.

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