

Snowball sampling by mail: application to a survey of smokers in the general population

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Background	In a series of surveys intended for current and former smokers but sent to a random sample of the general population, we asked never smokers and smokers who did not wish to participate to transmit the questionnaire to any ever smoker they knew. We compared participants who received the questionnaire directly from us (original participants) to participants who received it from an addressee (secondary participants).
Methods	Questionnaires on smoking were mailed to 3300 residents of Geneva (Switzerland) in 1997, and returned by 1167 people (35%).
Results	The final sample consisted of similar numbers of original participants (n = 578, primary response rate = 18% of total sample, or about 46% of ever smokers) and secondary participants (n = 566). Original participants were 1.7 years older than secondary participants ($P = 0.03$) and were more likely to be men (50% versus 43%, $P = 0.009$). Proportions of current smokers, stages of change, confidence in ability to quit smoking, cigarettes per day and attempts to quit smoking were similar in the two groups. Secondary participants had lower self-efficacy scores (-0.30 standard deviation (SD) units, $P \leq 0.03$), and they derived more pleasure from smoking ($+0.25$ SD units, $P = 0.04$). Among ex-smokers, direct participants were less active than secondary participants in coping with the temptation to smoke (-0.58 SD units, $P = 0.002$). Associations between smoking-related variables were similar in original and secondary participants.
Conclusion	Allowing non-eligible addressees to transmit the questionnaire to someone else doubled the response rate, produced moderate bias on some variables only and had no detectable impact on associations between smoking-related variables.
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Mail surveys are a cost-effective way of collecting epidemiological data.^{1,2} High response rates can be achieved in mail surveys³ and the quality of data collected by mail is equivalent or even superior to the quality of data collected by telephone or in face-to-face interviews.^{4,5} A limitation of mail surveys is that the eligibility of study participants may be known only after the questionnaire is returned. For instance, if only smokers are eligible for a given survey, researchers have to send the questionnaire and reminder mailings to many people who never smoked, which is a waste of resources. Asking participants who are not eligible or who do not wish to participate to transmit the questionnaire to someone else could be an effective means of

increasing the response rate and the cost-effectiveness of data collection. Similar 'snowball' sampling methods have been used to contact difficult-to-reach populations in studies using face-to-face interviews,^{6–9} but we found no published study using snowball recruitment in a mail survey of a general population. Since the choice of an eligible secondary survey recipient is not a random process, such a procedure could cause bias, but we know of no study addressing this point.

In a series of three mail surveys aimed at developing smoking-related psychometric scales, we asked addressees who did not wish to participate or who had never been regular smokers to transmit the questionnaire to any current or former smoker they knew. The aim of this paper was to assess bias due to snowball sampling, by comparing participants to whom the questionnaire was initially mailed with participants who received the questionnaire from an addressee, and by comparing these two categories of participants with a representative sample of the general population.

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Methods

Population and setting

All surveys were conducted in Geneva, Switzerland. For the three snowball surveys, random samples of 900 people each (surveys A and B) and 1500 people (survey C) aged 18–70 were drawn from the official file of Geneva residents. The surveys were mailed to potential participants in 1997 and non-respondents received a reminder postcard and two reminder questionnaires. The cover letter indicated that participation was limited to current smokers and to ex-smokers who quit smoking in the previous 2 years. We asked addressees who did not fulfil these criteria or who did not wish to participate to transmit the questionnaire to any current or former smoker they knew. The sampling method, the data collection method and the wording of a subset of questions were similar in all three surveys. The data of the three surveys were pooled for the present analysis.

To assess the representativeness of samples obtained by snowball sampling, we compared participants in the pooled snowball surveys to participants in a mail survey conducted in 1996 in a representative sample of the Geneva population.¹⁰ This survey covered smoking prevention and alcohol abuse. A random sample of 1000 people aged 18–70 was drawn from the official file of Geneva residents, and four reminder mailings were sent to non-respondents.

Comparison criteria between the representative sample and the snowball samples included age, sex, proportions of current and former smokers, stages of change,¹¹ and, among smokers, the number of cigarettes smoked per day and confidence in one's ability to quit smoking.

Questionnaires used in snowball surveys

Survey A aimed at developing a psychometric scale measuring attitudes towards smoking and survey B a scale measuring self-efficacy, i.e. the confidence of smokers and ex-smokers in their ability to abstain from smoking in high-risk situations. Survey C aimed at developing a scale measuring the frequency of utilization of self-change strategies used to progress towards smoking cessation and to maintain abstinence. Participants indicated whether they were the person whose name was on the envelope containing the questionnaire. Further content of the questionnaires is described below.

Comparison of original and secondary participants

Demographic characteristics and smoking-related variables

We compared the age and sex distributions of original and secondary participants, the distribution of stages of change,¹¹ the proportion of smokers and, among smokers, the number of cigarettes smoked per day, the number of minutes between waking up and smoking the first cigarette of the day and the proportion of people who attempted to quit smoking in the previous year.

Daily versus occasional smokers

We asked participants in survey C whether they smoked 'Never'; 'Occasionally (not every day)'; or 'Every day'.

Retest

Respondents who agreed to participate in a retest indicated their mail address and received the same questionnaire again one month later. Participants in the retest answered the second

questionnaire on average 37 days after the first survey. We compared the proportions of respondents who agreed to participate in the retest and who actually did.

Smoking cessation

We compared the proportions of smokers who quit smoking between the baseline survey and the retest survey.

Confidence in ability to quit smoking or to avoid relapse

We examined the participants' confidence in their ability to quit smoking (among smokers) or to avoid relapse (among ex-smokers). Answers to both questions were given on a four-point Likert scale.

Social desirability

Avoiding a social desirability bias is important in smoking-related questionnaires, since smoking is increasingly a socially undesirable behaviour. Social desirability was assessed with a short form of Marlowe and Crowne's scale.¹²

Attitudes towards smoking

In survey A, we used an 18-item questionnaire to measure three dimensions of attitudes towards smoking: the negative effects of smoking, the psychoactive benefits and the pleasure of smoking.

Self-efficacy

In survey B, we used a 12-item questionnaire to measure two dimensions of self-efficacy: confidence in one's ability to refrain from smoking when facing internal stimuli (e.g. when feeling anxious or depressed) and when facing external stimuli (e.g. when having a drink with friends).

Self-change strategies

Ex-smokers who quit smoking by themselves use a number of strategies to progress toward smoking cessation and the maintenance of abstinence.^{13–15} In survey C, we used a 28-item questionnaire to measure the frequency of use of five self-change strategies in current smokers and five strategies in former smokers.

Associations between smoking-related variables

Bias in descriptive statistics (i.e. distributions of variables) does not necessarily imply bias in analytical statistics (i.e. associations between variables). To assess whether snowball sampling caused bias in analytical statistics, we compared the strength of associations between smoking-related variables in original and secondary participants, using as framework the Transtheoretical Model of Behaviour Change.¹¹

First, we compared the size of differences between smokers in precontemplation and smokers in contemplation and preparation on scores of attitudes towards smoking, self-efficacy and self-change strategies. Second, we compared differences on these scores between light (≤ 10 cig/day) and heavy (> 20 cig/day) smokers.

Statistical procedures

Scores of psychometric scales (attitudes, self-efficacy, self-change strategies and social desirability) were standardized. T-tests were used when continuous variables were compared and χ^2 tests when dichotomous or categorical variables were compared. Comparisons that were statistically significant in bivariate analyses were adjusted for age, sex and smoking status in multivariate linear regression models (continuous variables) and in logistic regression models (dichotomous variables).

Results

Participation

In the snowball surveys, a total of 1167 questionnaires were returned (35% of the questionnaires initially mailed), in a population where smoking prevalence was 32%.¹⁶ Half of the participants received the questionnaire directly from us (primary response rate 18%, or about 46% among eligibles) and the other half indirectly, from an addressee (Table 1). The status of original or secondary participation could not be established in 23 people (2% of participants) who were excluded from further analyses. Original participants completed the questionnaire on average 4.3 days earlier than secondary participants ($P = 0.18$).

In the representative survey, 675 people (68%) returned the questionnaire. Of these, we retained only current smokers and former smokers who quit smoking in the previous 2 years ($n = 264$).

Comparison of the snowball sample with the representative sample

Compared to the representative sample, the snowball sample included more women and more smokers intending to quit smoking (contemplation and preparation stages) (Table 1). Smokers in the snowball sample smoked 1.7 cigarettes more per day and were somewhat less confident in their ability to quit smoking than smokers in the representative sample.

In current smokers, a multivariate model showed that sex, stages of change, confidence in ability to quit smoking and the number of cigarettes smoked per day were independently associated with the type of survey (snowball versus representative) ($P \leq 0.04$ for all variables).

Comparison of original and secondary participants in the snowball surveys

Original participants were older than secondary participants and were more likely to be men (Table 1). The age difference of the two groups remained statistically significant after adjustment for sex and smoking status. Similar proportions of original and secondary participants agreed to participate in a retest (49% versus 45%, $P = 0.16$), but more original than secondary participants actually returned the retest questionnaire (Table 1). This difference remained statistically significant after adjustment for age, sex and smoking status ($P = 0.015$).

The attitude score labelled 'Pleasure of smoking' was lower in original than in secondary participants (Table 2). This difference was no longer statistically significant after adjustment for age, sex and smoking status (difference: 0.21 SD unit, $P = 0.07$).

Self-efficacy scores were higher in original than in secondary participants ($P \leq 0.03$). These differences remained statistically significant after adjustment for age, sex and smoking status (0.24 and 0.22 SD units respectively, both $P \leq 0.03$).

Table 1 Characteristics of participants in a representative sample of ever smokers, and of participants in a 'snowball' mail survey who received the questionnaire either directly from the researchers (original participants) or indirectly, from an addressee (secondary participants). Geneva, Switzerland, 1996–1997

	Representative versus snowball			Snowball survey		
	Representative sample ¹⁰	Snowball survey	<i>P</i> -value	Original participants	Secondary participants	<i>P</i> -value
No. of participants	264	1144	–	578	566	–
Mean age (years)	39.7	39.2	0.66	40.1	38.3	0.03
Proportion of men (%)	55.1	46.4	0.01	50.2	42.5	0.01
Current smokers (%)	79.9	83.4	0.17	81.5	85.3	0.09
Stages of change (%)			0.003			0.04
precontemplation	52.9	49.8		48.0	51.5	
contemplation	16.2	25.0		23.0	27.0	
preparation	2.9	5.6		6.3	4.9	
action	11.8	10.0		12.4	7.5	
maintenance	16.2	9.7		10.3	9.1	
Participated in optional retest (%)	–	27.9	–	30.8	24.9	0.03
Social desirability score^a	–	0	–	0.01	–0.01	0.79
Ever used nicotine patch/gum (%)	–	22.4	–	19.8	25.1	0.11
Among current smokers:						
cigarettes per day	16.5	18.2	0.05	17.8	18.5	0.35
min to first cigarette of day	–	76.9	–	83.5	70.7	0.17
quit attempt in past year (%)	–	41.7	–	42.9	40.6	0.47
confidence in ability to quit ^b	2.76	2.41	0.002	2.36	2.45	0.19
quit smoking at follow-up (%)	–	4.8	–	5.8	3.7	0.45
intention to use nicotine patch/gum (%)	–	9.2	–	7.5	10.9	0.48
Occasional smokers (survey C)	–	12.2	–	13.8	10.6	0.46
Among ex-smokers:						
confidence in ability to avoid relapse ^b	–	1.74	–	1.71	1.77	0.67

^a Standardized score (mean = 0, SD = 1).

^b Average on a 1–4 score.

Table 2 Scores on psychometric smoking-related scales,^a for participants in a 'snowball' mail survey who received the questionnaire either directly from the researchers (original participants) or indirectly, from an addressee (secondary participants)

	Original participants	Secondary participants	Difference (95% CI)
Survey A: no. of participants	135	133	–
Attitudes towards smoking			
negative consequences	–0.05	0.03	0.08 (–0.17, 0.32)
psychoactive benefits	–0.01	0.03	0.04 (–0.21, 0.29)
pleasure of smoking	–0.13	0.12	0.25 (0.01, 0.49)
Survey B: no. of participants	125	122	–
Self-efficacy			
internal stimuli	0.15	–0.15	–0.31 (–0.56, –0.05)
external stimuli	0.14	–0.14	–0.29 (–0.54, –0.03)
Survey C: no. of participants	318	311	–
Self-change strategies, in smokers			
Risk assessment	–0.04	0.02	0.06 (–0.12, 0.23)
Commitment to change	–0.04	0.02	0.06 (–0.11, 0.24)
Taking control over the smoking habit	0.04	–0.03	–0.07 (–0.24, 0.11)
Helping relationships	–0.01	0.00	0.01 (–0.16, 0.19)
Coping with temptation to smoke	0.03	–0.02	–0.05 (–0.23, 0.13)
Self-change strategies, in ex-smokers			
Risk assessment	0.06	–0.07	–0.13 (–0.51, 0.25)
Coping with temptation to smoke	–0.26	0.32	0.58 (0.22, 0.95)
Commitment to maintain change	–0.14	0.18	0.32 (–0.06, 0.70)
Self-re-evaluation	–0.16	0.19	0.35 (–0.04, 0.73)
Stimulus control	0.07	–0.09	–0.16 (–0.53, 0.22)

^a Standardized scores (mean = 0, SD = 1).

Self-change strategies

In ex-smokers, original participants used the strategy labelled 'Coping with temptation to smoke' less frequently than secondary participants (difference 0.58 SD units, $P = 0.002$). This difference remained significant after adjustment for age and sex (difference 0.46 SD units, $P = 0.02$).

All other variables were similar in original and secondary participants.

Differences in associations between variables

Between-stage differences in attitudes, self-efficacy and the use of self-change strategies were similar in original and secondary participants (Table 3). Differences between light and heavy smokers were also similar in both groups.

Discussion

We examined bias due to transmission of a mailed questionnaire by original addressees to any person of their choice who fulfilled eligibility criteria (i.e. being a current or former smoker). We also compared this pooled 'snowball' sample to a representative sample of ever smokers drawn from the same population.

Compared to smokers in the representative sample, smokers in the pooled snowball sample were in more advanced stages of change, smoked more cigarettes and were less confident in their ability to quit smoking. These differences could be attributed to the purpose and content of the questionnaires: the snowball survey was aimed at developing psychometric scales, whereas

the representative survey was an opinion survey intended at informing policy. In addition, the snowball survey covered exclusively smoking, whereas the representative survey also covered alcohol use. Alternatively, differences between the snowball and the representative sample may be explained by non-response bias, as participation rates differed between the surveys.

Most smoking-related variables were similar in original and secondary participants in the snowball surveys, including smoking status and level of dependence on cigarettes (measured by the number of cigarettes smoked per day and the time of the first cigarette of the day).¹⁷ However, secondary participants found smoking more pleasurable than original participants and had lower self-efficacy scores. Among ex-smokers, secondary participants were more active than original participants in coping with the temptation to smoke. These differences can result either from selection bias (i.e. the two categories of respondents were actually different) or from information bias. Information bias would occur if receiving the questionnaire from a familiar person influenced the responses, compared to receiving it directly from the researchers. Selection bias could be caused by several mechanisms, which depend on the reasons why the original recipient does not participate (ineligibility or unwillingness to participate), on who decides to transmit the questionnaire instead of throwing it away, on the choice of the person to whom the questionnaire is transmitted (spouse, friend, colleague,...), and on who responds, among secondary recipients. Previous research suggests that different mechanisms of non-response produce different types of selection bias,¹⁸ but we

Table 3 Differences in psychometric scores^a between smokers in precontemplation versus contemplation/preparation stages of change, and between light and heavy smokers, for original and secondary participants in a snowball mail survey

	Differences between precontemplators and contemplators/preparators			Differences between light (≤ 10 cig/day) and heavy (> 20 cig) smokers		
	Original	Secondary	Difference (95% CI)	Original	Secondary	Difference (95% CI)
Attitudes:						
Negative consequences of smoking	0.64	0.80	0.15 (-0.38, 0.68)	-0.77	-0.58	0.19 (-0.44, 0.88)
Psychoactive benefits of smoking	-0.35	0.10	0.45 (-0.10, 1.00)	-0.68	-0.78	-0.10 (-0.84, 0.64)
Pleasure of smoking	-0.44	-0.53	-0.08 (-0.59, 0.42)	-0.26	-0.74	-0.48 (-1.18, 0.22)
Self-efficacy:						
Internal stimuli	0.19	0	-0.19 (-0.67, 0.29)	1.23	1.04	-0.19 (-0.86, 0.47)
External stimuli	0.38	0.10	-0.28 (-0.76, 0.20)	0.73	0.84	0.11 (-0.60, 0.82)
Self-change strategies:						
Risk assessment	0.81	0.78	0.03 (-0.38, 0.32)	0.13	-0.01	-0.15 (-0.66, 0.38)
Commitment to change	1.28	1.11	-0.17 (-0.48, 0.14)	-0.15	0.01	0.16 (-0.37, 0.69)
Taking control	0.40	0.43	0.03 (-0.32, 0.39)	1.59	1.52	-0.06 (-0.53, 0.42)
Helping relationships	0.87	0.78	-0.08 (-0.42, 0.25)	0.24	-0.07	-0.30 (-0.81, 0.21)
Coping with temptation	0.52	0.53	0.02 (-0.34, 0.37)	0.37	0.56	0.19 (-0.33, 0.71)

^a Standardized scores (mean = 0, SD = 1).

were unable to analyse this issue in this study. For instance, the greater proportion of women among secondary participants may be due to the lower prevalence of smoking among women: an original addressee who was a woman was more likely not to be eligible, and to transmit the questionnaire to a female friend who smoked.

Associations between smoking-related variables were similar in original and secondary participants, which suggests that snowball sampling is a potentially useful recruitment method for analytical studies which are focused on associations between variables. This was particularly meaningful for our surveys, which were designed to develop psychometric scales, and not to provide descriptive statistics. However, a lack of statistical power due to a small sample size may also explain why we found no significant between-group difference in associations between variables. Furthermore, associations between variables not assessed in this study may differ between original and secondary participants. Thus further studies are necessary to assess whether our finding on the absence of bias in analytical statistics is robust across different variables and populations.

This original study of an unconventional method of data collection suggests that snowball sampling in mail surveys deserves to be more thoroughly documented. The process of transmission of the questionnaire from original to secondary participants should be studied, social connections between original and secondary participants should be described, and response rates of secondary participants should be assessed. Snowball sampling should also be tested in several countries, to establish whether propensity to transmit the questionnaire varies across cultural contexts.

In summary, allowing addressees to transmit the questionnaire to someone else doubled the response rate, produced a moderately biased sample but did not affect associations between smoking-related variables. Thus, snowball sampling may be a cost-effective method of data collection for analytic studies which examine associations between variables (as was the case of our surveys). However, snowball sampling does not eliminate

potential bias between responders and non-responders and is therefore not a solution to non-response in mail surveys.

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