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METHODS

SMS versus telephone interviews for epidemiological data collection: feasibility study estimating influenza vaccination coverage in the Swedish population

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Abstract This study compared the use of Short Message Service (SMS) on mobile phones and the use of telephone interviews in collecting self-reported data about influenza vaccination. Through random selection from the Swedish population registry, 2,400 individuals were assigned to be contacted through SMS (SMS-group), and 2,150 were assigned to undergo personal telephone interviews (TI-group). Both groups were asked three questions about influenza and influenza vaccination. Mobile phone numbers were found for 1,055 persons in the SMS-group of whom 154 (6% of the original sample; 15% of all who had a listed mobile phone number) responded. Landline or mobile phone numbers were found for 1,636 persons in the TI-group and 1,009 (47% of the original TI sample; 62% of those where a telephone number was found) responded. The vaccination data collected via SMS was not statistically significantly different from data collected through telephone interviews, and adjustment for different background factors did not change this. Compared to the original sample, there was an under representation of elderly and less educated individuals among the participants in the SMS-group, and under representation of less educated in the TI-group. Though the participation rate was low, SMS is a feasible method for collection of information on vaccination status data among the Swedish population compared to telephone interviews.

Keywords Mobile phone · Telephone · Human interviews · Questionnaires · Vaccination · Influenza

Abbreviations

CI	Confidence interval
JAVA	Software platform
OR	Odds ratio
SMS	Short message service
TI	telephone interview
SMS-group	The group allocated to be contacted through SMS
SMS-1	Original sample in SMS-group
SMS-2	Group individuals where mobile phone number was found in SMS-group
SMS-3	Group of individuals who completed the SMS-interview
TI-group	The group allocated to be contacted through telephone interviews
TI-1	Original sample in TI-group
TI-2	Group of individuals where fixed or mobile phone number was found in TI-group
TI-3	Group of individuals who completed the telephone interview

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Introduction

The rapid transformation of technological knowledge in the society during the last decade has expanded the possibilities for data collection in epidemiological studies [1, 2].

The traditional approaches, face-to-face interviews, telephone interviews and paper questionnaires, are often time-consuming and labor-intensive [3, 4]. The introduction of information and communication technologies such as the web and mobile phones, hold great potential as innovative tools for epidemiological data collection [5–8]. Digital technologies in epidemiological research, referred to as e-epidemiology, are challenging traditionally used methods for data collection and are more adapted to today's society [9]. As an example, 6% of the population of Sweden has already chosen to give up landline phones in their households in favour of mobile phone subscriptions [10]. A similar telephone usage trend has been seen in other developed countries [11–13]. This trend leads to less complete telephone directories and undermines the use of landline phones and traditional telephone interviews as a means of collecting data in population-based epidemiological studies, forcing the development of new methods.

Among the new communication devices, mobile phones are the most widely used in the general Swedish population, and worldwide the use of mobile phones outnumbered the use of traditional landline phones in 2002 [10, 12]. Today, 94% of the adult Swedish population between the ages of 16 and 75 has access to a mobile phone. An increasing proportion of the Swedish population, 60% in 2007, had used the Short Message Service (SMS) function [10]. Mobile phones and SMS as tools for the exchange of data regarding infectious diseases and adverse events between public health laboratories and central sites have been tested in both Iran and Peru [14, 15]. Short Message Service has also been used and evaluated in different intervention studies [16–23]. Many new mobile phones include GPS (Global Positioning System) and JAVA technology, which gives even more opportunities for data collection not available without digital methods [24, 25].

This study tests the feasibility of using SMS as a means for collecting self-reported information about influenza vaccination status in a representative sample of the Swedish population. To evaluate the technique against a traditionally used method, the data will be compared to data obtained from telephone interviews in the same population.

Methods

Recruitment

A random sample of 4,550 individuals aged 0–100 years was drawn from a continuously updated population register at Statistics Sweden [26]. Children <16 were included in order to make the study material as complete as possible and to study spread within families. Through random allocation, the selected individuals were divided into two groups: 2,400 were to be administered questions through SMS on mobile phones (SMS-group) and 2,150 were to undergo personal telephone interviews (TI-group) via landline or mobile phones. Both samples was based on a previous study where 1,500 individuals were selected for a telephone interview regarding influenza coverage [27]. The TI-group was estimated to reach 70% coverage of telephone numbers sampled, and the SMS-group was slightly over sampled in order to compensate for coverage in the telephone register. Children under 16 years were contacted via their parents, and elderly people who were unable to handle the technique were encouraged to delegate the task to someone else.

Telephone numbers were extracted from the most complete telephone directory in Sweden [28]. As the telephone directory had more than one telephone number listed for many of the selected individuals, a scheme was created to decide which phone number to use. If more than one phone number was listed in either the SMS-group or the TI-group, one number was chosen randomly. If only a landline number to a partner to the selected individual was listed in the TI-group, this number was used. If the partner had more than one landline phone number listed, a random number was used. If only a mobile phone number was listed to the individual or the individuals' partner in the TI-group, this number was used (in the event of many mobile phone numbers, a random number was used). The selected individuals for whom we were able to find a mobile phone number (SMS-group) or any phone number (TI-group) received an invitation via regular mail. Individuals who did not decline participation were contacted through either an SMS or a telephone call.

The questionnaire consisted of the following questions:

1. "Do you want to answer a couple of questions about influenza?"
2. "Have you been vaccinated against influenza since October 2005?"
3. "Do you believe that you belong to a group that risks severe disease if infected by influenza?"

The SMS-group received the first SMS at 5 pm on a weekday. The individuals answered by messaging 1 for "yes", 2 for "no", 8 for "do not know" or 9 for "abort session". When a 9 was recorded (or 2 for question one), no further contacts were made. If the individual did not reply to the SMS, the same message was sent the following day and yet again one week later. Simultaneously, attempts were made to contact individuals in the TI-group between 5 pm and 8.30 pm during five consecutive weekdays. The interviewers were instructed to attempt to contact a participant a maximum of two times a day. The study was approved by the regional ethics committee at Karolinska Institute in March 2006, and conducted in March 2006.

When all interviews had been carried out, the data file was linked to the Longitudinal Integration Database for Sick Leave and Labour Market Studies at Statistics Sweden. Information was obtained about age and gender, marital status, size of household and family income, highest degree of education and occupation (categorised according to the Swedish Standard Classification of Occupations 1996 [29]. Largely corresponding to International Standard Classification of Occupations (ISCO-88) published in 1988 by the International Labour Office, Geneva [30, 31]. The data file was further linked to the Inpatient register at the National Board of Health and Welfare in order to get information about hospitalizations between 1999 and 2004. Before delivery from Statistics Sweden, the National Registration Numbers in the file were replaced by individually unique identification codes.

Statistical analysis

Both allocation groups were dimensioned to verify estimated vaccination coverage of 5% with 95% confidence limits not exceeding ±1% unit and allowing for non-response rates in the SMS-group and TI-group of 15% and 24%, respectively. The SMS-group and TI-group were categorized as original sample (SMS-1 and TI-1), group where phone numbers were found through the telephone directory (SMS-2 and TI-2), and respondents who completed the interview (SMS-3 and TI-3). All groups were compared on summary statistics and graphs to the original sample in the respective allocation group. Group differences for data on a categorical scale were summarized by side-by-side segmented bar charts with one bar for each sub-group and with the size of the bar segments proportional to the number of subjects in each category.

To compare the estimated vaccination coverage, logistic regression models were fitted to the vaccination data, using available baseline characteristics from the participants in the SMS-group and the TI-group. The log odds of proportion of a positive answer was the dependent variable. The analyses started with a model that only included the allocation group, and then stepwise introduced available background variables where data was complete for all participants (age, gender, education and family size), to explain observed dissimilarities in vaccination coverage between the SMS and TI-group. As influenza vaccination is rare in the younger age groups, the age groups 0–17 and 18–39 were merged into one group in the presentation of vaccination status.

To assess the importance of measured background factors as independent predictors of non-participation, a multivariable logistic regression model was fitted. In the logistical regression model, non-participants were defined as all individuals who did not respond to the questionnaire. The analysis proceeded from all individuals in the original sample (SMS-1 and TI-1) where information about background variables was found. As no information was collected on parents to children under the age of seventeen, this age group was excluded from the non-participation analysis along with individuals for which data was missing for other reasons. After exclusion, 1,264 individuals of the original sample in the SMS-group and 1,152 of the TI-group were included in the logistic regression model. Also, as marital status was highly correlated with size of family household, and occupation was highly correlated with highest degree of education, these variables were not used in the regression models. Analyses started separately for each allocation group (SMS and TI), and then comparing the two groups.

Group differences for all regression models were expressed in terms of odds ratios. All statistical tests were done on the two-sided 5% level of significance. The goodness of fit of the fitted models was evaluated by using the model deviance. Likelihood ratio tests were used in the logistic regression models to evaluate the addition of a variable. All analyses were performed with the SAS 9.1.3 statistical software program.

Results

Response rate

Attrition rate and drop-out in the SMS-group and the TI-group are presented in Fig. 1. Of the individuals allocated to the SMS-group (SMS-1, $n = 2{,}400$) linkage to the

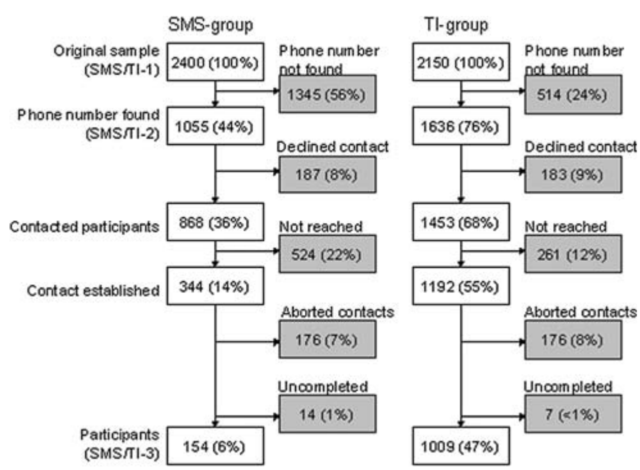

Fig. 1 Attrition rate and drop-out in the SMS-group and the TI-group. All figures are presented as percentage of the original sample in each group

telephone directory yielded mobile phone numbers for 1,055 individuals (SMS-2, 44%). In the TI-group (TI-1, $n = 2{,}150$), the yield of landline numbers was 1,193 (55%) while another 444 (21%) had a listed mobile phone number. In total, phone numbers were obtained for 1,636 (TI-2, 76%) individuals in the TI-group. In the SMS-group, 187 actively declined participation following the initial letter of invitation. In the SMS-group, 344 (40%) of the remaining 868 individuals responded to the first question, out of which 176 declined participation. Fourteen subjects responded to one additional question, but terminated the interview prematurely. Hence, 154 individuals (SMS-3, 6% of the original sample; 15% of all who had a listed mobile phone number) gave answers to all questions. Among the TI-group, 183 declined participation following the letter of invitation and 25 of the listed telephone numbers were invalid or linked to a fax. Contact was established with 1,192 (73%) of the 1,636 who had a listed telephone number. In response to the first question about willingness to participate, 176 declined further questioning. During the subsequent interview, seven individuals answered only one of the questions. In total, 1,009 (TI-3, 47% of the original TI sample; 62% of those where a telephone number was found) underwent the intended telephone interview.

Vaccination coverage

Tables 1, and 2 demonstrate the vaccination coverage and distribution of age and gender among the participants in both groups. Among those who answered the questions in the SMS-group, 12 (8%) stated that they had been vaccinated against influenza since October 2,005 compared to 113 (11%) in the TI-group. After fitting a logistic regression model, the crude OR for being vaccinated among the SMS participants, relative to the participants in the TI-group, was 0.7 (95% CI 0.4–1.3). Adjusting for the demographic variables age (categorized as 0–39, 40–64, $\geq$ 65), gender, education and size of household shifted the OR to 1.8 (95% CI 0.9–3.6). Most of this effect was noticeable after adjustment for age, though the adjustment did not statistically significantly change the effect of no difference between the groups. None of the tests for interaction between allocation group and each of the other covariates was statistically significant.

Table 1 Self-reported vaccination status among participants in SMS-group and participants in the TI-group

	SMS-3 $n = 154$	%	95% CI	TI-3 $n = 1{,}009$	%	95% CI
Vaccinated						
Yes	12	8	4–12	113	11	9–13
No	134	87	82–92	887	88	86–90
No answer[a]	8	5	2–9	9	1	0.3–1

[a] All participants had the opportunity to answer "do not know" or "do not want to answer"

Socio-demographic distribution

Distribution of gender was similar among the participants in the original samples (Fig. 2a). The age distribution in the TI-1 group seemed to be preserved in the TI-2 and TI-3 groups, while there was a shift toward the ages 18–39 years in SMS-3 group compared to SMS-1 and SMS-2 groups. Particularly noteworthy is a clear under representation of people above the age of 65 in SMS-3 (Fig. 2b). In terms of size of household, the proportion of one-person households was somewhat lower in TI-3 group compared to the original sample (Table 3). The excess of highly educated individuals (>13 years of education) was somewhat more marked in the SMS-3 group than in TI-3 (Table 3). The family income and level of skill of occupation was to some extent higher among participants compared to the original samples in both groups. Though the distribution of marital status was fairly well preserved in both allocation groups, widows/widowers were fewer among SMS-3, reflecting the deficit of elderly.

Previous hospitalizations for influenza were rare and neither of the two individuals with such a history was captured among the participants. In TI-1 and SMS-1, approximately 30% had been admitted to a hospital at least once between 1999 and 2004. The proportion with a recorded in-hospital episode was higher among TI-3 compared with SMS-3, reflecting the deficit of elderly

Table 2 Vaccination status distributed according to gender and age—both the SMS-group and the TI-group

	SMS-3 $n = 154$	Vaccinated (n)	%	TI-3 $n = 1{,}009$	Vaccinated (n)	(%)
Age group						
0–39	93	3	3	477	10	2
40–64	56	5	9	383	28	7
≥65	5	4	80	149	75	50
Gender						
Women	71	6	8	504	61	12
Men	83	6	7	505	52	10

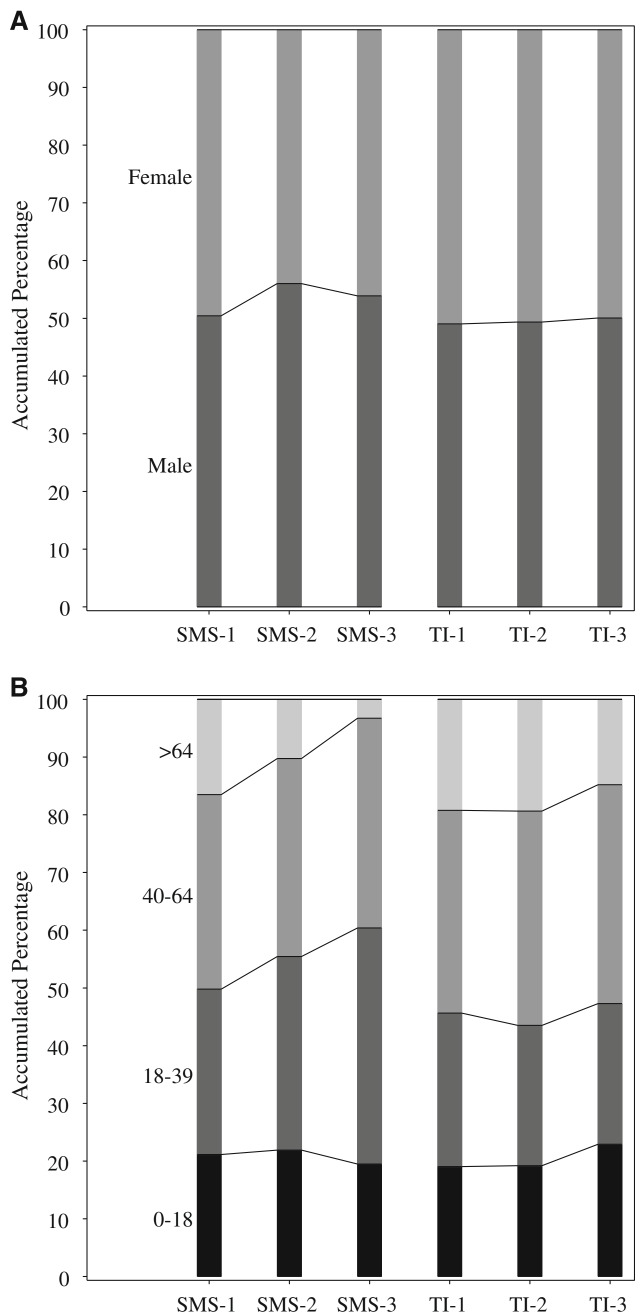

Fig. 2 Distribution of background characteristics by mode of contact (SMS or TI). The mode of contact was randomly assigned to representative samples of the Swedish population. Within each allocation group, the original population sample is compared with the subset of individuals who could be contacted because a listed telephone number was found, and with the sub-subset of individuals who actually participated through answering the questions **a** Gender; **b** Age group

among SMS-3. This difference was however not statistically significant.

After excluding data for missing values and the age group 0–17, a logistic regression model was fitted for non-participation among the SMS-group adjusted for available background factors. Statistically significant variables were education ($P = 0.01$) and age ($P = 0.03$), where the non-participants were less educated and older than the participants after adjustment for other background factors. When modelling non-participation among the TI-group, only adjusted for available background factors, education was statistically significant ($P = 0.003$) as the average non-participant was less educated than the average participant (Table 4).

After fitting a logistic regression model for non-participation in the total original sample comparing allocation group SMS to TI, the crude OR was estimated to 13.1 (95% CI 10.4–16.7). After adjustment for all available background variables, OR shifted to 14.2 (95% CI 11.2–18.1). The odds of non-participation was 14 times higher in the SMS-group compared with the TI-group, with higher group difference in the higher age category. Again, this is a consequence of the lack of participants in the age group ≥65 in SMS-3.

An interaction between allocation group and age was found ($P = 0.009$). Analysing subgroups by age, the adjusted OR in the age group 18–39 was 11.5 (95% CI 7.7–17.1), 16.4 in the age group 40–64 (95% CI 11.6–23.2) and 53.4 in the age group ≥65 (95% CI 18.4–155.4).

Discussion

This study, conducted in a random sample of the Swedish general population, was aimed at comparing SMS and Telephone interviews for the collection of vaccination status data.

The vaccination status reported in the SMS-group was not statistically significantly different from the vaccination status reported in the TI-group, and adjustment for unbalance between the two groups did not change this. The low response rate in the SMS-group did however affect the power, and the CI for this group was wider than expected. The change of OR after adjustment for different background factors (from 0.7 95% CI 0.4–1.3 to 1.8 95% CI 0.9–3.6) was mainly explained by the vaccination status in the age group ≥65, as the other age groups had similar vaccination status when comparing the two groups.

The participation rate compared to the original sample was low in both groups, but particularly low among those who were contacted through SMS. Using SMS as a means of contact gave a 14 times higher non-participation rate compared to the TI-group. This was partly explained by the low yield of extraction of mobile phone number from the telephone directory (44%). An interaction between allocation group and age was found ($P = 0.009$), indicating the impact of the low participation rate among the older age groups in the SMS-participants. Using SMS introduced

Table 3 Distribution of background characteristics by mode of contact (SMS or TI)

	SMS			Telephone interviews		
	SMS-1 $n = 2{,}400$ (%)	SMS-2 $n = 1{,}055$ (%)	SMS-3 $n = 154$ (%)	TI-1 $n = 2{,}150$ (%)	TI-2 $n = 1{,}636$ (%)	TI-3 $n = 1{,}009$ (%)
Education (years in school)						
≤9	17	16	10	17	16	11
10–12	33	37	33	31	32	34
13–15	10	10	16	11	12	12
≥15	11	13	21	12	12	14
Missing[a]	8	5		10	9	6
<18 years[b]	21	22	19	19	19	23
Household size						
1 person	27	24	27	29	28	23
2 persons	24	21	17	24	25	24
3 persons	15	17	13	15	15	16
4 persons	22	25	32	20	22	25
≥5 persons	9	10	8	8	9	10
Missing[a]	3	4	3	3	2	2
Household income[c]						
High	30	35	44	32	35	40
Middle/High	21	23	17	19	20	19
Middle	19	18	19	20	19	20
Middle/Low	14	13	10	13	13	11
Low	13	10	10	15	12	9
Missing[a]	2	2		1	1	1

The mode of contact was randomly assigned to representative samples of the Swedish population. Within each allocation group, the original population sample is compared with the subset of individuals who could be contacted because a listed telephone number was found, and with the sub-subset of individuals who actually participated through answering the questions

[a] Data missing in the Longitudinal Integration Database for Sick Leave and Labour Market Studies at Statistics Sweden

[b] Children under 18 where information on level of education is not yet available

[c] Income categorized as low (€ <14,915 per year), middle/low (€ 14,916–24,129), middle (€ 24,130–36,220) middle/high (€ 6,221–50,415), high (€ ≥50,416) and unknown

an imbalance in terms of age and level of education compared to non-participants in the same group. This imbalance was noticeable already when the mobile phone numbers were selected at the telephone directory level. The imbalance in educational level was seen also in the TI-group.

As noticed in several epidemiological investigations using telephones, individuals who participate tend to be better educated than non-participants, which could also be seen in our study [4, 32]. It is conceivable that participants and non-participants might differ in a number of lifestyle factors with bearing on health behaviours and health outcomes. Therefore, measurements done in the TI-group should not be viewed as gold standard with which to compare the results obtained in the SMS-group, as some systematic errors might be correlated. Contrary to the TI-group, where several attempts were made to contact the participants, the participants in the SMS-group had to actively answer the questions, which might indicate that those who answered might have been more motivated than participants in the TI-group. This appears to be reflected among the elderly in the SMS-group and the high impact on the assessment of influenza vaccination status in this sub-group (Table 2), as the risk group targeted vaccination is almost totally confined to these individuals. The distribution of previous hospital care in the original sample was however preserved in both SMS-3 and TI-3, indicating that health status probably did not affect inclination to participate.

Landline telephones have long been one of the basic tools in epidemiological data collections [32]. In Sweden, almost complete and unbiased telephone coverage has been taken for granted for several decades, and telephone surveys have typically proceeded from a random population

Table 4 Odds ratio for non-participation in original sample adjusted for allocation group, age category, gender, education, family size and household income

	SMS-group $n = 1,264$			TI-group $n = 1,152$		
	OR adjusted	CI 95 (%)	*P*-value	OR adjusted	CI 95 (%)	*P*-value
Age group						
18–39	1.0			1.0		
40–64	3.3	1.2–9.1	0.02	0.9	0.6–1.4	0.59
≥65	1.4	0.9–2.2	0.15	1.0	0.7–1.3	0.96
Gender						
Women	1.0			1.0		
Men	1.0	0.67–1.56	0.92	1.1	0.9–1.4	0.47
Education						
≤9 years	1.0			1.0		
10–12 years	0.9	0.4–1.9	0.85	0.6	0.4–0.8	0.001
13–15 years	0.5	0.2–1.2	0.13	0.6	0.4–0.9	0.01
≥15 years	0.4	0.2–0.9	0.03	0.5	0.3–0.7	0.005
Size of household						
1	1.0			1.0		
2	0.9	0.5–1.9	0.84	1.0	0.7–1.4	0.91
3	0.9	0.5–1.9	0.80	1.0	0.7–1.6	0.90
4	0.7	0.3–1.3	0.23	0.6	0.4–0.9	0.02
≥5	0.9	0.4–2.1	0.75	0.9	0.5–1.5	0.60
Household income[a]						
Low	1.0			1.0		
Middle/Low	0.8	0.3–2.4	0.73	1.2	0.7–2.1	0.52
Middle	0.7	0.3–1.8	0.41	0.8	0.5–1.4	0.51
Middle/High	1.1	0.4–3.0	0.89	1.1	0.6–1.8	0.85
High	0.7	0.3–2.1	0.92	0.6	0.4–1.1	0.08

[a] Income categorized as low (€ <14,915 per year), middle/low (€ 14,916–24,129), middle (€ 24,130–36,220) middle/high (€ 36,221–50,415), high (€ ≥50,416) and unknown

SMS-group and TI-group listed separately

sample for which most telephone numbers have been easily obtained from the local telephone directories. More and more households are currently substituting mobile phones for conventional landline telephone subscriptions [10]. In this study, less than 55% of the individuals selected for the TI-group could be reached through a landline phone number in the computerized phone directory (including a number to a partner to the selected individual). Mobile phone numbers were found for no more than 44% of the individuals selected for the SMS-group. Potential reasons for this low coverage is the use of mobile phones that are not registered to the individual but to his/her employer or business, and the common use of mobile phones with pre-paid mobile calling phone cards. In addition, many of the individuals for whom a phone number (both mobile and landline) was found had more than one number listed, while in other cases a non-functioning number was found. The difficulty in finding functioning/listed telephone numbers is a potential problem for all telephone-based studies, reflecting the need for rethinking epidemiological telephone-based data collection.

Strengths of this study include the representative sample of the general population. The unique personal identifiers made it possible to extract information through multiple record linkages on demographic and socioeconomic factors as well as previous hospitalization for all of the selected individuals.

The major weakness is the uncertain generalizability of our findings. There may be important international differences in telephone habits and attitudes, although the similarities between Sweden and other developed countries will probably outweigh the dissimilarities [12]. Sweden also has the advantage of linkage of data to population based registers, which give access to socio-demographic data. This implies shorter questionnaires, as no questions on background data are needed. This is usually not the case in other countries. In this study, a set of three questions was used. Today, there is no restriction of the length of SMS based questionnaires, but shorter questionnaires are probably to prefer, why the study might be difficult to repeat if background data is included. Each question was restricted to 160 characters, why the freedom in designing the questionnaire was limited. Therefore, SMS should be restricted to short questionnaires with set answering options. Some project-specific features might have exaggerated the disadvantage for the SMS-group. The SMS-group paid for the charge for answering through SMS, as there was no technically feasible alternative during the study period. The subcontractor that provided the technical platform was based in Great Britain, thus a foreign phone number was exhibited as sender on the mobile phone display. This might have decreased the trustworthiness. And finally, the SMS were sent at 5 pm, which is usually a time when many people are in transit, thus decreasing the probability of participation [8].

The vaccination coverage when collected through SMS was not statistically significantly different from data collected through telephone interviews, and adjustment for different background factors did not change this. The study technique should however be repeated in populations older than 65 years, as this group was poorly represented. Population sampling via existing telephone directories introduced a shift toward more educated people, and among mobile phones, a shift toward younger individuals. This imbalance is however not unusual in population-based studies, and did not effect the main parameter of outcome in this study. Technical developments appear to have striking effects on telephone habits in the population implicating a growing need for new, efficient strategies for telephone-based data collections in epidemiological studies. Using SMS in this study gave a low participation rate, but was feasible for the collection of vaccination status in the Swedish population compared to telephone interviews.

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