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Large scale questionnaire survey on respiratory health in Sweden: Effects of late- and non-response

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Summary
Background: Participation rates in epidemiologic studies conducted with postal questionnaires have steadily declined since 1970s. This can lead to an increased risk for selection bias. The aim of this study was to examine cause and effect of non-response in a large cross sectional study assessing respiratory health in western Sweden.
Methods: The study sample was 29,218. The response rate to the initial postal questionnaire was 33%. The response rates to subsequent postal reminders were 15%, 7% and 7% of eligible participants totalling a participation of 62%. Of those who did not respond to the postal survey, a random sample of 400 subjects were identified and contacted for interview by telephone.
Results: Non-responders did not differ significantly in prevalence of airway diseases or symptoms when compared with responders. Male sex, young age and smokers were underestimated among non-responders. No clear trends in prevalence of respiratory symptoms and report of asthma were found with delayed response to the postal survey. The proportion of smokers and men increased with increasing number of reminders. Letters reminding subjects about the study did increase the participation rate but did not alter the risk estimates.
Conclusion: We conclude that with a response rate of 62%, our estimate of disease and symptom prevalence was not biased in this Swedish population. However, smoking was

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underestimated. No general trend for late-responders was seen and therefore we conclude that extrapolation of results to non-responders is not possible in our study. Causes of non-response were mainly due to circumstantial factors.

Introduction

Postal enquiries are still the most important tool in assessing prevalence and risk factors in the epidemiologic study of obstructive pulmonary diseases and allergies.[1,2] However, in recent years the number of responders to postal questionnaires has decreased.[3,4] During 1970s and 1980s response rates in Nordic countries were most often 80—90%,[5,6] while recent studies have resulted in response rates of 70—80%[7—9] with some below 70%. This greater proportion of non-responders increases the possibility of bias.

A large number of non-responders may cause bias in the risk estimation due to confounding factors associated with the tendency to not respond. The identification and influence of these confounding factors have not been conclusive. The few studies of causes and consequences of non-response show conflicting results. Studies in Norway and Sweden found non-responders (NR) more often to be smokers, to have lower socio-economic status and to have more respiratory symptoms and diseases.[10,11] Contrary to those findings, a study from Finland found that non-responders were less likely to have respiratory symptoms.[12]

Due to the potential of confounding by variables associated with non-response, validation of non-responders in postal questionnaire based studies is important to evaluate bias. The most common way of surveying postal questionnaire non-responders is by telephone, which has been shown to correlate well with postal enquiries.[13]

Many previous postal surveys have demonstrated low response rates to initial contact. Therefore, the initial postal enquiry is generally followed by reminders if no response is obtained. The subjects responding to the initial survey are classified as early responders (ER), whereas the subjects responding to the reminders are classified in categories of late-responders (LR). The response rates tend to drop with every subsequent reminder and the ethics committee of the Norwegian Research Council for Science and Humanities[14] recommended that only one reminder should be sent. However, De Marco et al.[15] have reported that subjects responding to each subsequent reminder differ from each other and from the ER. This phenomenon makes characterizing the subpopulations of responders important to account for any bias.

The recent tendency of a growing proportion of NR necessitates development and implication of new methods to increase participation. One method already in use as a complement is internet based questionnaires. Previous methodological studies among young subjects using internet questionnaires have shown response rates equal to or slightly lower than those for postal surveys.[16,17] The recent accelerating use of the internet could provide an important tool to complement postal surveys and reduce non-responders. Further, understanding the reasons for non-response could lead to altered study designs to improve participation rates.

The aim of this study was to validate the representativeness of a large epidemiological questionnaire cohort recruited for a study of respiratory symptoms, asthma, bronchitis/COPD and allergies by investigating if the NR differed from the responders and to evaluate ER versus LR and NR. Further aims were to identify reasons for non-participation, and to evaluate the willingness of participants to complete questionnaires online.

Material & methods

Study population

A cross sectional study design was implemented to assess the prevalence and risk factors for obstructive and allergic lung diseases in western Sweden. This area of western Sweden consists of the city of Gothenburg, the second largest city in Sweden, and the neighbouring provinces, called Western Gothia. According to the Swedish government the population of this area was 1,547,298 in 2007 with 493,502 of those inhabitants living in the city of Gothenburg.

A randomly selected sample of 30,000 subjects aged 16 to 75 years was invited to participate. Proportions of subjects invited were set to reflect the age and sex composition of the area population demographics. Half of the subjects (i.e. 15,000) were recruited from the city of Gothenburg and the other half from the region outside the metropolitan city area. Names and addresses were obtained from the Swedish population registry provided by an external company.

Questionnaire

A postal questionnaire was sent to all invited subjects in March 2008. The questionnaire consisted of three parts; 1) the Finland Estonia Sweden (FinEsS) questionnaire version[7,9] of the Swedish Obstructive Lung Diseases in Northern Sweden (OLIN) Studies,[6] 2) questions about the participants' occupation, early retirement and exposure related symptoms, and 3) the Swedish version of the Global Allergy and Asthma European Network (GA2LEN) questionnaire. The questionnaire included queries related to respiratory symptoms, asthma, bronchitis, chronic obstructive pulmonary disease (COPD), allergy, rhinitis, eczema, use of medication, smoking habits and occupation. A reminder was mailed after one month to those who had not responded, a second reminder after another month and finally a last reminder after additionally two months. All reminders included the same questionnaire. Subjects could choose either to complete the questions by hand and mail it back in a prepaid enclosed envelope or answer the same questions by the internet. For the latter, the subjects were assigned individual logins and passwords along with instructions.

Postal survey — participation

From the initial 30,000 questionnaires, 489 were returned because of unknown recipients and 17 had died, 87 had moved, 121 were unable due to handicap or disease, and 68 had other reasons which mainly included not understanding the language. Thus the potential study sample consisted of 29,218 subjects. One month after the third reminder the study was closed, and by that time 18,087 (62%) subjects had completed the questionnaire.

From the remaining 10732 subjects of non-responders a sample of 400 persons where randomly selected for this study. The study was approved by the Ethical Committee at the University of Gothenburg.

Methods — non-responders study

Phone numbers for the non-responders were acquired from two commercial databases. Data was collected by structural interviews completed by a single investigator (Erik Rönmark) who identified himself as a researcher and physician at the University of Gothenburg. Interviews were conducted between the 6th and the 28th of October 2008. Verbal consent was obtained by all subjects before initiating the interview. All subjects were informed that the information they provided would be stored in a confidential database.

At least five telephone calls during both day and evening times were attempted before considering a subject unreachable. Important key questions regarding airway symptoms, smoking habits, diagnosis of asthma and occupation were chosen from the mailed questionnaire and phrased in an identical way. If not understood, the question was repeated and then explained. Questions regarding the reason for non-response to the postal questionnaire and what could have been done differently to increase the likelihood that the subject would have completed the postal questionnaire were asked.

Statistical methods

Hypothesis testing for significant differences between the groups of responders and non-responders for prevalence was analysed with Statistical Package for Social Sciences (SPSS) version 16.0. For this Fishers exact Chi^2 tests were used and a p-value < 0.05 was considered statistically significant. Odds ratios for responders vs. NR with 95% confidence intervals (CI) were calculated by multiple logistic regression analysis adjusting for age, sex, responding status and smoking habits. Chi^2 test for trend was used to compare outcomes of ER and LR. Odds ratios for recurrent wheeze and sputum production were calculated by a multiple logistic regression model cumulatively for each subsequent reminder including the possible risk factors age, sex, smoking, area of domicile, and occupational exposure for gas, dust or fumes.

Results

Participation

Male sex and living in the metropolitan area of Gothenburg were significantly associated with not being traceable (Table 1). Subjects living in the metropolitan area were more likely to have moved and to refuse participation. The response rate was greatest in the first mailed questionnaire

Table 1 Study sample. Invited, responders and non-responders by area of domicile and sex in the postal questionnaire survey. Difference (p-value) between area of domicile and sex, respectively.

Study population		Outside Gothenburg	Gothenburg	*P*-value	Men	Women	*P*-value	Total
Initial study sample	N							**30000**
Deceased	N							17
Not possible to trace	N (%)	175(1.2)	314(2.1)	<0.001	311(2.1)	187(1.2)	<0.001	489
Had moved	N (%)	30(0.2)	57(0.4)	0.005	41(0.3)	46(0.3)	0.594	87(0.3)
Not able because of disease or handicap	N (%)	64(0.4)	57(0.4)	0.525	66(0.4)	55(0.4)	0.318	121(0.4)
Other causes	N (%)	32(0.2)	36(0.2)	0.716	37(0.3)	31(0.2)	0.544	68(0.2)
Real study sample	N	**14691**	**14527**		**14534**	**14684**		**29218**
Did not want to participate or returned a blank questionnaire	N (%)	222(2)	177(1)	0.034	186(1)	213(2)	0.226	399(1)
Non-responders	N (%)	5039(34)	5693(39)	<0.001	6158(42)	4574(31)	<0.001	10732(37)
Responders, total	**N (%)**	**9430(64)**	**8657(60)**	**<0.001**	**8190(56)**	**9897(67)**	**<0.001**	**18087(62)**
Responders								
Responders by 1st mailed questionnaire	N (%)	5056(34)	4592(32)	<0.001	4112(28)	5536(38)	<0.001	9648(33)
Responders by 1st reminder	N (%)	2388(16)	2093(14)	<0.001	2035(14)	2446(17)	<0.001	4481(15)
Responders by 2nd reminder	N (%)	1024(7)	978(7)	0.431	1019(7)	983(7)	0.287	2002(7)
Responders by 3rd reminder	N (%)	962(7)	994(7)	0.326	1024(7)	932(6)	0.017	1956(7)

Table 2 Study sample of the study of non-response by area of domicile and sex with corresponding p-values between groups.

		Outside Gothenburg	Gothenburg	*P*-value	Men	Women	*P*-value	Total
Sample of non-responders	N	194	206		242	158		400
Agreed to participate	N (%)	110(57)	101(49)	0.134	120(50)	91(58)	0.125	211(53)
Not willing to participate	N (%)	13(7)	10(5)	0.521	14(6)	9(6)	1.000	23(6)
Missing phone number	N (%)	40(21)	71(35)	0.002	73(30)	38(24)	0.209	111(28)
Unable to get in contact with	N (%)	31(16)	24(12)	0.246	35(15)	20(13)	0.658	55(14)

and fell for each subsequent reminder. Non-response to the postal survey was more common in Gothenburg than outside of the metropolitan area (39% vs. 34%, $p < 0.001$), and for men as compared with women (42% vs. 31%, $p < 0.001$). These significant differences by location and sex were observed with both the first mailed questionnaire and first reminder. Significantly more men responded to the last questionnaire. However, when the cumulative response rate was calculated, a difference was noted for the cumulative response calculated after each mailing with fewer men and people living in Gothenburg responding (all $p < 0.001$). Of the responders, 814 (4.5%) subjects completed the questionnaire over the internet. Those who responded over the internet were more often men ($p < 0.001$) and they were younger, 36.0 (SD $\pm$ 13.5) vs 45.8 (SD $\pm$ 16.2) years old ($p < 0.001$), compared to those who answered by conventional mail.

The demographics of the NR chosen for telephone interviews are shown in Table 2. Of the 400 selected, 58.6% ($n = 234$) were successfully contacted and 52.8% ($n = 211$) agreed to participate. Among the 400 selected subjects, telephone numbers were not available for 27.8% and 13.8% appeared to have a valid phone number but did not respond to any of the five telephone contact attempts. Missing phone number was significantly more common for subjects living in Gothenburg (34.5% vs. 20.4% $p = 0.002$).

Reasons for non-response (Table 3)

Lack of time (24%) was the most commonly reported reason of non-response followed by having no memory of receiving the questionnaire (22%) and considering the study of little or no importance (21%). These results were similar for men and women. The most commonly reported reasons in the open ended response category, ''Other'' was that the questionnaire was too extensive followed by not having the energy to complete the questions and not understanding the language. Five individuals (2%) stated they did not respond because they did not have any of the symptoms asked for in the questionnaire.

Demographic data and respiratory health of non-responders vs. responders

NR were younger than responders; the mean age was 40.9 $\pm$ 15.1 vs. 45.4 $\pm$ 16.2 ($p < 0.001$). Smoking was more common in the NR group as compared to the responders, 30.3% vs. 18.6%, however this association was statistically significant only among women (Table 4). Full-time employment among those currently employed was significantly more common among the NR.

The prevalence of physician-diagnosed asthma was similar among the NR and responders, 8.1% vs. 8.3%. COPD, chronic bronchitis or emphysema tended to be more common (3.1% vs. 0.9%; $p = 0.07$) among the responders as compared with NR. No significant differences were found for any of the other health outcomes (Table 5).

When dividing NR and responders in young and old subjects, no additional differences in health outcomes were found except that wheeze was more common in the NR group among young people (23% vs. 16% $p = 0.041$). Further, current employment was more common in the NR group among the elderly (74% vs. 61% $p = 0.017$).

Early responders versus late- and non-responders

The prevalence of use of asthma medicines was highest among ER and decreased with subsequent reminders except for the last reminder, $p < 0.001$ (Fig. 1). Also the prevalence of ever having eczema ($p < 0.001$) and wheezing in the last 12 months ($p = 0.019$) decreased with increasing number of reminders. No other significant changes for other symptoms or diseases were found in relation to the time to response. The proportion of current smokers was lowest among ER (15.6%) and increased with each mailing with the proportion of smokers responding to the 3rd reminder 24.7% ($p < 0.001$). The proportion among NR was 30.3% ($p > 0.001$).

Multivariate relationships

The risk of having diseases and symptoms among non-responders compared with responders were analysed by

Table 3 Causes of non-response in the postal questionnaire survey reported by the participants in the study of non-response.

Cause of non-response		Men	Women	Total
No memory of receiving the questionnaire	N (%)	29 (24)	17 (19)	46 (22)
Moved	N (%)	3 (2)	1 (1)	4 (2)
Forgot	N (%)	10 (8)	5 (6)	15 (7)
Not important	N (%)	28 (23)	17 (19)	45 (21)
Lack of time	N (%)	24 (20)	26 (29)	50 (24)
Did mail the questionnaire	N (%)	5 (4)	3 (3)	8 (4)
Personal reasons for not wanting to	N (%)	5 (4)	2 (2)	7 (3)
Other causes	N (%)	17 (14)	19 (21)	36 (17)
Total	N (%)	121	90	211

Table 4 Prevalence (%) of demographic data in men and women among non-responders (NR) and responders (R). Difference (*p*-value) between responders and non-responders.

Demographic data	Response category	Men	*p*-value	Women	*p*-value	Total	*p*-value
Current smoker	R	17.6	0.072	19.5	<0.001	18.6	<0.001
	NR	24.0		38.9		30.3	
Ex-smoker	R	22.9	0.914	22.2	0.799	22.6	0.820
	NR	23.1		23.3		23.2	
Current working	R	70.9	0.315	66.6	0.432	68.5	0.137
	NR	75.2		71.1		73.5	
Working full time	R	76.6	<0.001	58.1	0.162	66.7	<0.001
	NR	91.3		67.2		81.4	
Sick leave from work	R	25.9	0.343	31.7	0.421	29.0	0.316
	NR	29.7		35.6		32.2	
Exposed to gas, dust or fumes	R	32.4	0.558	13.8	0.760	22.2	0.318
	NR	34.7		12.2		25.1	

multiple logistic regression controlling for age, sex and smoking habits. Response to the postal versus telephone questionnaire was included in the model as an independent variable. Being a non-responder did not significantly alter the risk for having any of the symptoms or outcome variables (Fig. 2).

Recurrent wheeze and sputum production were strongly associated with smoking (OR = 3.4 and OR = 2.4, respectively) and exposure to gas, dust or fumes at work (OR = 2.4 and OR = 1.9, respectively) when the analysis was based on all responders (Fig. 3). The associations were statistically significant even when the sample was limited to the participants who answered the first postal questionnaire. When the sample was increased to include the respondents to the subsequent reminders, the confidence intervals of the associations narrowed, but the magnitude of the odds ratios remained similar.

Table 5 Prevalence (%) of diseases, symptoms and medication in men and women among non-responders (NR) and responders (R). Difference (*p*-value) between responders and non-responders.

Diseases, medication and symptoms	Response category	Men	*p*-value	Women	*p*-value	Total	*p*-value
Physician-diagnosed asthma	R	7.4	0.862	9.1	1.000	8.3	0.986
	NR	7.4		8.9		8.1	
Ever asthma	R	8.5	0.744	10.3	0.730	9.5	0.460
	NR	9.1		11.1		10.0	
Physician diagnosed COPD, chronic Bronchitis or emphysema	R	2.5	0.375	3.6	0.384	3.1	0.071
	NR	0.8		1.1		0.9	
Use of asthma medicines	R	6.8	0.855	10.1	0.861	8.6	0.530
	NR	5.8		8.9		7.1	
Longstanding cough	R	10.2	0.449	12.4	0.749	11.4	0.521
	NR	12.4		13.3		12.8	
Sputum production	R	13.1	0.222	13.5	0.537	13.3	0.604
	NR	9.1		15.6		11.8	
Recurrent wheeze	R	6.8	0.583	6.9	1.000	6.8	0.585
	NR	5.0		6.7		5.7	
Wheezing last 12 months	R	15.3	0.375	17.6	0.266	16.6	0.192
	NR	18.2		22.2		19.9	
Rhinitis	R	23.1	0.157	24.0	0.136	23.6	0.994
	NR	17.4		31.1		23.2	
Ever eczema	R	32.7	0.241	47.3	0.916	40.7	0.140
	NR	27.3		46.7		35.5	

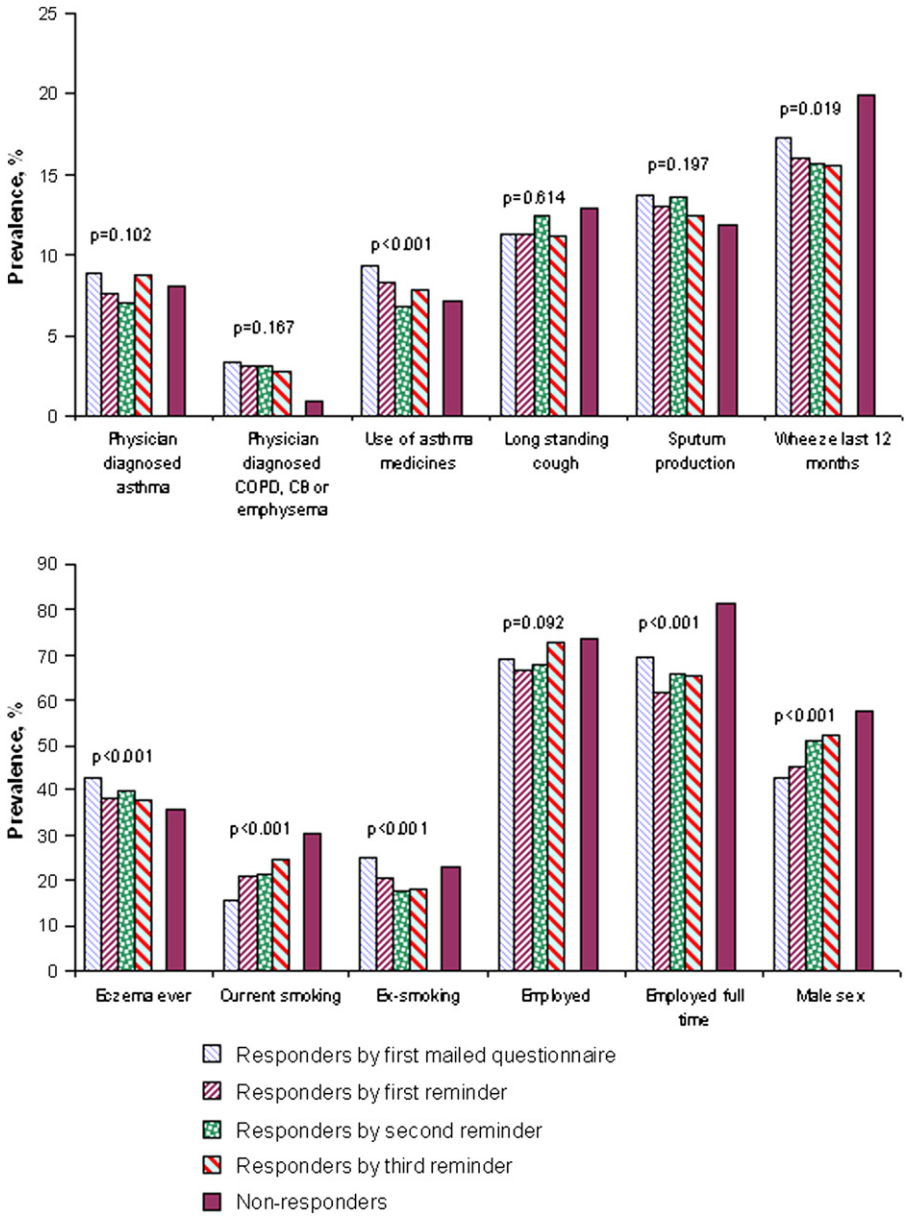

Figure 1 Prevalence of symptoms, diseases, medication and demographic variables among early responders and the three groups of late-responders. The *p*-values express Chi^2 test for trend. For each symptom and condition, the prevalence among the non-responders are included in a separate column.

Discussion

In this population based study, we found that non-responders to a postal survey were more likely to be younger, live in a metropolitan area and be male when compared with those who did respond to the postal survey. There was no difference between responders and non-responders in reported airway symptoms or in obstructive lung diseases, rhinitis and eczema. In multivariable analyses adjusting for potential confounders and covariates, the odds ratios for symptoms and diseases associated with response versus non-response generally approached to unity. The associations between smoking and exposure to gas, dust and fumes and respiratory symptoms were statistically significant when the analyses were restricted to the individuals who responded to the first postal questionnaire and the magnitude of the associations remained stable with narrowing confidence intervals when the later responders were added to the analyses.

There have been few studies published to date which have investigated the bias induced to population based postal questionnaire studies both by late and non-response. Our findings in western Sweden are in contrast to those from a similar study of non-responders in northern Sweden.[11] In that study, as compared with the responders, the non-responders reported more respiratory symptoms, physician-diagnosed asthma and use of asthma medications. Two studies from Finland observed that prevalence of symptoms and disease tended generally to be lower among the non-responders as compared to responders.[12,18] In line with our

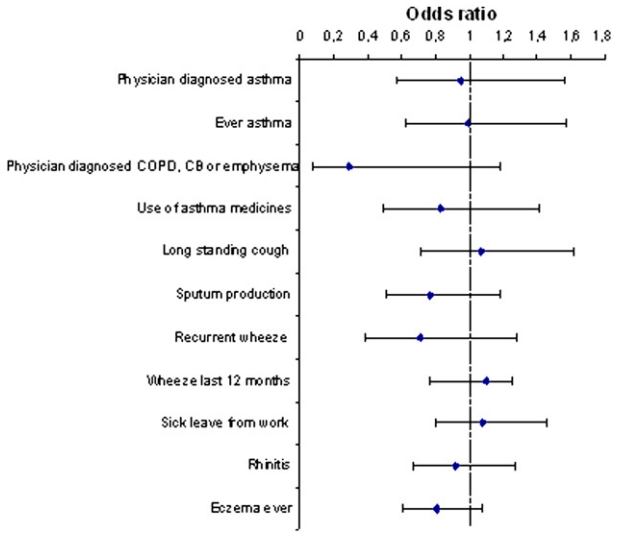

Figure 2 The risk of having symptoms, diseases, asthma medication and being on sick leave from work among non-responders compared to responders by using multiple logistic regression analysis. The independent variables used in the model were age, sex, smoking habits and non-responders/responders. The risks are expressed as Odds ratios (OR) with 95% confidence intervals.

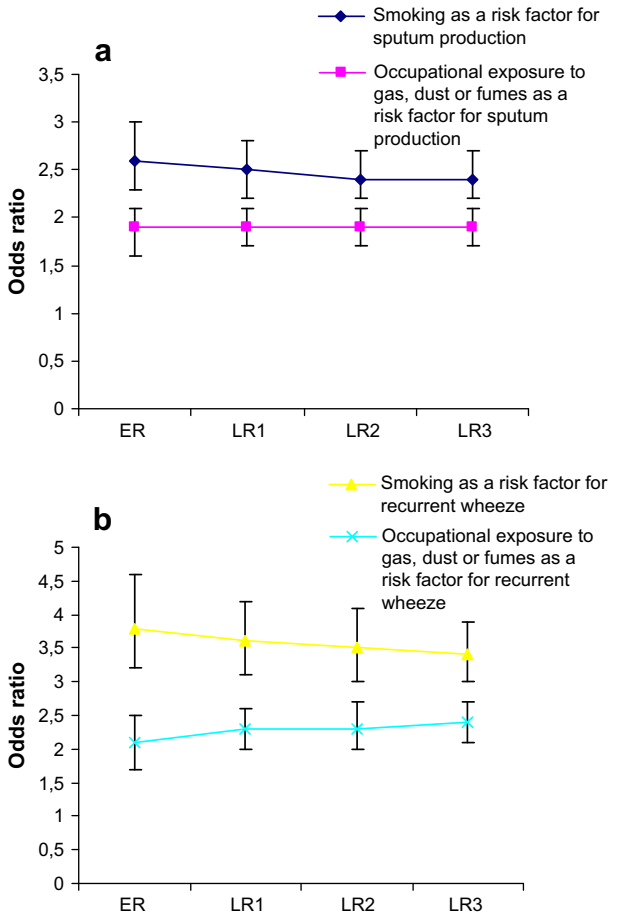

Figure 3 Current smoking and occupational exposure to gas, dust or fumes, respectively, as risk factors for sputum production (a) and recurrent wheeze (b). Risks in odds ratios (OR) with 95% confidence intervals (CI) corrected for age, sex and area of domicile by using multiple logistic regression analysis. The risk calculations are based on responders to first mailed questionnaire (ER), all responders after the first reminder (LR1), all responders after the second reminder (LR2) and all responders after the third reminder (LR3).

results, Bakke et al. found that non-responders in Bergen, Norway, predominantly lived in urban areas, were younger and of male sex.[19] Also in studies in Bergen, Brögger et al. found the proportion of smokers to be greater among non-responders,[20] while Eagan et al. examined factors for non-response in a longitudinal study and found similar results.[10]

Smoking was more common among the non-responders in our study. This finding further reinforce those from other populations[11,12] that the prevalence of smoking can be underestimated by postal surveys. Recent studies have reported a decline in the prevalence of smoking in Sweden,[21] but those studies have not accounted for non-responders. In our study, when accounting for the non-responders, the estimated population prevalence of smokers would rise from 18.6 to 22.9% assuming that the smoking prevalence among the postal non-responders that we contacted was representative of non-responders in general. However, this difference in smoking was not followed by an increase in symptoms except of wheeze among young adults. This is in contrast to studies were symptoms are linked to smoking.[22] It is possible that symptoms correlate with disease awareness, which also may lead to an increased participation rate. The association between non-responders and smoking was also investigated in Spain,[23] and smoking was more common among non-responders.

In contrast to smoking, early responders tended to have the highest prevalence of symptoms and diseases, and for every subsequent reminder there was a tendency towards lower proportions, however not significantly so for most symptoms. Our results are in keeping with those reported in a study from Italy that also found late-responders to be healthier but to smoke more than early responders.[15] However, not all studies have found late responders to be healthier than earlier responders. As in the referred study from northern Sweden on obstructive airway disease,[11] a study from Denmark[24] assessing cardiovascular health found the responders to be healthier. The discordant findings emphasize the importance of assessing the non-response bias for postal questionnaire studies which may vary for individual populations, risk exposures and disease outcomes.

Our findings further confirmed that exposure to cigarette smoke and gas, dust or fumes at work were strongly associated to airway symptoms.[6] Interestingly, the associations were evident already after the first mailed questionnaire which only had a participation rate of 33%. The subsequent reminders resulted only in small changes to the initial odds ratios but in narrowing confidence intervals consistent with the increased sample size.

From our data we can conclude that late-responders did not affect the outcome of the study. This is in disagreement with De Marco et al. who demonstrated a linear trend for response time and symptoms.[15] Further, De Marco et al. proposed a linear method for estimating the prevalence among the non-responders and then adjusting for that

group when calculating ''true'' prevalence.[25] However, in our study we would not make such assumptions because the non-responders did not differ significantly from responders with the exception of smoking habits. Does this mean that response rate does not matter? Clearly response rate is important because a low participation rate lowers the statistical power to detect differences. With a smaller sample size, the probability of type 2 error increase.

Out of the 400 non-responders randomly selected for the study, 234 subjects could be reached, and of those 90% agreed to participate. The general attitude towards this research field is positive, and once reached by telephone, a majority participated. The stated reasons for non-response to the postal survey were in two thirds of the cases attributed to lack of time, little interest in the matter or no recall of having received the questionnaire. Other studies have also found lack of interest to be a common cause for non-response.[11,12] When asking the non-responders if something could have been done to obtain their participation in the postal survey, the only suggestion that could reasonably be implemented was the use of a shorter questionnaire, similar to reports from a previous study.[26] Only three subjects stated that they did not participate because of the lack of a financial incentive. Another epidemiologic study in Sweden did use financial incentives, but their response rate was still low.[27]

A limitation of the study of non-response was that 41% could not be contacted. For successful contact in this telephone survey we required a unique name and a telephone number. Obviously those not reached could not be studied and they may differ from the standard population probably containing the most socially exposed individuals. Thus it is not possible to extrapolate the results of our study to all non-responders. A Norwegian study tried to examine this group by home visits,[19] but had a similar participation rate to our study.

Despite the large majority of the Swedish population having access to internet, only 814 subjects completed the questionnaire online. This was an important alternative for young men, a group that was underrepresented among the postal survey responders. With technological advances and the increasing commonality of use of the internet in everyday life, online surveys might become an important alternative in future. In online surveys of asthma among adolescents, the response rate has been equal for postal and internet based questionnaire response,[28] and have yielded equivalent results.[29] The low proportion of participants using internet in our study reduce the potential bias caused by questionnaires administered by different methods.

We conclude that non-responders tended to be men, young and smokers. Further, non-responders did not differ from the responders in terms of airway symptoms or diseases and do not represent a homogenous group leading to bias in risk estimates for airway diseases. This suggests that in the studied population, researchers could make reasonably accurate risk assessments for respiratory disease based on the response to the postal questionnaire.

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Conflict of interest statement

No financial or personal conflict of interest regarding these results exists for any of the authors.

Supplementary data

Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.rmed.2009.07.014.

References

1. Samet JM. Epidemiologic approaches for the identification of asthma. *Chest* 1987;**91**(6 Suppl.):74S—8S.
2. Toren K, Brisman J, Järvholm B. Asthma and asthma-like symptoms in adults assessed by questionnaires. A literature review. *Chest* 1993;**104**(2):600—8.
3. de Heer W. International response trends: results of an international survey. *J Offic Stat* 1999:13. 142 ed.
4. Hartge P. Raising response rates: getting to yes. *Epidemiology* 1999;**10**(2):105—7.
5. Gulsvik A. Prevalence of respiratory symptoms in the city of Oslo. *Scand J Respir Dis* 1979;**60**(5):275—85.
6. Lundbäck B, Nyström L, Rosenhall L, Stjernberg N. Obstructive lung disease in northern Sweden: respiratory symptoms assessed in a postal survey. *Eur Respir J* 1991;**4**(3):257—66.
7. Ekerljung L, Rönmark E, Larsson K, et al. No further increase of incidence of asthma: incidence, remission and relapse of adult asthma in Sweden. *Respir Med* 2008;**102**(12):1730—6.
8. Pallasaho P, Lindström M, Polluste J, et al. Low socio-economic status is a risk factor for respiratory symptoms: a comparison between Finland, Sweden and Estonia. *Int J Tuberc Lung Dis* 2004;**8**(11):1292—300.
9. Pallasaho P, Lundbäck B, Läspä SL, et al. Increasing prevalence of asthma but not of chronic bronchitis in Finland? Report from the FinEsS-Helsinki Study. *Respir Med* 1999;**93**(11):798—809.
10. Eagan TM, Eide GE, Gulsvik A, Bakke PS. Nonresponse in a community cohort study: predictors and consequences for exposure-disease associations. *J Clin Epidemiol* 2002;**55**(8):775—81.
11. Rönmark E, Lundqvist A, Lundbäck B, Nyström L. Non-responders to a postal questionnaire on respiratory symptoms and diseases. *Eur J Epidemiol* 1999;**15**(3):293—9.
12. Kotaniemi JT, Hassi J, Kataja M, et al. Does non-responder bias have a significant effect on the results in a postal questionnaire study? *Eur J Epidemiol* 2001;**17**(9):809—17.
13. Brögger J, Bakke P, Eide GE, Gulsvik A. Comparison of telephone and postal survey modes on respiratory symptoms and risk factors. *Am J Epidemiol* 2002;**155**(6):572—6.
14. Oftstad JAG, Austad T. *Information and approval in biomedical research*. Oslo: Norges allmenvitenskaplige forskiningsråd; 1987.

15. de Marco R, Verlato G, Zanolin E, Bugiani M, Drane JW. Nonresponse bias in EC Respiratory Health Survey in Italy. *Eur Respir J* 1994;**7**(12):2139—45.
16. Pealer LN, Weiler RM, Pigg Jr RM, Miller D, Dorman SM. The feasibility of a web-based surveillance system to collect health risk behavior data from college students. *Health Educ Behav* 2001;**28**(5):547—59.
17. Radon K, Goldberg M, Becklake M, et al. Low acceptance of an internet-based online questionnaire by young adults. *Epidemiology* 2002;**13**(6):748—9.
18. Hedman J, Kaprio J, Poussa T, Nieminen MM. Prevalence of asthma, aspirin intolerance, nasal polyposis and chronic obstructive pulmonary disease in a population-based study. *Int J Epidemiol* 1999;**28**(4):717—22.
19. Bakke P, Gulsvik A, Lilleng P, et al. Postal survey on airborne occupational exposure and respiratory disorders in Norway: causes and consequences of non-response. *J Epidemiol Community Health* 1990;**44**(4):316—20.
20. Brögger J, Bakke P, Eide GE, Gulsvik A. Contribution of follow-up of nonresponders to prevalence and risk estimates: a Norwegian respiratory health survey. *Am J Epidemiol* 2003; **157**(6):558—66.
21. Statistics Sweden, Living Conditions, Report no 114: Use of alcohol and tobacco. 2007.
22. Lindström M, Kotaniemi J, Jonsson E, Lundbäck B. Smoking, respiratory symptoms, and diseases: a comparative study between northern Sweden and northern Finland: report from the FinEsS study. *Chest* 2001;**119**(3):852—61.
23. Monso E, Munoz-Rino F, Izquierdo J, et al. Occupational asthma in the community: risk factors in a western Mediterranean population. *Arch Environ Health* 1998;**53**(2):93—8.
24. Drivsholm T, Eplov LF, Davidsen M, et al. Representativeness in population-based studies: a detailed description of non-response in a Danish cohort study. *Scand J Public Health* 2006; **34**(6):623—31.
25. Drane JW. Imputing nonresponses to mail-back questionnaires. *Am J Epidemiol* 1991;**134**(8):908—12.
26. Lund E, Gram IT. Response rate according to title and length of questionnaire. *Scand J Soc Med* 1998;**26**(2):154—60.
27. Boström M, Dellve L, Thomee S, Hagberg M. Risk factors for generally reduced productivity—a prospective cohort study of young adults with neck or upper-extremity musculoskeletal symptoms. *Scand J Work Environ Health* 2008;**34**(2): 120—32.
28. Weisel CP, Weiss SH, Tasslimi A, Alimokhtari S, Belby K. Development of a Web-based questionnaire to collect exposure and symptom data in children and adolescents with asthma. *Ann Allergy Asthma Immunol* 2008;**100**(2):112—9.
29. Raat H, Mangunkusumo RT, Mohangoo AD, Juniper EF, Van Der Lei J. Internet and written respiratory questionnaires yield equivalent results for adolescents. *Pediatr Pulmonol* 2007; **42**(4):357—61.