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Evaluation of a tobacco prevention program among teenagers

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ABSTRACT

Objective: to study the prevalence of tobacco use among teenagers, to evaluate a tobacco prevention program, and to study factors related to participation in the prevention program.

Design and setting: Population-based prospective cohort study.

Method: Within the Obstructive Lung disease in Northern Sweden (OLIN) studies, a cohort study about asthma in schoolchildren started in 2006. All children aged 7-8y in three municipalities were invited to a questionnaire survey and 2,585 (96%) participated. The cohort was followed-up at age 11-12y (n=2,612, 95% of invited), and 14-15y (n=2,345, 88% of invited). In 2010, some of the children in the OLIN cohort (n=447) were invited to a local tobacco prevention program and 224 (50%) chose to participate.

Results: At the age of 14-15y, the prevalence of daily smoking was 3.5%. Factors related to smoking were female sex, having a smoking mother, participation in sports, and lower parental socio-economic status (SES). The prevalence of using snus was 3.3% and risk factors were male sex, having a smoking mother, having a snus using father, and non-particpation in the prevention program. In the prevention program, the prevalence of tobacco use was significantly lower among the participants compared to the controls in the cohort. Factors related to non-participation were male sex, having a smoking mother, parental SES, and participation in sports.

Conclusion: The prevalence of tobacco use was lower among the participants in the tobacco prevention program compared both to the non-participants and the controls in the cohort. However, the observed benefit of the intervention may be overestimated as participation was biased by selection.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This paper present data from a prospective cohort study with high response rates and few lost to follow-up.
- A validated questionnaire about asthma and respiratory symptoms was used.
- Collaboration with a tobacco prevention program (Tobacco free duo) enabled us to combine the longitudinal data from the OLIN studies with intervention data on participation in the prevention program.
- We lack information about the level of activity in the tobacco prevention program during the follow-up time.
- Self-reported smoking was not validated by objective measures.

INTRODUCTION

Smoking is the single most important and preventable risk factor for all respiratory symptoms and a large number of diseases. Although the health consequences are well-known, smoking is still common.[1] Daily smoking is usually established during the teen years, most commonly between 14-17 years of age,[2] and rarely after the age of 24.[3] Although Sweden is often mentioned as a country with decreasing prevalence of smokers and high quit-rates among adults,[4] the decrease in smoking prevalence among teenagers has been limited.[5] Therefore, reducing smoking in teenagers is an important public health matter.

In the last decades, a wide range of prevention efforts have been carried out in order to reduce smoking among teenagers.[6-10] A key factor for successful prevention is long term collaborations between national, regional and local organisations. On the national and regional levels, smoking bans in schools,[11] and combination approaches that include policies, media campaigns and school-based programs [12] have been shown to be effective methods to decrease smoking among adolescents. However, many prevention efforts aimed at teenagers are voluntary and participation may be affected by selection bias if those with the greatest need of the intervention choose not to participate. Among adults, it is known that the prevalence of smokers is higher among non-participants in questionnaire surveys regarding respiratory conditions [13-15] and in health promotion interventions.[16] However, few studies have reported on factors related to non-participation in tobacco intervention among teenagers. One available study showed that non-participation in a family directed tobacco and alcohol prevention program was related to male sex, lower parental education and parental smoking.[17]

The aim of the present study was to determine the prevalence of tobacco use among teenagers and to evaluate the outcome of a school-based voluntary tobacco prevention program for teenagers. Further, factors related to participation in the prevention program were investigated.

METHODS

Study population

As a part of the Obstructive Lung Disease in Northern Sweden (OLIN) studies, a population-based paediatric cohort was recruited in 2006. The parents to all children in first and second grade (age 7-8 years) in three municipalities of northern Sweden: Luleå, Piteå, and Kiruna, were invited to complete a questionnaire and 2,585 participated (96% of invited).[18,19] Four years later, at the age of 11-12 years, the parents were invited to a follow-up questionnaire survey using the same methods, and 2,612 completed the questionnaire (95% of invited). At the age of 14-15 years, those who had participated in any of the previous two surveys were re-invited (n=2,657) and 2,345 participated (88.3%) (Figure 1). In this latter survey the questionnaire was completed by the teenagers. The study was approved by the Regional Ethical Review Board at Umeå University, Sweden.

The questionnaire

The questionnaire included the International Study of Asthma and Allergies in Childhood (ISAAC) core questionnaire.[20] It was expanded with additional questions about asthma and allergic diseases including physician diagnoses, symptoms, use of medicine and heredity. Other questions included possible risk factors such as living conditions, physical activity, parental smoking and socio-economic status (SES).[19] In the questionnaire completed by the teenagers at the age of 14-15 years, questions about tobacco use were added.

The tobacco prevention program

Tobacco free duo is a long-term school-based tobacco prevention programme with the aim to prevent tobacco use initiation during the teen ages.[7] At the end of sixth grade, the teenager had the possibility to team up with an adult. The pair signed a contract to stay tobacco free for the next three years. The prevention programme included information to increase knowledge and awareness on tobacco-related issues both to the teenagers and to the adults. It also included an annual assurance of fulfilment of the contract after grade seven, eight and nine, and positive reinforcements to the participants. An evaluation of Tobacco Free Duo in Västerbotten county, Sweden, showed significantly lower prevalence of smoking in the intervention schools compared to control schools.[7]

In 2010, Tobacco free duo was initiated in several municipalities in Norrbotten county, including Luleå and Kiruna; two of the OLIN study areas. The children in 13 schools in Kiruna (n=360), and four schools in Luleå (n=87) were invited to participate by signing the contract at the age of 12 years (Figure 1). A collaboration between the OLIN studies and Tobacco free duo enabled a joint database with data on participation in the prevention program and longitudinal questionnaire data from the OLIN studies.

Definitions

Participants: those who attended a school in the study area that was invited to participate in Tobacco free duo, and chose to sign the contract to participate at the age of 12 years.

Non-participants: those who attended a school in the study area that was invited to participate in Tobacco free duo, but chose not to participate.

Controls: those who attended the schools in the study area that were not invited to Tobacco free duo.

Snus: moist ground tobacco which is placed under the upper lip.

Any smoking/snus use: those reporting smoking/snus use daily, weekly, or monthly.

Classification of socio-economic status (SES) was based on parental occupation according to a system developed by Statistics Sweden. The highest level of SES of the adults in the household was chosen. The following classifications were used: 1) Professionals and executives; 2) Self-employed; 3) Intermediate non-manual employees; 4) Assistant non-manual employees; 5) Manual workers in industry; 6) Manual workers in service; 7) Unemployed, including students, unemployed, retired and housewives.

Statistical analysis

Analyses were made using the computer software IBM SPSS Statistics (Version 22.0; IBM SPSS Statistics, New York, USA). For assessment of differences between groups, $\chi 2$-tests were used and a p-value <0.05 was considered statistically significant. Dependent variables were smoking and use of snus, respectively, at the age of 15 years, and participation in the tobacco prevention program from the age of 12 years. Independent variables included sex, having smoking or snus using parents, living conditions, participation in sports, and parental socio-economic status. Significant factors identified in the bi-variate analyses were included in multivariate analysis which were performed by multiple logistic regression analysis and expressed as odds ratios (OR) with 95% confidence intervals (CI).

RESULTS

Prevalence of tobacco use at the age of 14-15 years

The prevalence of *any smoking* was 5.9% and *any snus use* was 4.7%. A report of both *any smoking* and *any snus use* was significantly more common among the boys, 3.4% compared to 1.4% among the girls (p=0.002). The prevalence of monthly smoking was 1.5%, weekly smoking was 0.9%, monthly use of snus was 0.9% and weekly snus use was 0.5%, and there were no statistically significant differences by sex.

The prevalence of daily smoking in the cohort was 3.5%, and significantly higher among the girls than among boys (Table 1). For daily snus use, the overall prevalence was 3.3%, significantly more common among boys. The prevalence of daily smoking and daily use of snus, respectively, was significantly higher among those with smoking or snus using parents, living in an apartment, living in a single parent household, not participating in sports, and among those with lower parental SES (Table 1). There were no significant differences in the prevalence of smoking or snus use related to urban or rural living, having older siblings, having a physician-diagnosed asthma or a positive skin prick test.

In a multivariate analysis, daily smoking was related to female sex, having a smoking mother, a smoking father, not participating in sports, and parental SES of *self-employed, assistant non-manual, manual worker in industry,* and *unemployed*. Daily use of snus was related to male sex, having a smoking mother, and having a father who used snus (Table 1).

Participation in the tobacco prevention program

There were no statistically significant differences in the prevalence of male sex, parental smoking, living conditions, physician-diagnosis of asthma, participation in sports or parental

SES between the sample invited to the tobacco prevention program (n=447) and the controls that were not invited (n=2165). However, among those invited to the prevention program, the prevalence of urban living (81% vs. 58% p<0.001), and having older siblings (67% vs. 62% p=0.047) were significantly higher compared to the controls. Among the 447 invited to join the prevention program, 224 (50%) chose to participate by signing a contract. Comparison of baseline characteristics between participants and non-participants in the tobacco prevention program is presented in Table 2. Comparing non-participants with participants, the prevalence of boys (59% vs. 43%), having a smoking mother (20% vs. 9%), and living in a single parent household (16% vs. 8%) was significantly higher among the non-participants, while fewer non-participants were doing sports (65% vs. 79%). Among the participants, it was more common having parental SES at the professional and assistant non-manual level, while among non-participants the intermediate non-manual and manual workers in industry and service level was more common (test-for-trend p<0.005). There were no significant differences between participants and non-participants regarding living in a house vs. living in an apartment, urban vs. rural living, having older siblings, or having a physician-diagnosed asthma.

Significant factors related to non-participation in the tobacco prevention program identified in the bi-variate analyses were included in a multivariate analysis. Non-participation was related to male sex (OR 1.8 95% 1.2-2.7), having a smoking mother (OR 2.1 95% CI 1.1-3.8) and parental SES of manual workers in service (OR 3.0 95% CI 1.3-6.7). Participation in sports was inversely related to non-participation (OR 0.6 95% CI 0.3-0.9) (Table 3).

Effect of the intervention

The prevalence of both smoking and use of snus was significantly lower among the participants in the prevention program compared to both the non-participants and the controls in the rest of the cohort (Figure 2). Of the participants in the program, only four individuals were daily smokers or snus users at the age of 14-15 years. On the school-level, there was no spill-over effect, i.e. there was no difference in tobacco use between the children at the invited schools and the control schools.

Among the controls at baseline at the age of 11-12 years, the prevalence of having a smoking mother was 14.4% and 11.4% had a smoking father. In the follow-up, the corresponding proportions were very similar: 13.4% and 12.4%. However, among the participants in the intervention, the prevalence of having a smoking mother decreased from 9.0% to 5.8% (p=0.201), while having a smoking father remained similar, 10.5% and 11.5%. However, none of these differences in prevalence were statistically significant.

Table 1. Prevalence (%) of tobacco use in relation to demographic factors, at the age of 14-15 years. Significant factors in the bivariate analyses were included in a multiple logistic regression analysis and expressed as odds ratios with 95% confidence interval.

		Smoking				Snus use			
		Bivariate analysis		Multivariate analysis		Bivariate analysis		Multivariate analysis	
		Daily smoking %	Difference p-value	OR	95% CI	Daily use of snus %	Difference p-value	OR	95% CI
Sex	Boys	2.7%		1.00		5.5%		5.72	2.76-11.85
	Girls	4.4%	0.021	1.95	1.11-3.41	1.0%	<0.001	1.00	
Tobacco intervention	Control	3.5%		1.00		3.1%		1.00	
	Participant	0.9%		0.20	0.03-1.48	0.9%		0.53	0.12-2.27
	Non-participant	4.9%	0.073	1.26	0.51-3.16	7.7%	0.023	2.14	1.05-4.37
Mother smoking	No	2.5%				2.5%			
	Yes	10.1%	<0.001	2.46	1.29-4.68	8.4%	<0.001	3.38	1.76-6.50
Father smoking	No	2.6%				3.0%			
	Yes	10.2%	<0.001	1.79	0.93-3.45	5.6%	0.023	0.76	0.34-1.66
Mother using snus	No	3.1%				2.7%			
	Yes	6.7%	0.005	1.19	0.54-2.64	8.0%	<0.001	1.72	0.85-3.48
Father using snus	No	2.5%				1.8%			
	Yes	5.8%	<0.001	1.65	0.94-2.90	6.6%	<0.001	3.20	1.81-5.64
Living conditions	House	3.1%		1.00		2.7%		1.00	
	Apartment	5.9%		0.79	0.38-1.63	6.1%		1.78	0.91-3.47
	Both	2.6%	0.026	0.75	0.21-2.71	1.7%	0.002	0.32	0.04-2.49
	Single parent household	7.4%		1.34	0.64-2.81	6.4%		1.07	0.49-2.34
	Two parent household	3,0%	<0.001	1.00		2.8%	0.001	1.00	
Participation in sports	No	7.8%		1.00		4.9%		1,00	
	Yes	1.8%	<0.001	0.30	0.17-0.52	2.7%	0.006	0.67	0.39-1.18
Parental socioeconomic status									
Professionals		0.8%		1.00		2.1%		1.00	
Self-employed		7.2%		6.07	1.70-21.72	3.2%		0.90	0.23-3.50
Intermediate non-manual		1.9%		2.22	0.68-7.25	2.8%		1.25	0.53-2.94
Assistant non-manual		3.7%		3.65	1.09-12.21	2.6%		0.75	0.24-2.37
Manual workers industry		5.6%		4.57	1.44-14.47	4.9%		1.58	0.64-3.93
Manual workers service		4.4%		3.06	0.89-10.50	5.6%		1.63	0.63-4.22
Unemployed		20.0%	<0.001	14.21	3.49-57.84	5.0%	0.005	0.80	0.14-4.60

Table 2. Baseline characteristics at the age of 11-12 years among the participants and non-participants in a tobacco prevention program.

	Participants n=224	Non-participants n=223	Difference p-value
Male sex	42.9%	59.2%	0.001
Smoking mother	9.0%	20.4%	0.001
Smoking father	10.5%	8.2%	0.412
Living conditions			
House	75.5%	69.0%	
Apartment	20.5%	25.8%	
Both	4.1%	5.2%	0.326
Urban	80.0%	78.9%	
Rural	19.5%	19.1%	0.530
Single parent household	7.6%	15.7%	0.008
Having older siblings	62.4%	70.0%	0.094
Physician-diagnosed asthma	13.5%	14.1%	0.846
Participation in sports	78.5%	65.3%	0.002
Parental socioeconomic status			
Professionals	28.0%	18.1%	
Self-employed	6.4%	6.0%	
Intermediate non-manual	28.0%	32.4%	
Assistant non-manual	15.1%	10.6%	
Manual workers industry	14.2%	16.7%	
Manual workers service	6.9%	13.4%	
Unemployed	1.4%	2.8%	0.005

Table 3. Factors related to non-participation in a tobacco prevention program, analysed by multiple logistic regression and expressed as odds ratios with 95% confidence interval.

	Non-participation	
	OR	95% CI
Male sex	1.81	1.20-2.74
Smoking mother	2.05	1.09-3.84
Single parent household	1.78	0.90-3.51
Participation in sports	0.55	0.34-0.89
Parental socioeconomic status		
Professionals	1.00	
Self-employed	1.06	0.43-2.63
Intermediate non-manual	1.56	0.90-2.71
Assistant non-manual	0.85	0.42-1.72
Manual workers industry	1.37	0.70-2.70
Manual workers service	2.98	1.32-6.74
Unemployed	2.87	0.25-33.38

DISCUSSION

In this population-based prospective study, we report a low prevalence of tobacco use among Swedish teenagers, especially among the participants in a tobacco prevention program. Further, we found that participation in the prevention program was affected by a selection bias as those in most need of smoking prevention, i.e. children having smoking parents and a lower socio-economic status, did not participate.

From the 1980s to the 2000s, smoking steadily decreased among Swedish adults,[21,22] while the prevalence of smoking initiation among teenagers remained relatively stable.[5] However, in the last decade there have been some reports of a decrease also among teenagers. In 2003, the prevalence of daily smoking at the age of 14-15 years was 5.8% and using snus 9.9% in a similar cohort in the same study area,[9] compared to 3.5% and 3.3% in the present study. Thus, both smoking and the use of snus had decreased, in accordance with recent nationwide reports among Swedish [5] and Norwegian teenagers.[23]

Despite the low prevalence of tobacco use, some teenagers were more likely to be tobacco users than others. Tobacco use was related to socio-economic factors such as parental socio-economic level, living in a single parent household, and living in an apartment, in accordance with other studies.[9,23-25] There are socio-economic inequalities in health,[26] and the fact that smoking is more common among those with lower socio-economic level contribute to these inequalities.[23,27] Other factors related to smoking were female sex, having smoking family members and not doing sports, as shown in other studies.[9,28,29]

By identification and characterisation of tobacco users but also populations at risk of becoming tobacco users, prevention efforts might be improved. Because parental tobacco use

is an important risk factor for tobacco use among teenagers,[9,28] the study design of the present prevention program (Tobacco free duo) included the partnership with a tobacco free adult. In an evaluation of Tobacco free duo in another county in Sweden, it was shown that the prevalence of smoking not only decreased among the teenagers, but also among the adult participants in the program.[30] This was seen also in our study, but the decrease was not statistically significant. Having tobacco free role models are an important aspect of tobacco prevention among teenagers.

In studies among adults, non-participation in studies about respiratory conditions is associated with higher prevalence of smoking,[13,14,31] and lower socio-economic status.[16] Further, non-participation in an alcohol use prevention study among teenagers was related to lower parental socio-economic level.[32] However, little is known about non-participation in smoking prevention programs among teenagers. In a review of the long-term effects of smoking prevention programs, the authors noted a selection bias, as most reviewed programs were based on convenience samples and not random samples.[33] This may impact the external validity of a study because the sample may not be representative of the general population. Further, it has been shown that having smoking family members decreased the efficacy of a school-based smoking prevention program.[34] Thus, involving the family in smoking prevention seems to be a good idea. However, although the prevention program in our study involved the child and an adult, and was a collaboration between schools, Norrbotten county council, and local organisations, the participation rate was low as only 50% chose to join the program. Furthermore, the prevalence of having a smoking mother was twice as high among the non-participants compared to the participants. Thus, many of those who would have benefited from the prevention efforts chose not to participate. We suggest that in order to avoid this bias and improve the efficacy of smoking prevention, an even closer

collaboration between policy makers, community, school and the family are needed. If we succeed in reaching and informing these actors, the prevention strategies may target a larger population. Further, as most of the teenagers were at a low risk of becoming smokers, the 'prevention paradox' may apply, similar to smoking cessation intervention among smokers.[35] It states that prevention strategies on the population level are more likely to reduce the smoking related health problems in the population compared to strategies on the individual level. Although strategies on the individual level may target teenagers at high risk of becoming smokers, these individuals are relatively few and only account for a minority of the overall public health burden. Prevention strategies on the population level are said to be more effective, simply because they reach a higher number of individuals. Promising prevention strategies aimed at teenagers that have been suggested include media campaigns, increasing cigarette price, and restricting access to tobacco products, but also social environment changes such as reduction of smoking among adult role models.[36]

The strengths of this study included the longitudinal study design, with the high response rates, few lost to follow up, and the use of validated questionnaires. Further, the collaboration with the prevention program Tobacco free duo enabled us to combine the longitudinal data from the OLIN studies with intervention data on participation in the prevention program. A limitation of the study included the lack of information about the level of activity in the tobacco prevention program during the follow-up time. Another limitation is that self-reported smoking was not validated by objective measures. However, others that compared self-reports of smoking with cotinine levels in saliva found good agreement.[37]

In conclusion, prevalence of tobacco use was significantly lower among the participants in the tobacco prevention program compared to the controls after three years. However, the

observed benefit of the intervention may be overestimated as the participation was related to a selection bias as those in most need of smoking prevention, i.e. children having smoking parents and a lower socio-economic status, did not participate. One way to improve the efficacy of smoking prevention efforts is to have an even closer collaboration between policy makers, community, school and the family. Developing comprehensive strategies for including more high risk children in prevention efforts at the population level will be an important measure to reduce tobacco use among teenagers.

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COMPETING INTERESTS

None of the authors have any conflicts of interests to declare.

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AUTHOR CONTRIBUTION

LH is responsible for the study design, collected the data, performed the statistical analyses, drafted and revised the manuscript and approved the final manuscript. MA and CS contributed to the analysis and interpretation of data, reviewed and revised the manuscript and approved the final manuscript. ER is responsible for study conception and design, has

contributed to the analysis and interpretation of data, reviewed and revised the manuscript and approved the final manuscript.

DATA SHARING STATEMENT

Data from this study are available through contact with the study authors.

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LEGENDS TO FIGURES

Figure 1. Flow chart of the study design and participation in a cohort study about asthma and allergic diseases, and in a tobacco prevention program.

Figure 2. Prevalence of tobacco use at the age of 14-15 years among participants and non-participants in the prevention program and among the controls in the rest of the cohort*.

*Test for trend: Participants vs. non-participants: smoking p<0.001; snus p<0.001
Participants vs. controls: smoking p=0.007; snus p=0.026
Non-participants vs. controls: smoking p=0.054; snus p=0.002

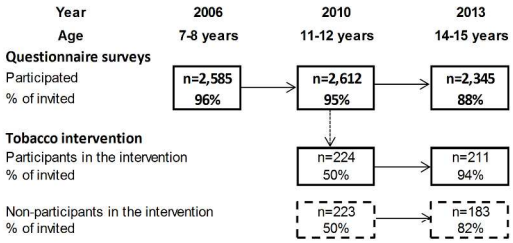

Figure 1.

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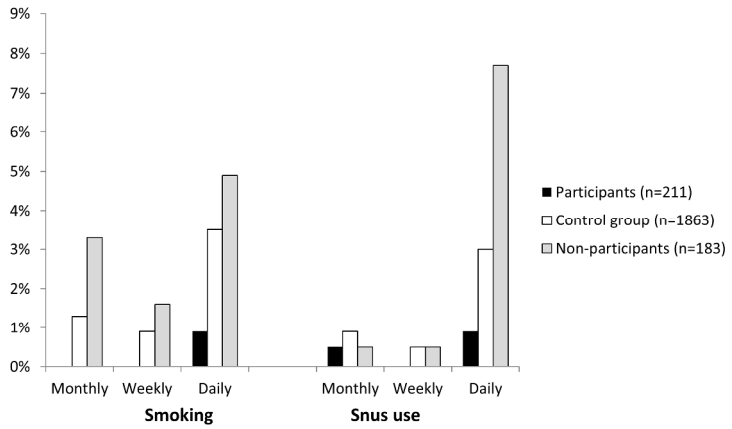

Figure 2.

254x190mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) We state in the abstract that this is a cohort study.	2
		(*b*) The abstract provides an informative summary of what was done and what we found.	2
Introduction			
Background/rationale	2	In the Introduction, we explain the scientific background and rationale for the investigation being reported	4
Objectives	3	The objective of the study is stated in the first sentence in page 5.	5
Methods			
Study design	4	The study design, study population, material and methods are presented in the abstract and early in the method section.	5-6
Setting	5	The study was performed in northern Sweden and the locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection is presented in the method section, and further clarified in a flow chart (Figure 1).	5-7
Participants	6	(*a*) The methods of recruitment and follow up is described in the method section and further clarified in Figure 1.	5-6
		(*b*) Not applicable	
Variables	7	The main outcome variables and the factors included in the analyses are defined in the section “Statistical analysis”.	7
Data sources/ measurement	8*	How the data was managed is presented in page 7.	7
Bias	9	An important finding in this study was that participation was biased by selection and this is presented and discussed throughout the paper, both in text and in tables.	
Study size	10	All children in three municipalities were invited. The inhabitants in these municipalities include 60% of the total population in the county of Norrbotten, Sweden.	
Quantitative variables	11	How the quantitative variables were handled in the analyses is presented in page 7. We performed analyses stratified by sex because there were statistically significant differences in tobacco use between boys and girls.	
Statistical methods	12	(*a*) Statistical methods are presented in page 7.	7
		(*b*) As stated in point 11, some analyses were stratified by sex. Interaction analyses were not included in the paper.	
		(*c*) Teenagers with missing answers in individual questions were excluded from the specific analyses where those questions were included.	

		(*d*) The follow-up time was three years and the number of individuals that was lost to follow-up was low. In the paper we present both data from baseline at the age of 12 years and data from the follow-up at the age of 15 years.	
		(*e*) Not applicable	
Results			
Participants	13*	(a) The number of individuals at each stage of study is presented both in the Method section, in Study population, as well as in Figure 1.	5
		(b) We do not have information on reasons for non-response. However, the participation rates have been high at each questionnaire survey.	
		(c) The study design is presented as a flow chart in figure 1.	
Descriptive data	14*	(a) Characteristics of study participants and information on exposures are presented in the Method section, in Study population, and in table 1, and table 2.	5
		(b) We considered including number of participants with missing data for each variable of interest in table 1, but it made the table too extensive.	
		(c) The follow-up time was three years, as the questionnaire surveys at each occasion were performed in January-March.	
Outcome data	15*	The prevalence of tobacco users in relation to several different background factors is presented in table 1.	
Main results	16	(*a*) Both unadjusted and adjusted estimates are presented in table 1, while unadjusted prevalence rates are presented in table 2. Multivariate analyses are presented in tables 3 (results expressed as odds ratios with 95% confidence interval).	
		(*b*) Not applicable	
		(*c*) Not applicable	
Other analyses	17	Not applicable	
Discussion			
Key results	18	Key results are summarised in the first paragraph in the discussion.	14
Limitations			
Interpretation	20	We cautiously interpret our results in relation to other studies throughout the discussion.	14-17
Generalisability	21	The external validity of the results is discussed by comparing our findings with other studies. For instance, in the discussion, page 14, third paragraph.	14
Other information			
Funding	22	The sources of funding are presented in page 17. None of the funders had any role in the analysis or writing of the current paper.	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Evaluation of a tobacco prevention program among teenagers in Sweden

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Evaluation of a tobacco prevention program among teenagers in Sweden

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ABSTRACT

Objective: to study the prevalence of tobacco use among teenagers, to evaluate a tobacco prevention program, and to study factors related to participation in the prevention program.

Design and setting: Population-based prospective cohort study.

Method: Within the Obstructive Lung disease in Northern Sweden (OLIN) studies, a cohort study about asthma in schoolchildren started in 2006. All children aged 7-8y in three municipalities were invited to a questionnaire survey and 2,585 (96%) participated. The cohort was followed-up at age 11-12y (n=2,612, 95% of invited), and 14-15y (n=2,345, 88% of invited). In 2010, some of the children in the OLIN cohort (n=447) were invited to a local tobacco prevention program and 224 (50%) chose to participate.

Results: At the age of 14-15y, the prevalence of daily smoking was 3.5%. Factors related to smoking were female sex, having a smoking mother, participation in sports, and lower parental socio-economic status (SES). The prevalence of using snus was 3.3% and risk factors were male sex, having a smoking mother, having a snus using father, and non-particpation in the prevention program. In the prevention program, the prevalence of tobacco use was significantly lower among the participants compared to the controls in the cohort. Factors related to non-participation were male sex, having a smoking mother, lower parental SES, and participation in sports.

Conclusion: The prevalence of tobacco use was lower among the participants in the tobacco prevention program compared both to the non-participants and the controls in the cohort. However, the observed benefit of the intervention may be overestimated as participation was biased by selection.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This paper present data from a prospective cohort study with high response rates and few lost to follow-up.
- A validated questionnaire about asthma and respiratory symptoms was used.
- Collaboration with a tobacco prevention program (Tobacco free duo) enabled us to combine the longitudinal data from the OLIN studies with intervention data on participation in the prevention program.
- We lack information about the level of activity in the tobacco prevention program during the follow-up time.
- Self-reported smoking was not validated by objective measures.

INTRODUCTION

Smoking is the single most important and preventable risk factor for all respiratory symptoms and a large number of diseases. Although the health consequences are well-known, smoking is still common.[1] Daily smoking is usually established during the teen years, most commonly between 14-17 years of age,[2] and rarely after the age of 24.[3] Although Sweden is often mentioned as a country with decreasing prevalence of smokers and high quit-rates among adults,[4] the decrease in smoking prevalence among teenagers has been limited.[5] Therefore, reducing smoking in teenagers is an important public health matter.

In the last decades, a wide range of prevention efforts have been carried out in order to reduce smoking among teenagers.[6-10] A key factor for successful prevention is long term collaborations between national, regional and local organisations. On the national and regional levels, smoking bans in schools,[11] and combination approaches that include policies, media campaigns and school-based programs [12] have been shown to be effective methods to decrease smoking among adolescents. However, many prevention efforts aimed at teenagers are voluntary and participation may be affected by selection bias if those with the greatest need of the intervention choose not to participate. Among adults, it is known that the prevalence of smokers is higher among non-participants in questionnaire surveys regarding respiratory conditions [13-15] and in health promotion interventions.[16] However, few studies have reported on factors related to non-participation in tobacco intervention among teenagers. One available study showed that non-participation in a family directed tobacco and alcohol prevention program was related to male sex, lower parental education and parental smoking.[17]

The aim of the present study was to determine the prevalence of tobacco use among teenagers and to evaluate the outcome of a school-based voluntary tobacco prevention program for teenagers. Further, factors related to participation in the prevention program were investigated.

METHODS

Study population

As a part of the Obstructive Lung Disease in Northern Sweden (OLIN) studies, a population-based paediatric cohort was recruited in 2006. The parents to all children in first and second grade (age 7-8 years) in three municipalities of northern Sweden: Luleå, Piteå, and Kiruna, were invited to complete a questionnaire and 2,585 participated (96% of invited).[18,19] Four years later, at the age of 11-12 years, the parents were invited to a follow-up questionnaire survey using the same methods, and 2,612 completed the questionnaire (95% of invited). At the age of 14-15 years, those who had participated in any of the previous two surveys were re-invited (n=2,657) and 2,345 participated (88.3%) (Figure 1). In this latter survey the questionnaire was completed by the teenagers. The study was approved by the Regional Ethical Review Board at Umeå University, Sweden.

The questionnaire

The questionnaire included the International Study of Asthma and Allergies in Childhood (ISAAC) core questionnaire.[20] It was expanded with additional questions about asthma and allergic diseases including physician diagnoses, symptoms, use of medicine and heredity. Other questions included possible risk factors such as living conditions, physical activity, parental smoking and socio-economic status (SES).[19] In the questionnaire completed by the teenagers at the age of 14-15 years, questions about tobacco use were added.

The tobacco prevention program

Tobacco free duo is a long-term school-based tobacco prevention programme with the aim to prevent tobacco use initiation during the teen ages.[7] At the end of sixth grade, the teenager had the possibility to team up with an adult. The pair signed a contract to stay tobacco free for the next three years. The prevention programme included information to increase knowledge and awareness on tobacco-related issues both to the teenagers and to the adults. It also included an annual assurance of fulfilment of the contract after grade seven, eight and nine, and positive reinforcements to the participants. An evaluation of Tobacco Free Duo in Västerbotten county, Sweden, showed significantly lower prevalence of smoking in the intervention schools compared to control schools.[7]

In 2010, Tobacco free duo was initiated in several municipalities in Norrbotten county, including Luleå and Kiruna; two of the OLIN study areas. It was up to the schools to decide whether they wanted to participate in the prevention program. The children in 13 schools in Kiruna (n=360), and four schools in Luleå (n=87) were invited to participate by signing the contract at the age of 12 years (Figure 1). A collaboration between the OLIN studies and Tobacco free duo enabled a joint database with data on participation in the prevention program and longitudinal questionnaire data from the OLIN studies.

Definitions

Participants: those who attended a school in the study area that was invited to participate in Tobacco free duo, and chose to sign the contract to participate at the age of 12 years.

Non-participants: those who attended a school in the study area that was invited to participate in Tobacco free duo, but chose not to participate.

Controls: those who attended the schools in the study area that were not invited to Tobacco free duo.

Snus: moist ground tobacco which is placed under the upper lip.

Any smoking/snus use: those reporting smoking/snus use daily, weekly, or monthly.

Classification of socio-economic status (SES) was based on parental occupation according to a system developed by Statistics Sweden.[21] The highest level of SES of the adults in the household was chosen. The following classifications were used: 1) Professionals and executives; 2) Self-employed; 3) Intermediate non-manual employees; 4) Assistant non-manual employees; 5) Manual workers in industry; 6) Manual workers in service; 7) Unemployed, including students, unemployed, retired and housewives.

Statistical analysis

Analyses were made using the computer software IBM SPSS Statistics (Version 22.0; IBM SPSS Statistics, New York, USA). For assessment of differences between groups, $\chi 2$-tests were used and a p-value <0.05 was considered statistically significant. Dependent variables were smoking and use of snus, respectively, at the age of 15 years, and participation in the tobacco prevention program from the age of 12 years. Independent variables included sex, having smoking or snus using parents, living conditions, participation in sports, and parental socio-economic status. Significant and borderline significant factors identified in the bi-variate analyses were included in multivariate analysis which were performed by multiple logistic regression analysis and expressed as odds ratios (OR) with 95% confidence intervals (CI).

RESULTS

Prevalence of tobacco use at the age of 14-15 years

The prevalence of *any smoking* was 5.9%, with no statistically difference by sex. *Any snus use* was 4.7%, and significantly more common among boys than girls (7.2% and 1.9% p<0.001). The prevalence of monthly smoking was 1.5%, weekly smoking was 0.9%, monthly use of snus was 0.9% and weekly snus use was 0.5%.

The prevalence of daily smoking in the cohort was 3.5%, and significantly higher among the girls than among boys (Table 1). For daily snus use, the overall prevalence was 3.3%, significantly more common among boys. Both the prevalence of daily smoking and the use of snus were significantly lower compared to the prevalence in a similar cohort, surveyed ten years previously in the same study area. At that survey the prevalence of daily smoking was 5.8% and using snus 9.9%.[9] In the present study, the prevalence of daily smoking and daily use of snus, respectively, was significantly higher among those with smoking or snus using parents, living in an apartment, living in a single parent household, not participating in sports, and among those with lower parental SES (Table 1). There were no significant differences in the prevalence of smoking or snus use related to urban or rural living, having older siblings, having a physician-diagnosed asthma or a positive skin prick test.

In a multivariate analysis, daily smoking was related to female sex, having a smoking mother, a smoking father, not participating in sports, and parental SES of *self-employed, assistant non-manual, manual worker in industry,* and *unemployed*. Daily use of snus was related to male sex, having a smoking mother, and having a father who used snus (Table 1).

Participation in the tobacco prevention program

The children in the participating schools (n=447) were compared to children in non-participating schools (n=2165). There were no statistically significant differences in the prevalence of male sex, parental smoking, living conditions, physician-diagnosis of asthma, participation in sports or parental SES between the sample invited to the tobacco prevention program and the controls that were not invited. However, among those invited to the prevention program, the prevalence of urban living (81% vs. 58% p<0.001), and having older siblings (67% vs. 62% p=0.047) were significantly higher compared to the controls. Among the 447 invited to join the prevention program, 224 (50%) chose to participate by signing a contract. Comparison of baseline characteristics between participants and non-participants in the tobacco prevention program is presented in Table 2. Comparing non-participants with participants, the prevalence of boys (59% vs. 43%), having a smoking mother (20% vs. 9%), and living in a single parent household (16% vs. 8%) was significantly higher among the non-participants, while fewer non-participants were doing sports (65% vs. 79%). Among the participants, it was more common having parental SES at the professional and assistant non-manual level, while among non-participants the intermediate non-manual and manual workers in industry and service level was more common (test-for-trend p<0.005). There were no significant differences between participants and non-participants regarding living in a house vs. living in an apartment, urban vs. rural living, having older siblings, or having a physician-diagnosed asthma.

Significant factors related to non-participation in the tobacco prevention program identified in the bi-variate analyses were included in a multivariate analysis. Non-participation was related to male sex (OR 1.8 95% 1.2-2.7), having a smoking mother (OR 2.1 95% CI 1.1-3.8) and

parental SES of manual workers in service (OR 3.0 95% CI 1.3-6.7). Participation in sports was inversely related to non-participation (OR 0.6 95% CI 0.3-0.9) (Table 3).

Effect of the intervention

The prevalence of both smoking and use of snus was significantly lower among the participants in the prevention program compared to both the non-participants and the controls in the rest of the cohort (Figure 2). Of the participants in the program, only four individuals were daily smokers or snus users at the age of 14-15 years. On the school-level, there was no spill-over effect, i.e. there was no difference in tobacco use between the children at the invited schools and the control schools.

Among the controls at baseline at the age of 11-12 years, the prevalence of having a smoking mother was 14.4% and 11.4% had a smoking father. In the follow-up, the corresponding proportions were very similar: 13.4% and 12.4%. However, among the participants in the intervention, the prevalence of having a smoking mother decreased from 9.0% to 5.8% (p=0.201), while having a smoking father remained similar, 10.5% and 11.5%. However, none of these differences in prevalence were statistically significant.

Table 1. Prevalence (%) of tobacco use in relation to demographic factors, at the age of 14-15 years. Significant factors in the bivariate analyses were included in a multiple logistic regression analysis and expressed as odds ratios with 95% confidence interval.

		Smoking				Snus use			
		Bivariate analysis		Multivariate analysis		Bivariate analysis		Multivariate analysis	
		Daily smoking %	Difference p-value	OR	95% CI	Daily use of snus %	Difference p-value	OR	95% CI
Sex	Boys	2.7%		1.00		5.5%		5.72	2.76-11.85
	Girls	4.4%	0.021	1.95	1.11-3.41	1.0%	<0.001	1.00	
Tobacco intervention	Control	3.5%		1.00		3.1%		1.00	
	Participant	0.9%		0.20	0.03-1.48	0.9%		0.53	0.12-2.27
	Non-participant	4.9%	0.073	1.26	0.51-3.16	7.7%	0.023	2.14	1.05-4.37
Mother smoking	No	2.5%				2.5%			
	Yes	10.1%	<0.001	2.46	1.29-4.68	8.4%	<0.001	3.38	1.76-6.50
Father smoking	No	2.6%				3.0%			
	Yes	10.2%	<0.001	1.79	0.93-3.45	5.6%	0.023	0.76	0.34-1.66
Mother using snus	No	3.1%				2.7%			
	Yes	6.7%	0.005	1.19	0.54-2.64	8.0%	<0.001	1.72	0.85-3.48
Father using snus	No	2.5%				1.8%			
	Yes	5.8%	<0.001	1.65	0.94-2.90	6.6%	<0.001	3.20	1.81-5.64
Living conditions	House	3.1%		1.00		2.7%		1.00	
	Apartment	5.9%		0.79	0.38-1.63	6.1%		1.78	0.91-3.47
	Both	2.6%	0.026	0.75	0.21-2.71	1.7%	0.002	0.32	0.04-2.49
	Single parent household	7.4%		1.34	0.64-2.81	6.4%		1.07	0.49-2.34
	Two parent household	3,0%	<0.001	1.00		2.8%	0.001	1.00	
Participation in sports	No	7.8%		1.00		4.9%		1,00	
	Yes	1.8%	<0.001	0.30	0.17-0.52	2.7%	0.006	0.67	0.39-1.18
Parental socioeconomic status									
Professionals		0.8%		1.00		2.1%		1.00	
Self-employed		7.2%		6.07	1.70-21.72	3.2%		0.90	0.23-3.50
Intermediate non-manual		1.9%		2.22	0.68-7.25	2.8%		1.25	0.53-2.94
Assistant non-manual		3.7%		3.65	1.09-12.21	2.6%		0.75	0.24-2.37
Manual workers industry		5.6%		4.57	1.44-14.47	4.9%		1.58	0.64-3.93
Manual workers service		4.4%		3.06	0.89-10.50	5.6%		1.63	0.63-4.22
Unemployed		20.0%	<0.001	14.21	3.49-57.84	5.0%	0.005	0.80	0.14-4.60

Table 2. Baseline characteristics at the age of 11-12 years among the participants and non-participants in a tobacco prevention program.

	Participants n=224	Non-participants n=223	Difference p-value
Male sex	42.9%	59.2%	0.001
Smoking mother	9.0%	20.4%	0.001
Smoking father	10.5%	8.2%	0.412
Living conditions			
House	75.5%	69.0%	
Apartment	20.5%	25.8%	
Both	4.1%	5.2%	0.326
Urban	80.0%	78.9%	
Rural	19.5%	19.1%	0.530
Single parent household	7.6%	15.7%	0.008
Having older siblings	62.4%	70.0%	0.094
Physician-diagnosed asthma	13.5%	14.1%	0.846
Participation in sports	78.5%	65.3%	0.002
Parental socioeconomic status			
Professionals	28.0%	18.1%	
Self-employed	6.4%	6.0%	
Intermediate non-manual	28.0%	32.4%	
Assistant non-manual	15.1%	10.6%	
Manual workers industry	14.2%	16.7%	
Manual workers service	6.9%	13.4%	
Unemployed	1.4%	2.8%	0.005

Table 3. Factors related to non-participation in a tobacco prevention program, analysed by multiple logistic regression and expressed as odds ratios with 95% confidence interval.

	Non-participation	
	OR	95% CI
Male sex	1.81	1.20-2.74
Smoking mother	2.05	1.09-3.84
Single parent household	1.78	0.90-3.51
Participation in sports	0.55	0.34-0.89
Parental socioeconomic status		
Professionals	1.00	
Self-employed	1.06	0.43-2.63
Intermediate non-manual	1.56	0.90-2.71
Assistant non-manual	0.85	0.42-1.72
Manual workers industry	1.37	0.70-2.70
Manual workers service	2.98	1.32-6.74
Unemployed	2.87	0.25-33.38

DISCUSSION

In this population-based prospective study, we report a low prevalence of tobacco use among Swedish teenagers, especially among the participants in a tobacco prevention program. Further, we found that participation in the prevention program was affected by a selection bias as those in most need of smoking prevention, i.e. children having smoking parents and a lower socio-economic status, did not participate.

From the 1980s to the 2000s, smoking steadily decreased among Swedish adults,[22,23] while the prevalence of smoking initiation among teenagers remained relatively stable.[5] However, in the last decade there have been some reports of a decrease also among teenagers. In 2003, the prevalence of daily smoking at the age of 14-15 years was 5.8% and using snus 9.9% in a similar cohort in the same study area,[9] compared to 3.5% and 3.3% in the present study. Thus, both smoking and the use of snus had decreased, a positive result in accordance with recent nationwide reports among Swedish [5] and Norwegian teenagers.[24]

Despite the low prevalence of tobacco use, some teenagers were more likely to be tobacco users than others. Smoking was related to socio-economic factors such as parental socio-economic level, living in a single parent household, and living in an apartment, in accordance with other studies.[9,24-26] There are socio-economic inequalities in health,[27] and the fact that smoking is more common among those with lower socio-economic level contribute to these inequalities.[24,28] Other factors related to smoking were female sex, having smoking family members and not doing sports, as shown in other studies.[9,29,30] Few studies have reported on factors related to snus use among teenagers.[9] Similar to other studies,[29] the risk factors for using snus were male sex and parental tobacco use. Additionally, we found a significant association between snus use and parental SES of manual workers in industry and

in service. However, in the multivariate analysis, this association lost significance. It has been shown that lower educational level and income was related to snus use among adults in Sweden.[31]

By identification and characterisation of tobacco users but also populations at risk of becoming tobacco users, prevention efforts might be improved. Because parental tobacco use is an important risk factor for tobacco use among teenagers,[9,29] the study design of the present prevention program (Tobacco free duo) included the partnership with a tobacco free adult. In an evaluation of Tobacco free duo in another county in Sweden, it was shown that the prevalence of smoking not only decreased among the teenagers, but also among the adult participants in the program.[32] This was seen also in our study, but the decrease was not statistically significant. Having tobacco free role models are an important aspect of tobacco prevention among teenagers.

In studies among adults, non-participation in studies about respiratory conditions is associated with higher prevalence of smoking,[13,14,33] and lower socio-economic status.[16] Further, non-participation in an alcohol use prevention study among teenagers was related to lower parental socio-economic level.[34] However, little is known about non-participation in smoking prevention programs among teenagers. In a review of the long-term effects of smoking prevention programs, the authors noted a selection bias, as most reviewed programs were based on convenience samples and not random samples.[35] This may impact the external validity of a study because the sample may not be representative of the general population. Further, it has been shown that having smoking family members decreased the efficacy of a school-based smoking prevention program.[36] Thus, involving the family in smoking prevention seems to be a good idea. However, although the prevention program in

our study involved the child and an adult, and was a collaboration between schools, Norrbotten county council, and local organisations, the participation rate was low as only 50% chose to join the program. Furthermore, the prevalence of having a smoking mother was twice as high among the non-participants compared to the participants. Thus, many of those who would have benefited from the prevention efforts chose not to participate. Another factor related to non-participation was parental SES of manual workers in service. One explanation for this finding may be that both manual workers in service as well as smoking is more common among women, in this case the mothers, and both these factors were related to non-participation.

We suggest that in order to avoid this bias and improve the efficacy of smoking prevention, an even closer collaboration between policy makers, community, school and the family are needed. If we succeed in reaching and informing these actors, the prevention strategies may target a larger population. Further, as most of the teenagers were at a low risk of becoming smokers, the 'prevention paradox' may apply, similar to smoking cessation intervention among smokers.[37] It states that prevention strategies on the population level are more likely to reduce the smoking related health problems in the population compared to strategies on the individual level. Although strategies on the individual level may target teenagers at high risk of becoming smokers, these individuals are relatively few and only account for a minority of the overall public health burden. Prevention strategies on the population level are said to be more effective, simply because they reach a higher number of individuals. Promising prevention strategies aimed at teenagers that have been suggested include media campaigns, increasing cigarette price, and restricting access to tobacco products, but also social environment changes such as reduction of smoking among adult role models.[38]

The strengths of this study included the longitudinal study design, with the high response rates, few lost to follow up, and the use of validated questionnaires. Further, the collaboration with the prevention program Tobacco free duo enabled us to combine the longitudinal data from the OLIN studies with intervention data on participation in the prevention program. A limitation of the study included the lack of information about the level of activity in the tobacco prevention program during the follow-up time. Another limitation is that self-reported smoking was not validated by objective measures. However, others that compared self-reports of smoking with cotinine levels in saliva found good agreement.[39]

In conclusion, prevalence of tobacco use was significantly lower among the participants in the tobacco prevention program compared to the controls after three years. However, the observed benefit of the intervention may be overestimated as the participation was related to a selection bias as those in most need of smoking prevention, i.e. children having smoking parents and a lower socio-economic status, did not participate. One way to improve the efficacy of smoking prevention efforts is to have an even closer collaboration between policy makers, community, school and the family. Developing comprehensive strategies for including more high risk children in prevention efforts at the population level will be an important measure to reduce tobacco use among teenagers.

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COMPETING INTERESTS

None of the authors have any conflicts of interests to declare.

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AUTHOR CONTRIBUTION

LH is responsible for the study design, collected the data, performed the statistical analyses, drafted and revised the manuscript and approved the final manuscript. MA and CS contributed to the analysis and interpretation of data, reviewed and revised the manuscript and approved the final manuscript. ER is responsible for study conception and design, has contributed to the analysis and interpretation of data, reviewed and revised the manuscript and approved the final manuscript.

DATA SHARING STATEMENT

No additional data available.

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LEGENDS TO FIGURES

Figure 1. Flow chart of the study design and participation in a cohort study about asthma and allergic diseases, and in a tobacco prevention program.

Figure 2. Prevalence of tobacco use at the age of 14-15 years among participants and non-participants in the prevention program and among the controls in the rest of the cohort*.

*Test for trend: Participants vs. non-participants: smoking p<0.001; snus p<0.001
Participants vs. controls: smoking p=0.007; snus p=0.026
Non-participants vs. controls: smoking p=0.054; snus p=0.002

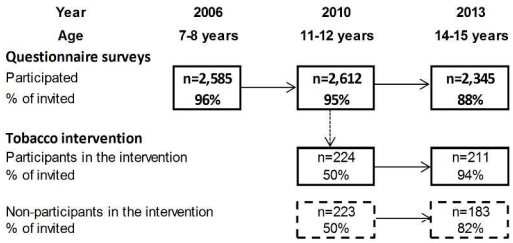

Figure 1.

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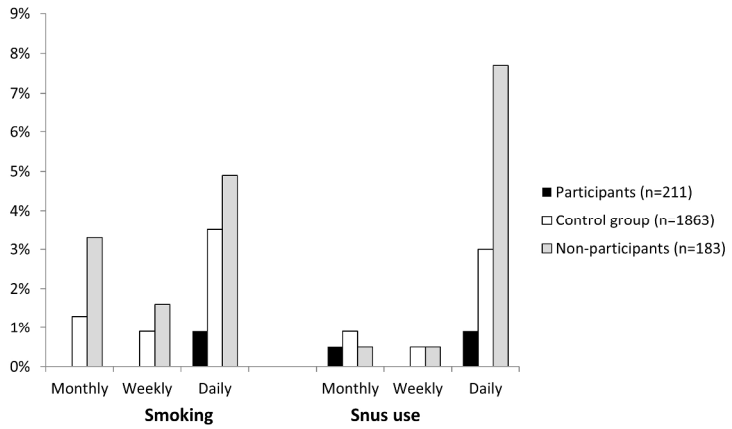

Figure 2.

254x190mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) We state in the abstract that this is a cohort study.	2
		(*b*) The abstract provides an informative summary of what was done and what we found.	2
Introduction			
Background/rationale	2	In the Introduction, we explain the scientific background and rationale for the investigation being reported	4
Objectives	3	The objective of the study is stated in the first sentence in page 5.	5
Methods			
Study design	4	The study design, study population, material and methods are presented in the abstract and early in the method section.	5-6
Setting	5	The study was performed in northern Sweden and the locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection is presented in the method section, and further clarified in a flow chart (Figure 1).	5-7
Participants	6	(*a*) The methods of recruitment and follow up is described in the method section and further clarified in Figure 1.	5-6
		(*b*) Not applicable	
Variables	7	The main outcome variables and the factors included in the analyses are defined in the section “Statistical analysis”.	7
Data sources/ measurement	8*	How the data was managed is presented in page 7.	7
Bias	9	An important finding in this study was that participation was biased by selection and this is presented and discussed throughout the paper, both in text and in tables.	
Study size	10	All children in three municipalities were invited. The inhabitants in these municipalities include 60% of the total population in the county of Norrbotten, Sweden.	
Quantitative variables	11	How the quantitative variables were handled in the analyses is presented in page 7. We performed analyses stratified by sex because there were statistically significant differences in tobacco use between boys and girls.	
Statistical methods	12	(*a*) Statistical methods are presented in page 7.	7
		(*b*) As stated in point 11, some analyses were stratified by sex. Interaction analyses were not included in the paper.	
		(*c*) Teenagers with missing answers in individual questions were excluded from the specific analyses where those questions were included.	

		(*d*) The follow-up time was three years and the number of individuals that was lost to follow-up was low. In the paper we present both data from baseline at the age of 12 years and data from the follow-up at the age of 15 years.	
		(*e*) Not applicable	
Results			
Participants	13*	(a) The number of individuals at each stage of study is presented both in the Method section, in Study population, as well as in Figure 1.	5
		(b) We do not have information on reasons for non-response. However, the participation rates have been high at each questionnaire survey.	
		(c) The study design is presented as a flow chart in figure 1.	
Descriptive data	14*	(a) Characteristics of study participants and information on exposures are presented in the Method section, in Study population, and in table 1, and table 2.	5
		(b) We considered including number of participants with missing data for each variable of interest in table 1, but it made the table too extensive.	
		(c) The follow-up time was three years, as the questionnaire surveys at each occasion were performed in January-March.	
Outcome data	15*	The prevalence of tobacco users in relation to several different background factors is presented in table 1.	
Main results	16	(*a*) Both unadjusted and adjusted estimates are presented in table 1, while unadjusted prevalence rates are presented in table 2. Multivariate analyses are presented in tables 3 (results expressed as odds ratios with 95% confidence interval).	
		(*b*) Not applicable	
		(*c*) Not applicable	
Other analyses	17	Not applicable	
Discussion			
Key results	18	Key results are summarised in the first paragraph in the discussion.	14
Limitations			
Interpretation	20	We cautiously interpret our results in relation to other studies throughout the discussion.	14-17
Generalisability	21	The external validity of the results is discussed by comparing our findings with other studies. For instance, in the discussion, page 14, third paragraph.	14
Other information			
Funding	22	The sources of funding are presented in page 17. None of the funders had any role in the analysis or writing of the current paper.	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Evaluation of a tobacco prevention program among teenagers in Sweden

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Evaluation of a tobacco prevention program among teenagers in Sweden

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ABSTRACT

Objective: to study the prevalence of tobacco use among teenagers, to evaluate a tobacco prevention program, and to study factors related to participation in the prevention program.

Design and setting: Population-based prospective cohort study.

Method: Within the Obstructive Lung disease in Northern Sweden (OLIN) studies, a cohort study about asthma in schoolchildren started in 2006. All children aged 7-8y in three municipalities were invited to a questionnaire survey and 2,585 (96%) participated. The cohort was followed-up at age 11-12y (n=2,612, 95% of invited), and 14-15y (n=2,345, 88% of invited). In 2010, some of the children in the OLIN cohort (n=447) were invited to a local tobacco prevention program and 224 (50%) chose to participate.

Results: At the age of 14-15y, the prevalence of daily smoking was 3.5%. Factors related to smoking were female sex, having a smoking mother, participation in sports, and lower parental socio-economic status (SES). The prevalence of using snus was 3.3% and risk factors were male sex, having a smoking mother, having a snus using father, and non-particpation in the prevention program. In the prevention program, the prevalence of tobacco use was significantly lower among the participants compared to the controls in the cohort. Factors related to non-participation were male sex, having a smoking mother, lower parental SES, and participation in sports.

Conclusion: The prevalence of tobacco use was lower among the participants in the tobacco prevention program compared both to the non-participants and the controls in the cohort. However, the observed benefit of the intervention may be overestimated as participation was biased by selection.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This paper present data from a prospective cohort study with high response rates and few lost to follow-up.
- A validated questionnaire about asthma and respiratory symptoms was used.
- Collaboration with a tobacco prevention program (Tobacco free duo) enabled us to combine the longitudinal data from the OLIN studies with intervention data on participation in the prevention program.
- We lack information about the level of activity in the tobacco prevention program during the follow-up time.
- Self-reported smoking was not validated by objective measures.

INTRODUCTION

Smoking is the single most important and preventable risk factor for all respiratory symptoms and a large number of diseases. Although the health consequences are well-known, smoking is still common.[1] Daily smoking is usually established during the teen years, most commonly between 14-17 years of age,[2] and rarely after the age of 24.[3] Although Sweden is often mentioned as a country with decreasing prevalence of smokers and high quit-rates among adults,[4] the decrease in smoking prevalence among teenagers has been limited.[5] Therefore, reducing smoking in teenagers is an important public health matter.

In the last decades, a wide range of prevention efforts have been carried out in order to reduce smoking among teenagers.[6-10] A key factor for successful prevention is long term collaborations between national, regional and local organisations. On the national and regional levels, smoking bans in schools,[11] and combination approaches that include policies, media campaigns and school-based programs [12] have been shown to be effective methods to decrease smoking among adolescents. However, many prevention efforts aimed at teenagers are voluntary and participation may be affected by selection bias if those with the greatest need of the intervention choose not to participate. Among adults, it is known that the prevalence of smokers is higher among non-participants in questionnaire surveys regarding respiratory conditions [13-15] and in health promotion interventions.[16] However, few studies have reported on factors related to non-participation in tobacco intervention among teenagers. One available study showed that non-participation in a family directed tobacco and alcohol prevention program was related to male sex, lower parental education and parental smoking.[17]

The aim of the present study was to determine the prevalence of tobacco use among teenagers and to evaluate the outcome of a school-based voluntary tobacco prevention program for teenagers. Further, factors related to participation in the prevention program were investigated.

METHODS

Study population

As a part of the Obstructive Lung Disease in Northern Sweden (OLIN) studies, a population-based paediatric cohort was recruited in 2006. The parents to all children in first and second grade (age 7-8 years) in three municipalities of northern Sweden: Luleå, Piteå, and Kiruna, were invited to complete a questionnaire and 2,585 participated (96% of invited).[18,19] Four years later, at the age of 11-12 years, the parents were invited to a follow-up questionnaire survey using the same methods, and 2,612 completed the questionnaire (95% of invited). At the age of 14-15 years, those who had participated in any of the previous two surveys were re-invited (n=2,657) and 2,345 participated (88.3%) (Figure 1). In this latter survey the questionnaire was completed by the teenagers. The study was approved by the Regional Ethical Review Board at Umeå University, Sweden.

The questionnaire

The questionnaire included the International Study of Asthma and Allergies in Childhood (ISAAC) core questionnaire.[20] It was expanded with additional questions about asthma and allergic diseases including physician diagnoses, symptoms, use of medicine and heredity. Other questions included possible risk factors such as living conditions, physical activity, parental smoking and socio-economic status (SES).[19] In the questionnaire completed by the teenagers at the age of 14-15 years, questions about tobacco use were added.

The tobacco prevention program

Tobacco free duo is a long-term school-based tobacco prevention programme with the aim to prevent tobacco use initiation during the teen ages.[7] At the end of sixth grade, the teenager had the possibility to team up with an adult. The pair signed a contract to stay tobacco free for the next three years. The prevention programme included information to increase knowledge and awareness on tobacco-related issues both to the teenagers and to the adults. It also included an annual assurance of fulfilment of the contract after grade seven, eight and nine, and positive reinforcements to the participants. An evaluation of Tobacco Free Duo in Västerbotten county, Sweden, showed significantly lower prevalence of smoking in the intervention schools compared to control schools.[7]

In 2010, Tobacco free duo was initiated in several municipalities in Norrbotten county, including Luleå and Kiruna; two of the OLIN study areas. It was up to the schools to decide whether they wanted to participate in the prevention program. The children in 13 schools in Kiruna (n=360), and four schools in Luleå (n=87) were invited to participate by signing the contract at the age of 12 years (Figure 1). A collaboration between the OLIN studies and Tobacco free duo enabled a joint database with data on participation in the prevention program and longitudinal questionnaire data from the OLIN studies.

Definitions

Participants: those who attended a school in the study area that was invited to participate in Tobacco free duo, and chose to sign the contract to participate at the age of 12 years.

Non-participants: those who attended a school in the study area that was invited to participate in Tobacco free duo, but chose not to participate.

Controls: those who attended the schools in the study area that were not invited to Tobacco free duo.

Snus: moist ground tobacco which is placed under the upper lip.

Any smoking/snus use: those reporting smoking/snus use daily, weekly, or monthly.

Classification of socio-economic status (SES) was based on parental occupation according to a system developed by Statistics Sweden.[21] The highest level of SES of the adults in the household was chosen. In an aggregated form, the classification consist of six groups of occupationally active persons, and one group of non-active persons as follows:

1) Professionals and executives; 2) Self-employed; 3) Intermediate non-manual employees; 4) Assistant non-manual employees; 5) Manual workers in industry; 6) Manual workers in service; 7) Unemployed, including students, unemployed, retired and housewives.

Statistical analysis

Analyses were made using the computer software IBM SPSS Statistics (Version 22.0; IBM SPSS Statistics, New York, USA). For assessment of differences between groups, $\chi 2$-tests were used and a p-value <0.05 was considered statistically significant. Dependent variables were smoking and use of snus, respectively, at the age of 15 years, and participation in the tobacco prevention program from the age of 12 years. Independent variables included sex, having smoking or snus using parents, living conditions, participation in sports, and parental socio-economic status. Significant and borderline significant factors identified in the bi-variate analyses were included in multivariate analysis which were performed by multiple logistic regression analysis and expressed as odds ratios (OR) with 95% confidence intervals (CI).

RESULTS

Prevalence of tobacco use at the age of 14-15 years

The prevalence of *any smoking* was 5.9%, with no statistically difference by sex. *Any snus use* was 4.7%, and significantly more common among boys than girls (7.2% and 1.9% $p<0.001$). The prevalence of monthly smoking was 1.5%, weekly smoking was 0.9%, monthly use of snus was 0.9% and weekly snus use was 0.5%.

The prevalence of daily smoking in the cohort was 3.5%, and significantly higher among the girls than among boys (Table 1). For daily snus use, the overall prevalence was 3.3%, significantly more common among boys. Both the prevalence of daily smoking and the use of snus were significantly lower compared to the prevalence in a similar cohort, surveyed ten years previously in the same study area. At that survey the prevalence of daily smoking was 5.8% and using snus 9.9%.[9] In the present study, the prevalence of daily smoking and daily use of snus, respectively, was significantly higher among those with smoking or snus using parents, living in an apartment, living in a single parent household, not participating in sports, and among those with lower parental SES (Table 1). There were no significant differences in the prevalence of smoking or snus use related to urban or rural living, having older siblings, having a physician-diagnosed asthma or a positive skin prick test.

In a multivariate analysis, daily smoking was related to female sex, having a smoking mother, a smoking father, not participating in sports, and parental SES of *self-employed, assistant non-manual, manual worker in industry,* and *unemployed*. Daily use of snus was related to male sex, having a smoking mother, and having a father who used snus (Table 1).

Participation in the tobacco prevention program

The children in the participating schools (n=447) were compared to children in non-participating schools (n=2165). There were no statistically significant differences in the prevalence of male sex, parental smoking, living conditions, physician-diagnosis of asthma, participation in sports or parental SES between the sample invited to the tobacco prevention program and the controls that were not invited. However, among those invited to the prevention program, the prevalence of urban living (81% vs. 58% p<0.001), and having older siblings (67% vs. 62% p=0.047) were significantly higher compared to the controls. Among the 447 invited to join the prevention program, 224 (50%) chose to participate by signing a contract. Comparison of baseline characteristics between participants and non-participants in the tobacco prevention program is presented in Table 2. Comparing non-participants with participants, the prevalence of boys (59% vs. 43%), having a smoking mother (20% vs. 9%), and living in a single parent household (16% vs. 8%) was significantly higher among the non-participants, while fewer non-participants were doing sports (65% vs. 79%). Among the participants, it was more common having parental SES at the professional and assistant non-manual level, while among non-participants the intermediate non-manual and manual workers in industry and service level was more common (test-for-trend p<0.005). There were no significant differences between participants and non-participants regarding living in a house vs. living in an apartment, urban vs. rural living, having older siblings, or having a physician-diagnosed asthma.

Significant factors related to non-participation in the tobacco prevention program identified in the bi-variate analyses were included in a multivariate analysis. Non-participation was related to male sex (OR 1.8 95% 1.2-2.7), having a smoking mother (OR 2.1 95% CI 1.1-3.8) and

parental SES of manual workers in service (OR 3.0 95% CI 1.3-6.7). Participation in sports was inversely related to non-participation (OR 0.6 95% CI 0.3-0.9) (Table 3).

Effect of the intervention

The prevalence of both smoking and use of snus was significantly lower among the participants in the prevention program compared to both the non-participants and the controls in the rest of the cohort (Figure 2). Of the participants in the program, only four individuals were daily smokers or snus users at the age of 14-15 years. On the school-level, there was no spill-over effect, i.e. there was no difference in tobacco use between the children at the invited schools and the control schools.

Among the controls at baseline at the age of 11-12 years, the prevalence of having a smoking mother was 14.4% and 11.4% had a smoking father. In the follow-up, the corresponding proportions were very similar: 13.4% and 12.4%. However, among the participants in the intervention, the prevalence of having a smoking mother decreased from 9.0% to 5.8% (p=0.201), while having a smoking father remained similar, 10.5% and 11.5%. However, none of these differences in prevalence were statistically significant.

Table 1. Prevalence (%) of tobacco use in relation to demographic factors, at the age of 14-15 years. Significant factors in the bivariate analyses were included in a multiple logistic regression analysis and expressed as odds ratios with 95% confidence interval.

		Smoking				Snus use			
		Bivariate analysis		Multivariate analysis		Bivariate analysis		Multivariate analysis	
		Daily smoking %	Difference p-value	OR	95% CI	Daily use of snus %	Difference p-value	OR	95% CI
Sex	Boys	2.7%		1.00		5.5%		5.72	2.76-11.85
	Girls	4.4%	0.021	1.95	1.11-3.41	1.0%	<0.001	1.00	
Tobacco intervention	Control	3.5%		1.00		3.1%		1.00	
	Participant	0.9%		0.20	0.03-1.48	0.9%		0.53	0.12-2.27
	Non-participant	4.9%	0.073	1.26	0.51-3.16	7.7%	0.023	2.14	1.05-4.37
Mother smoking	No	2.5%				2.5%			
	Yes	10.1%	<0.001	2.46	1.29-4.68	8.4%	<0.001	3.38	1.76-6.50
Father smoking	No	2.6%				3.0%			
	Yes	10.2%	<0.001	1.79	0.93-3.45	5.6%	0.023	0.76	0.34-1.66
Mother using snus	No	3.1%				2.7%			
	Yes	6.7%	0.005	1.19	0.54-2.64	8.0%	<0.001	1.72	0.85-3.48
Father using snus	No	2.5%				1.8%			
	Yes	5.8%	<0.001	1.65	0.94-2.90	6.6%	<0.001	3.20	1.81-5.64
Living conditions	House	3.1%		1.00		2.7%		1.00	
	Apartment	5.9%		0.79	0.38-1.63	6.1%		1.78	0.91-3.47
	Both	2.6%	0.026	0.75	0.21-2.71	1.7%	0.002	0.32	0.04-2.49
	Single parent household	7.4%		1.34	0.64-2.81	6.4%		1.07	0.49-2.34
	Two parent household	3,0%	<0.001	1.00		2.8%	0.001	1.00	
Participation in sports	No	7.8%		1.00		4.9%		1,00	
	Yes	1.8%	<0.001	0.30	0.17-0.52	2.7%	0.006	0.67	0.39-1.18
Parental socioeconomic status									
Professionals		0.8%		1.00		2.1%		1.00	
Self-employed		7.2%		6.07	1.70-21.72	3.2%		0.90	0.23-3.50
Intermediate non-manual		1.9%		2.22	0.68-7.25	2.8%		1.25	0.53-2.94
Assistant non-manual		3.7%		3.65	1.09-12.21	2.6%		0.75	0.24-2.37
Manual workers industry		5.6%		4.57	1.44-14.47	4.9%		1.58	0.64-3.93
Manual workers service		4.4%		3.06	0.89-10.50	5.6%		1.63	0.63-4.22
Unemployed		20.0%	<0.001	14.21	3.49-57.84	5.0%	0.005	0.80	0.14-4.60

Table 2. Baseline characteristics at the age of 11-12 years among the participants and non-participants in a tobacco prevention program.

	Participants n=224	Non-participants n=223	Difference p-value
Male sex	42.9%	59.2%	0.001
Smoking mother	9.0%	20.4%	0.001
Smoking father	10.5%	8.2%	0.412
Living conditions			
House	75.5%	69.0%	
Apartment	20.5%	25.8%	
Both	4.1%	5.2%	0.326
Urban	80.0%	78.9%	
Rural	19.5%	19.1%	0.530
Single parent household	7.6%	15.7%	0.008
Having older siblings	62.4%	70.0%	0.094
Physician-diagnosed asthma	13.5%	14.1%	0.846
Participation in sports	78.5%	65.3%	0.002
Parental socioeconomic status			
Professionals	28.0%	18.1%	
Self-employed	6.4%	6.0%	
Intermediate non-manual	28.0%	32.4%	
Assistant non-manual	15.1%	10.6%	
Manual workers industry	14.2%	16.7%	
Manual workers service	6.9%	13.4%	
Unemployed	1.4%	2.8%	0.005

Table 3. Factors related to non-participation in a tobacco prevention program, analysed by multiple logistic regression and expressed as odds ratios with 95% confidence interval.

	Non-participation	
	OR	95% CI
Male sex	1.81	1.20-2.74
Smoking mother	2.05	1.09-3.84
Single parent household	1.78	0.90-3.51
Participation in sports	0.55	0.34-0.89
Parental socioeconomic status		
Professionals	1.00	
Self-employed	1.06	0.43-2.63
Intermediate non-manual	1.56	0.90-2.71
Assistant non-manual	0.85	0.42-1.72
Manual workers industry	1.37	0.70-2.70
Manual workers service	2.98	1.32-6.74
Unemployed	2.87	0.25-33.38

DISCUSSION

In this population-based prospective study, we report a low prevalence of tobacco use among Swedish teenagers, especially among the participants in a tobacco prevention program. Further, we found that participation in the prevention program was affected by a selection bias as those in most need of smoking prevention, i.e. children having smoking parents and a lower socio-economic status, did not participate.

From the 1980s to the 2000s, smoking steadily decreased among Swedish adults,[22,23] while the prevalence of smoking initiation among teenagers remained relatively stable.[5] However, in the last decade there have been some reports of a decrease also among teenagers. In 2003, the prevalence of daily smoking at the age of 14-15 years was 5.8% and using snus 9.9% in a similar cohort in the same study area,[9] compared to 3.5% and 3.3% in the present study. Thus, both smoking and the use of snus had decreased, a positive result in accordance with recent nationwide reports among Swedish [5] and Norwegian teenagers.[24]

Despite the low prevalence of tobacco use, some teenagers were more likely to be tobacco users than others. Smoking was related to socio-economic factors such as parental socio-economic level, living in a single parent household, and living in an apartment, in accordance with other studies.[9,24-26] There are socio-economic inequalities in health,[27] and the fact that smoking is more common among those with lower socio-economic level contribute to these inequalities.[24,28] Other factors related to smoking were female sex, having smoking family members and not doing sports, as shown in other studies.[9,29,30] Few studies have reported on factors related to snus use among teenagers.[9] Similar to other studies,[29] the risk factors for using snus were male sex and parental tobacco use. Additionally, we found a significant association between snus use and parental SES of manual workers in industry and

in service. However, in the multivariate analysis, this association lost significance. It has been shown that lower educational level and income was related to snus use among adults in Sweden.[31]

By identification and characterisation of tobacco users but also populations at risk of becoming tobacco users, prevention efforts might be improved. Because parental tobacco use is an important risk factor for tobacco use among teenagers,[9,29] the study design of the present prevention program (Tobacco free duo) included the partnership with a tobacco free adult. In an evaluation of Tobacco free duo in another county in Sweden, it was shown that the prevalence of smoking not only decreased among the teenagers, but also among the adult participants in the program.[32] This was seen also in our study, but the decrease was not statistically significant. Having tobacco free role models are an important aspect of tobacco prevention among teenagers.

In studies among adults, non-participation in studies about respiratory conditions is associated with higher prevalence of smoking,[13,14,33] and lower socio-economic status.[16] Further, non-participation in an alcohol use prevention study among teenagers was related to lower parental socio-economic level.[34] However, little is known about non-participation in smoking prevention programs among teenagers. In a review of the long-term effects of smoking prevention programs, the authors noted a selection bias, as most reviewed programs were based on convenience samples and not random samples.[35] This may impact the external validity of a study because the sample may not be representative of the general population. Further, it has been shown that having smoking family members decreased the efficacy of a school-based smoking prevention program.[36] Thus, involving the family in smoking prevention seems to be a good idea. However, although the prevention program in

our study involved the child and an adult, and was a collaboration between schools, Norrbotten county council, and local organisations, the participation rate was low as only 50% chose to join the program. Furthermore, the prevalence of having a smoking mother was twice as high among the non-participants compared to the participants. Thus, many of those who would have benefited from the prevention efforts chose not to participate. Another factor related to non-participation was parental SES of manual workers in service. One explanation for this finding may be that both manual workers in service as well as smoking is more common among women, in this case the mothers, and both these factors were related to non-participation.

We suggest that in order to avoid this bias and improve the efficacy of smoking prevention, an even closer collaboration between policy makers, community, school and the family are needed. If we succeed in reaching and informing these actors, the prevention strategies may target a larger population. Further, as most of the teenagers were at a low risk of becoming smokers, the 'prevention paradox' may apply, similar to smoking cessation intervention among smokers.[37] It states that prevention strategies on the population level are more likely to reduce the smoking related health problems in the population compared to strategies on the individual level. Although strategies on the individual level may target teenagers at high risk of becoming smokers, these individuals are relatively few and only account for a minority of the overall public health burden. Prevention strategies on the population level are said to be more effective, simply because they reach a higher number of individuals. Promising prevention strategies aimed at teenagers that have been suggested include media campaigns, increasing cigarette price, and restricting access to tobacco products, but also social environment changes such as reduction of smoking among adult role models.[38]

The strengths of this study included the longitudinal study design, with the high response rates, few lost to follow up, and the use of validated questionnaires. Further, the collaboration with the prevention program Tobacco free duo enabled us to combine the longitudinal data from the OLIN studies with intervention data on participation in the prevention program. A limitation of the study included the lack of information about the level of activity in the tobacco prevention program during the follow-up time. Another limitation is that self-reported smoking was not validated by objective measures. However, others that compared self-reports of smoking with cotinine levels in saliva found good agreement.[39]

In conclusion, prevalence of tobacco use was significantly lower among the participants in the tobacco prevention program compared to the controls after three years. However, the observed benefit of the intervention may be overestimated as the participation was related to a selection bias as those in most need of smoking prevention, i.e. children having smoking parents and a lower socio-economic status, did not participate. One way to improve the efficacy of smoking prevention efforts is to have an even closer collaboration between policy makers, community, school and the family. Developing comprehensive strategies for including more high risk children in prevention efforts at the population level will be an important measure to reduce tobacco use among teenagers.

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COMPETING INTERESTS

None of the authors have any conflicts of interests to declare.

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AUTHOR CONTRIBUTION

LH is responsible for the study design, collected the data, performed the statistical analyses, drafted and revised the manuscript and approved the final manuscript. MA and CS contributed to the analysis and interpretation of data, reviewed and revised the manuscript and approved the final manuscript. ER is responsible for study conception and design, has contributed to the analysis and interpretation of data, reviewed and revised the manuscript and approved the final manuscript.

DATA SHARING STATEMENT

No additional data available.

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LEGENDS TO FIGURES

Figure 1. Flow chart of the study design and participation in a cohort study about asthma and allergic diseases, and in a tobacco prevention program.

Figure 2. Prevalence of tobacco use at the age of 14-15 years among participants and non-participants in the prevention program and among the controls in the rest of the cohort*.

*Test for trend: Participants vs. non-participants: smoking p<0.001; snus p<0.001
Participants vs. controls: smoking p=0.007; snus p=0.026
Non-participants vs. controls: smoking p=0.054; snus p=0.002

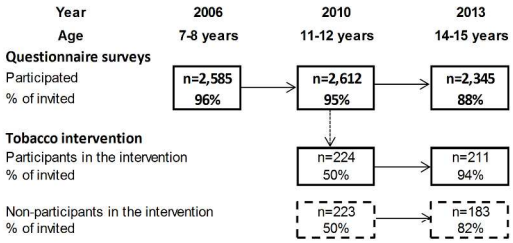

Figure 1.

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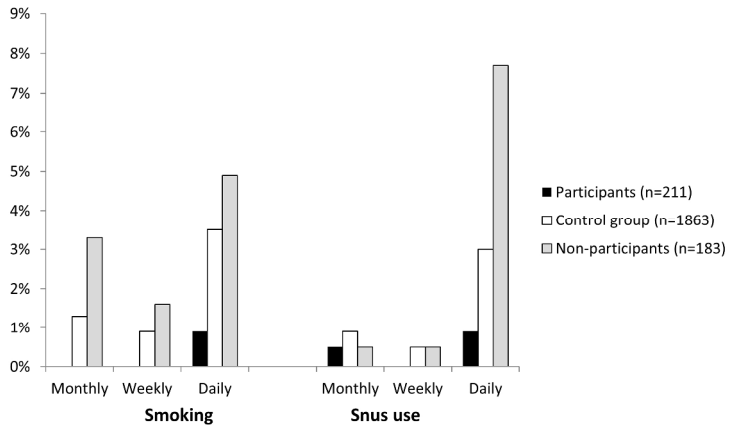

Figure 2.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) We state in the abstract that this is a cohort study.	2
		(*b*) The abstract provides an informative summary of what was done and what we found.	2
Introduction			
Background/rationale	2	In the Introduction, we explain the scientific background and rationale for the investigation being reported	4
Objectives	3	The objective of the study is stated in the first sentence in page 5.	5
Methods			
Study design	4	The study design, study population, material and methods are presented in the abstract and early in the method section.	5-6
Setting	5	The study was performed in northern Sweden and the locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection is presented in the method section, and further clarified in a flow chart (Figure 1).	5-7
Participants	6	(*a*) The methods of recruitment and follow up is described in the method section and further clarified in Figure 1.	5-6
		(*b*) Not applicable	
Variables	7	The main outcome variables and the factors included in the analyses are defined in the section “Statistical analysis”.	7
Data sources/ measurement	8*	How the data was managed is presented in page 7.	7
Bias	9	An important finding in this study was that participation was biased by selection and this is presented and discussed throughout the paper, both in text and in tables.	
Study size	10	All children in three municipalities were invited. The inhabitants in these municipalities include 60% of the total population in the county of Norrbotten, Sweden.	
Quantitative variables	11	How the quantitative variables were handled in the analyses is presented in page 7. We performed analyses stratified by sex because there were statistically significant differences in tobacco use between boys and girls.	
Statistical methods	12	(*a*) Statistical methods are presented in page 7.	7
		(*b*) As stated in point 11, some analyses were stratified by sex. Interaction analyses were not included in the paper.	
		(*c*) Teenagers with missing answers in individual questions were excluded from the specific analyses where those questions were included.	

		(*d*) The follow-up time was three years and the number of individuals that was lost to follow-up was low. In the paper we present both data from baseline at the age of 12 years and data from the follow-up at the age of 15 years.	
		(*e*) Not applicable	
Results			
Participants	13*	(a) The number of individuals at each stage of study is presented both in the Method section, in Study population, as well as in Figure 1.	5
		(b) We do not have information on reasons for non-response. However, the participation rates have been high at each questionnaire survey.	
		(c) The study design is presented as a flow chart in figure 1.	
Descriptive data	14*	(a) Characteristics of study participants and information on exposures are presented in the Method section, in Study population, and in table 1, and table 2.	5
		(b) We considered including number of participants with missing data for each variable of interest in table 1, but it made the table too extensive.	
		(c) The follow-up time was three years, as the questionnaire surveys at each occasion were performed in January-March.	
Outcome data	15*	The prevalence of tobacco users in relation to several different background factors is presented in table 1.	
Main results	16	(*a*) Both unadjusted and adjusted estimates are presented in table 1, while unadjusted prevalence rates are presented in table 2. Multivariate analyses are presented in tables 3 (results expressed as odds ratios with 95% confidence interval).	
		(*b*) Not applicable	
		(*c*) Not applicable	
Other analyses	17	Not applicable	
Discussion			
Key results	18	Key results are summarised in the first paragraph in the discussion.	14
Limitations			
Interpretation	20	We cautiously interpret our results in relation to other studies throughout the discussion.	14-17
Generalisability	21	The external validity of the results is discussed by comparing our findings with other studies. For instance, in the discussion, page 14, third paragraph.	14
Other information			
Funding	22	The sources of funding are presented in page 17. None of the funders had any role in the analysis or writing of the current paper.	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.