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Predictors of electronic cigarette use among Swedish teenagers – a population-based cohort study

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Abstract

Objectives: The aim was to identify predictors of e-cigarette use among teenagers.

Design and setting: a prospective population-based cohort study of schoolchildren in northern Sweden.

Participants: In 2006, a cohort study about asthma and allergic diseases among schoolchildren started within the Obstructive Lung Disease in Northern Sweden (OLIN) studies. The study sample (n=2185) was recruited at age 7-8y and participated in questionnaire surveys at age 14-15y, and 19y. The questionnaire included questions about respiratory symptoms, living conditions, upper secondary education, physical activity, diet, health-related quality of life, parental smoking and parental occupation. Questions about tobacco use were included at age 14-15 and 19y.

Primary outcome: E-cigarette use at age 19y.

Results: At age 19y, 21.4% had ever tried e-cigarettes and 4.2% were current users. Among those who were daily tobacco smokers at age 14-15y, 60.9% had tried e-cigarettes at age 19y compared with 19.1% of never-smokers and 34.0% of occasional smokers (p<0.001). Among those who had tried e-cigarettes 28.1% were never smokers both at age 14-15 and 19y, and 14.4% were never smokers among the current e-cigarette users. In unadjusted analyses, e-cigarette use was associated with daily smoking, use of snus and having a smoking father at age 14-15y, as well as with attending vocational education, physical inactivity and unhealthy diet. In adjusted analyses, current e-cigarette use was associated with daily tobacco smoking at age 14-15y (OR 6.27 95%CI 3.12-12.58), attending a vocational art program (OR 2.22 95% CI 1.04-4.77), and inversely associated with eating a healthy diet (OR 0.74 95% CI 0.59-0.92).

Conclusions: E-cigarette use was associated with personal and parental tobacco use as well as with physical inactivity, unhealthy diet and attending vocational upper secondary education. Importantly,

almost one-third of those who had tried e-cigarettes at age 19 years had never been tobacco smokers.

Keywords: adolescents, electronic cigarettes, epidemiology, smoking, vaping

Strenghts and limitations of this study

- This paper presents data from a prospective cohort study with high response rates and few participants lost to follow-up
- Self-reported use of tobacco or e-cigarettes was not validated by objective measures
- E-cigarette use was measured only at the last follow-up

Introduction

In the last ten years, the use of electronic cigarettes (e-cigarettes) has increased rapidly among teenagers[1-3], but the increase seems to level off in some countries including England[1] and Sweden[4]. One explanation for their popularity may be that they are perceived as less harmful and less addictive than tobacco cigarettes[5-7]. Although the levels are considerably lower than in conventional cigarette smoke, e-cigarette aerosol does contain carcinogenic and toxic substances[8,9] and they can deliver similar nicotine levels as conventional cigarettes and thereby cause nicotine addiction[10,11].

Because e-cigarettes are portrayed as an alternative to tobacco smoking, studies of predictors for e-cigarette use have mostly evaluated the association with smoking conventional cigarettes[12,13]. For instance, e-cigarette use was more common among current smokers than former smokers[14,15] and younger smokers appear to be more prone to start using e-cigarettes than older smokers[15,16]. A major concern regarding e-cigarettes is that they also seem to appeal to non-smoking teenagers[17,18] and might serve as a gateway to initiation of tobacco smoking as well as other drugs[11,17,19]. However, another explanation for the association between e-cigarette use and tobacco smoking may be that these behaviors share many risk factors such as social disadvantage, addictive behaviors, low academic achievement and having family members or friends that smoke[20-24]. These shared characteristics may serve as a common liability for any tobacco or nicotine product[25,26], which implies

that the sequential order of product initiation is of less importance. Nevertheless, predictors of e-cigarette use need to be identified both among smoking and non-smoking teenagers but prospective studies are lacking[27].

The aim of the present study was to identify predictors of e-cigarette use in a prospective population-based cohort study of teenagers in Sweden followed from 14-15 to 19 years of age.

Methods

Study sample

Within the Obstructive Lung Disease in Northern Sweden (OLIN) studies, a population-based paediatric cohort study has been ongoing since 2006. The starting point was a parental questionnaire survey inviting all children in first and second grade (age 7-8 years) in three municipalities of northern Sweden: Luleå, Piteå, and Kiruna[28,29 30]. The cohort was followed-up at age 14-15 years and 19 years. At age 19 years, the study sample consists of the 2,185 individuals that participated in all surveys, corresponding to 82% of the invited and 78% of the original cohort. The study was approved by the Regional Ethical Review Board in Umeå, Sweden. At recruitment the parents gave consent for their child to participate. The participants gave written informed consent at the follow-up at 19 years.

Questionnaire

The questionnaire surveys at age 14-15y and 19y were performed at school. The questionnaire included the International Study of Asthma and Allergies in Childhood (ISAAC) core questionnaire[31] with additional questions about asthma and allergic diseases including physician diagnoses, symptoms, use of medicine and heredity[28]. Other questions included possible risk factors such as living conditions, physical activity, diet, parental smoking and parental occupation. In the questionnaire at the age of 14-15 years, questions about smoking and use of snus were included[32] and at age 19 years, questions about e-cigarettes were added. At age 14-15 years, health-related

quality of life (HRQoL) was assessed using the KIDSCREEN-10 questionnaire which consists of 10 items with responses on a five-point ordinal scale[33]. The crude values were transformed into a single score and poor HRQoL was defined as a value lower than the group mean score minus 0.5 standard deviation.

Definitions

At age 14-15 years and 19 years, respectively, tobacco use was defined based on the questions 'Do you smoke/use snus?' as *Never* if they smoked/used snus 'Never'; *Occasional,* if they smoked/used snus 'Almost never', 'Monthly' or 'Weekly'; and *Daily* if they smoked/used snus 'Almost daily' or 'Daily'. At age 19 years, the category Former smoker was also included in the analyses.

At age 19 years, e-cigarette use was defined based on the question 'Do you use e-cigarettes?' as *Ever tried e-cigarettes* if they responded 'No, have quit', 'Have only tried', 'Use sometimes' or 'Use daily'; and *Current e-cigarette user* if they responded 'Use sometimes' or 'Use daily'.

In Sweden, the upper secondary school education offers three year programs that are vocational or preparatory for higher education (e.g. economics, natural science, social science or technology). We divided the vocational programs into *work shop* (e.g. building and construction, electricity, energy, vehicle, transport or industrial technology), *service* (e.g. child and recreation, hotel and tourism, restaurant management, or health and social care), and *art* (theater, dance, or music).

Healthy diet was defined based on a score between 0-4 with one point each for: eating fish every week; eating a fruit every day; eating fast food less than every week; and drinking soda less than every week.

Parental socioeconomic status was based on parental occupation reported in a parentally completed questionnaire at age 7-8 years, defined according to the socio-economic classification by Statistics Sweden[34] and categorized into the following groups: manual workers in service, manual workers in

industry, assistant non-manual employees, intermediate non-manual employees, self-employed, unemployed and professionals and executives.

Statistical analyses

Analyses were performed using the IBM SPSS statistics version 24 (IBM, Armonk, NY). Differences in proportions between groups were analysed by the Chi square test. A p-value <0.05 was considered statistically significant. Individuals with missing data in questions about exposure to parental smoking and tobacco use at age 14-15y, and e-cigarette use at age 19y were excluded from the analyses. Factors significantly associated with e-cigarette use in unadjusted analyses were included in adjusted logistic regression models and the results were expressed as odds ratios (OR) with 95% confidence intervals (CI). The adjusted analyses were also performed among those who were never smokers and did not use snus at age 14-15 years. A representativeness analysis was performed comparing the n=2,185 participants at age 19 years with the n=153 individuals that were invited but did not participate. Participants and non-participants were compared regarding sex, parental smoking habits, single parent household and prevalence of asthma at recruitment.

Results

The prevalence of tobacco use at ages 14-15 and 19 years

At age 14-15 years, the majority of the adolescents were never smokers, 90.0% (Table 1). The prevalence of occasional smoking (7.7% vs. 6.0%) and daily smoking (3.8% vs. 2.6%) was similar in girls and boys (p=0.083). Daily use of snus was significantly more common among boys than girls, 5.0% vs 0.8%, p<0.001.

At age 19 years, 61.8% were never smokers and 8.3% daily smokers. Occasional smoking was more common among boys than girls, 31.3% vs 25.6%, while daily smoking was more common among girls

than boys, 9.3% vs 7.4% (p=0.021). Daily use of snus was more common among boys than girls, 22.2% vs 6.2%, p<0.001.

The prevalence of e-cigarette use at age 19 years

At age 19 years, 21.4% (n=460) of the cohort had ever tried e-cigarettes, with a higher prevalence among boys than girls, 27.6% vs 15.1%, p<0.001. Current e-cigarette use (n=90 or 4.2%) was also more common among boys than girls, 4.9% vs 3.4%, but the difference was not statistically significant, p=0.084 (Table 1). The prevalence of dual use of e-cigarettes and conventional cigarettes was 1.7% (n=36), dual use of e-cigarettes and snus was 1.3% (n=28) while 0.5% (n=10) used all three products.

E-cigarette use at age 19 years in relation to tobacco use at age 14-15 years

Among those who were daily tobacco smokers at age 14-15 years, 60.9% (n=39) had tried e-cigarettes at age 19 years, compared with 34.0% (n=50) among occasional smokers and 19.1% (n=364) among never smokers (p<0.001). Of the daily smokers at age 14-15 years, 28.1% (n=18) were current e-cigarette users compared with 7.5% (n=11) among occasional smokers and 3.2% (n=61) among never smokers (Table 2). Of the current e-cigarette users at age 19 years, 14.4% reported being never smokers both at age 14-15 years and at 19 years (Figure 1). Corresponding proportion of never smokers among those who had tried e-cigarettes was 28.5%. Among those who were former smokers at age 19 years, 24.1% had tried e-cigarettes but only one individual was a current user.

The prevalence of e-cigarette use as well as current smoking at age 19 years increased with increasing number of tobacco smoking family members (Figure 2). Among those with two or more smoking family members, 33.1% had ever tried e-cigarettes and 8.4% were current users, compared with 18.7% and 3.3% among those with no smoking family members (p<0.001).

Predictors of e-cigarette use

In unadjusted analyses, current e-cigarette use at age 19 years was associated with daily smoking (OR 10.79 95% CI 5.96-19.53) and use of snus (OR 4.24 95% CI 2.02-8.89) at age 14-15 years. Further, it was associated with the vocational programs of work shop (OR 2.68 95% CI 1.59-4.49), service (OR 2.15 95% CI 1.01-4.54), and art (OR 2.22 95% CI 1.07-4.58) using preparatory programs as reference category. E-cigarette use was also associated with poor HRQoL (OR 1.59 95% CI 1.03-2.46), having a smoking father (OR 2.20 95% CI 1.31-3.68) and inversely associated with physical activity (OR 0.56 95% CI 0.37-0.86) and eating a healthy diet (OR 0.64 95% CI 0.53-0.78). We found no significant associations between current e-cigarette use and sex, having a smoking mother, physician diagnosis of asthma, living in a single parent household or parental socioeconomic status at age 14-15 years.

In the adjusted analyses, current e-cigarette use remained significantly associated with daily smoking (OR 6.27 95% CI 3.12-12.58), the vocational program of art (OR 2.22 95% CI 1.04-4.77), and inversely associated with eating a healthy diet (OR 0.74 95% CI 0.59-0.92) (Figure 3).

In analyses stratified by sex, current e-cigarette use among the girls was associated with poor HRQoL at age 14-15 years (OR 2.92 95% CI 1.25-6.81), the vocational program of art (OR 3.13 95% CI 1.17-8.34) and inversely associated with eating a healthy diet (OR 0.64 95% CI 0.45-0.91). Among the boys current e-cigarette use was significantly associated only with daily smoking (OR 5.37 95% CI 1.94-14.84).

Predictors of e-cigarette use among non-tobacco users

Adjusted analyses were also performed among those who were never smokers and did not use snus at age 14-15 years. Current e-cigarette use at age 19 years was associated with male sex (OR 2.29 95% CI 1.19-4.43) and having a smoking father (OR 2.48 95% CI 1.28-4.81) (Figure 4).

Analyses of representativeness

The sex distribution did not differ significantly between participants (n=2,185) and non-participants (n=153), female sex: 48.5% vs. 41.2%, p=0.081, and there was no difference in the prevalence of

asthma, 6.7% vs. 8.0%, p=0.564. However, compared with the participants, the non-participants more often had a smoking mother (16.2% vs. 23.7%, p<0.017), a smoking father (13.7% vs. 19.6%, p=0.046), and lived in a single-parent household (10.5% vs. 17.2%, p=0.012) at recruitment.

Discussion

In this population-based cohort study, daily smoking, use of snus and having a smoking father at age 14-15 years predicted e-cigarette use at age 19 years. Furthermore, e-cigarette use was more common among boys and less common among teenagers who were physically active and ate a healthy diet. Among never smokers and non-snus users at age 14-15 years, male sex and having a smoking father predicted e-cigarette use at age 19 years. Importantly, almost one-third of those who had tried e-cigarettes at age 19 years had never been smokers.

Biologically, teenagers are particularly susceptible to nicotine addiction and it has been shown that occasional smoking at a young age is associated with greater likelihood of daily smoking and future nicotine dependence[35,36]. Even occasional smoking is sufficient to develop abstinence symptoms[36] and may increase the likelihood of trying new nicotine delivery products out of curiosity[37,38]. Thus, we were not surprised that smoking conventional cigarettes and using snus predicted e-cigarette use in our study. Although the prevalence of dual use was low in our study, other studies have shown that the use of multiple tobacco and nicotine products has become more common particularly among young adults[39]. The different properties and legislation of cigarettes, snus and e-cigarettes enable the user to choose product depending on the situation. We found that one-fifth of never smokers and never snus users, respectively, at age 14-15 years had tried e-cigarettes four years later. Notably, even though the proportion of e-cigarette users was higher among the daily smokers than never smokers, the absolute number of individuals using e-cigarettes without being a smoker was high in the cohort. Moreover, almost one-third of e-cigarette users had never been a tobacco user, which is a cause for concern as the association seems to be bidirectional - it has been shown that e-cigarette

use is a predictor of becoming a tobacco smoker[17]. Finally, the teenagers in this cohort did not seem to use e-cigarettes as a smoking cessation method, as only one former smoker was a current e-cigarette user. Thus, due to the appeal of e-cigarettes among never smokers, our findings further undermine the claim that e-cigarettes are a useful harm reduction product.

One explanation for the strong appeal of e-cigarettes to non-smoking teenagers may be the plethora of flavors, including fruits, sweets and desserts[40,41] . In order to make e-cigarettes less appealing it has been suggested, for instance by the Food And Drug Administration (FDA) in the U.S. that flavors other than tobacco, mint and menthol should be banned[42]. The prominent taste of conventional cigarettes and most varieties of Swedish snus may avert teenagers from use. Consequently, e-cigarettes seem to appeal to new users that may not have initiated tobacco use otherwise, supporting the gateway theory[19].

In line with other studies, we found that e-cigarette use was more common in boys than girls[23,24,43]. One explanation may be that teenaged boys have a more risk-taking behavior than girls and therefore are willing to try a new nicotine delivery product. For a long time, tobacco smoking was more common among men than women in Sweden, but during the 1990s and 2000s it was more common among women[44]. It may be that e-cigarette use follows the same pattern as the traditional tobacco epidemic, with a higher uptake among men in the beginning followed by an increase among women. Among teenagers, social role modelling may contribute to the choice of tobacco product as smoking is more common among mothers and daughters, while snus use is more common among fathers and sons[45,46]. Unfortunately we did not ask for parental e-cigarette use, but we did find that e-cigarette use was associated with having a smoking father and that it was more common the more family members that smoked, suggesting that parental smoking habits play an important role for e-cigarette uptake.

We did not find any associations with parental socio-economic status, but e-cigarette use was more common among teenagers in vocational than preparatory upper secondary education. In Sweden, the vocational programs mainly lead to jobs within the industry and service, while many attending preparatory programs continue on to higher education. It is well known that smoking conventional cigarettes is associated with lower educational level, while studies of e-cigarette use have shown inconsistent results[27,47]. Nevertheless, our results indicate that the associations between lower educational level and smoking conventional or electronic cigarettes seen among adults is present already in early teenage in the choice of education. Moreover, e-cigarette use was less common among the teenagers who were physically active and ate a healthy diet. Tobacco use, physical inactivity and unhealthy diet as well as low educational level are known risk factors for public health diseases, for instance cardiovascular disease, and regrettably, the same individuals often recur in all of these high-risk groups[48,49], in accordance with the common liability theory[19,25]. Another interesting finding was that e-cigarette use was associated with poor HRQoL, particularly among the girls. An association between HRQoL and tobacco smoking has been demonstrated among teenagers[32]. Thus, the predictors for e-cigarette use were to a large extent the same as for conventional cigarettes, which implies that the already available successful tobacco prevention measures only need minor modifications to also include e-cigarette use. Supporting teenagers to choose a healthy lifestyle without any tobacco or nicotine products is an important public health effort.

The strengths of the study include the prospective study design, with high initial participation rates and few individuals lost to follow-up. Among those lost to follow-up, there was a higher proportion of children having smoking parents than among those who participated in the survey at age 19 years. As having smoking parents and initiation of tobacco use in teenage is strongly correlated, we may have underestimated the prevalence of tobacco and e-cigarette use. On the other hand, most likely we have not overestimated the significance of the associations[50]. Tobacco and e-cigarette use was

based on self-reports and not verified by objective measures such as level of cotinine. However, the prevalence of smokers, snus and e-cigarette users were in line with the prevalence in corresponding ages reported in Swedish national surveys[4], supporting the external validity of our results. The main focus of this cohort study is asthma and allergic diseases, therefore we did not include questions about alcohol intake or other risk-taking behavior in the questionnaire.

In conclusion, daily smoking, use of snus and having a smoking father at age 14-15 years predicted e-cigarette use at age 19 years. Furthermore, e-cigarette use was associated with male sex, physical inactivity, eating an unhealthy diet and attending vocational upper secondary education. Alarmingly, almost one-third of those who had tried e-cigarettes at age 19 years had never been smokers or used snus. Until the effects of e-cigarette use on respiratory and cardiovascular health have been fully elucidated, the rapid increase of e-cigarette use among teenagers needs to be curbed. In order to increase the efficacy of intervention efforts, the predictors and pattern of e-cigarette use among teenagers need to be studied in detail and our study contribute new knowledge in the field.

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Competing interests

None declared

Author contributions

LH participated in study design, data collection, performed the statistical analyses, drafted and revised the manuscript and approved the final manuscript. HB, CS, ML and MA contributed to the analyses and interpretation of data, revised the manuscript for important intellectual content and approved the final manuscript. ER is responsible for study conception and study design, participated in data collection, contributed to the analyses and interpretation of data, revised the manuscript for important intellectual content and approved the final manuscript. All authors are accountable for all aspects of the work.

Data sharing statement

No additional data available.

Patient and public involvement statement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

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Table 1. The prevalence of smoking and use of snus at age 14-15 years and 19 years, and e-cigarette use at age 19 years*.

	Girls		Boys		Difference by sex,	All	
	n	%	n	%	p-value	n	%
Parental smoking at age 14-15years							
Father smoker	129/1034	12.5	127/1093	11.6	0.544	256/2127	12.0
Mother smoker	115/1036	11.1	146/1092	13.4	0.111	261/2128	12.3
Tobacco use at age 14-15 years							
Never smoker	932/1053	88.5	1012/1108	91.3		1944/2161	90.0
Occasional smoker	81/1053	7.7	67/1108	6.0		148/2161	6.8
Daily smoker	40/1053	3.8	29/1108	2.6	0.083	69/2161	3.2
Never snus user	1036/1055	98.2	1034/1109	93.2		2070/2164	95.7
Occasional snus user	11/1055	1.0	19/1109	1.7		30/2164	1.4
Daily snus user	8/1055	0.8	56/1109	5.0	<0.001	64/2164	3.0
Tobacco use at age 19 years							
Never smoker	666/1044	63.8	662/1105	59.9		1328/2149	61.8
Former smoker	14/1044	1.3	15/1105	1.4		29/2149	1.3
Occasional smoker	267/1044	25.6	346/1105	31.3		613/2149	28.5
Daily smoker	97/1044	9.3	82/1105	7.4	0.021	179/2149	8.3
Daily snus user	65/1052	6.2	247/1111	22.2	<0.001	312/2163	14.4
E-cigarette use at age 19 years							
Ever tried/used e-cigarettes	158/1049	15.1	302/1096	27.6	<0.001	460/2145	21.4
Current e-cigarette user	36/1049	3.4	54/1096	4.9	0.084	90/2145	4.2

*Individuals with missing answers in the individual questions about tobacco use and e-cigarette use were excluded from the analysis.

Table 2. E-cigarette use at the age of 19 years in relation to smoking, use of snus and parental tobacco use at age 14-15 years*.

		Ever tried/used e-cigarettes			Current e-cigarette use		
		n	%	p-value	n	%	p-value
Smoking at age 14-15 years							
Never		364/1910	19.1		61/1910	3.2	
Occasionally		50/147	34.0		11/147	7.5	
Daily		39/64	60.9	<0.001	18/64	28.1	<0.001
Use of snus at age 14-15 years							
Never		405/2035	19.9		76/2035	3.7	
Occasionally		16/28	57.1		5/28	17.9	
Daily		31/61	50.8	<0.001	9/61	14.8	<0.001
Parental smoking at age 14-15 years							
Father smoker	No	374/1835	20.4		69/1835	3.8	
	Yes	72/253	28.5	0.003	20/253	7.9	0.002
Mother smoker	No	368/1832	20.1		73/1832	4.0	
	Yes	76/256	29.7	<0.001	16/256	6.3	0.093

*Individuals with missing answers in the individual questions about tobacco use and e-cigarette use were excluded from the analysis.

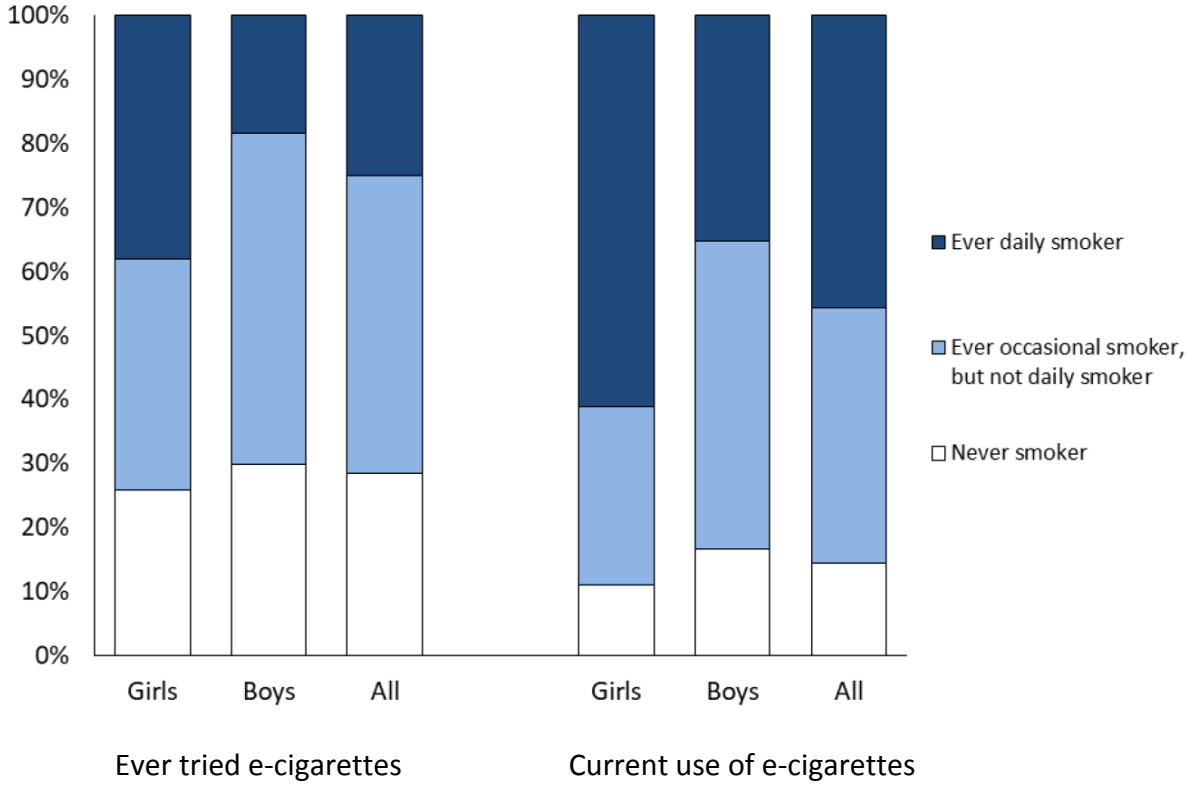

Figure 1. Smoking habits among e-cigarette users, based on questionnaire reports both at age 14-15 years and 19 years. The bars represent all those who had ever tried e-cigarettes and all current e-cigarette users at age 19 years, respectively.

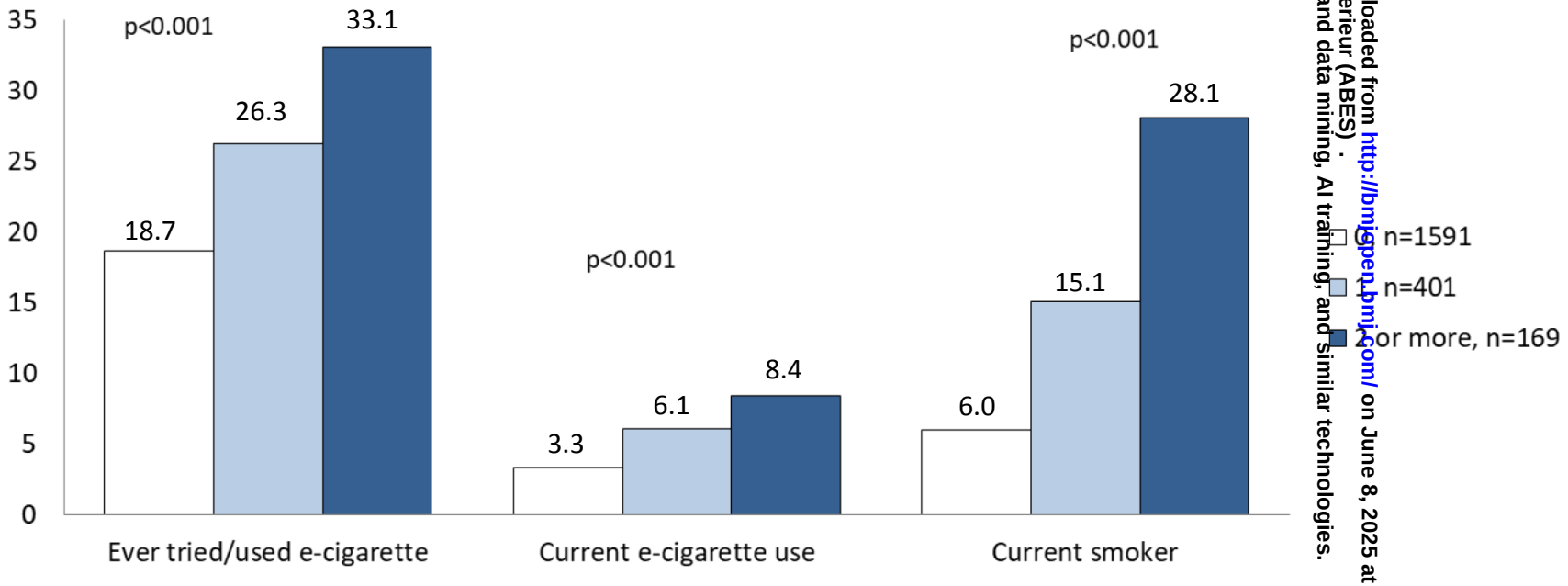

Figure 2. The prevalence of ever and current e-cigarette use and current tobacco smoking at age 19 years in relation to number of smoking family members at age 14-15 years.

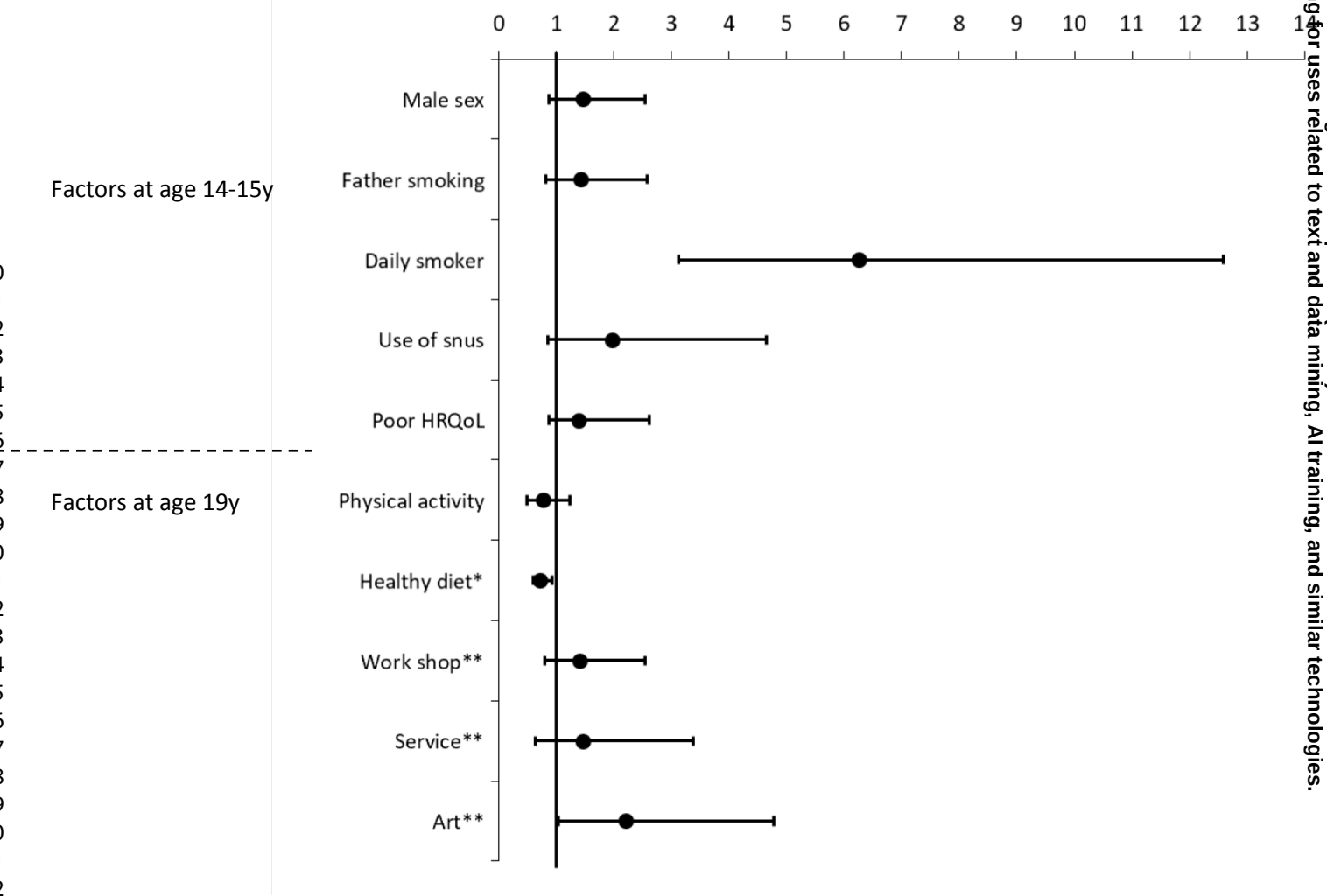

Figure 3. Risk factors for current e-cigarette use at age 19 years, analysed in an adjusted logistic regression analysis (including all factors listed in the figure) with the result expressed as odds ratios with 95% confidence intervals.

*Entered as a continuous variable (score 0-4)

**Upper secondary education, reference category: preparatory education

HRQoL: health-related quality of life

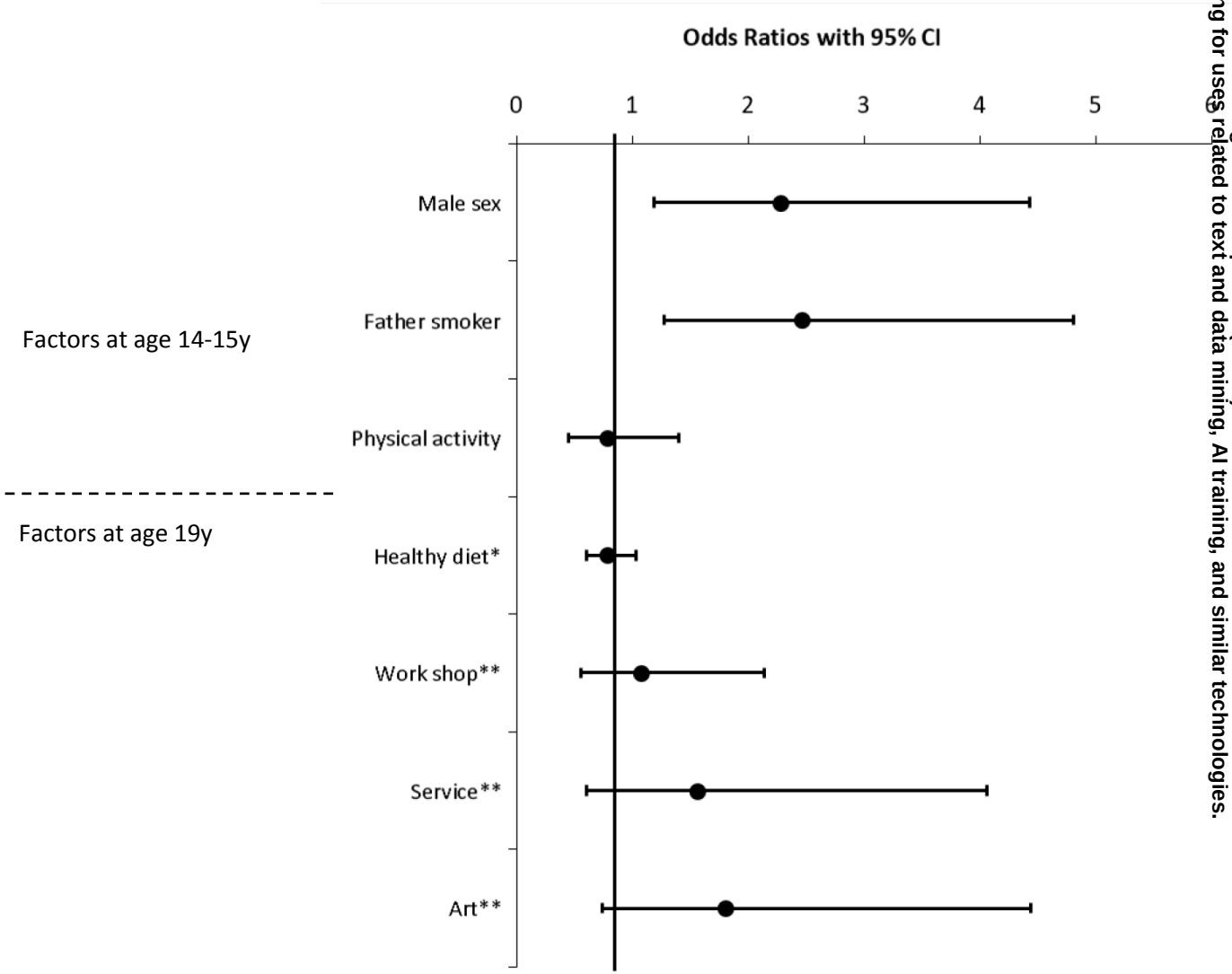

Figure 4. Risk factors for current e-cigarette use at age 19 years among the teenagers who were never-smokers and did not use snus at age 14-15 years, analysed in an adjusted logistic regression analysis (including all factors listed in the figure) with the results expressed as odds ratios with 95% confidence intervals.

* Entered as a continuous variable (score 0-4)

**Upper secondary education, reference category: preparatory education

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*) Indicate the study's design with a commonly used term in the title or the abstract	1 and 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4; Study sample
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4; Study sample
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4; Study sample
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4; Questionnaire 5; Definitions
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4; Questionnaire 5; Definitions
Bias	9	Describe any efforts to address potential sources of bias	6; Statistical analyses
Study size	10	Explain how the study size was arrived at	4; Study sample 6; Statistical analyses
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6; Statistical analyses
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6; Statistical analyses
		(*b*) Describe any methods used to examine subgroups and interactions	6; Statistical analyses
		(*c*) Explain how missing data were addressed	6; Statistical analyses
		(*d*) If applicable, explain how loss to follow-up was addressed	6; Statistical analyses
		(*e*) Describe any sensitivity analyses	NA

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4; Study sample 6; Statistical analyses 7-8; Analyses of representativeness
		(b) Give reasons for non-participation at each stage	7-8; Analyses of representativeness
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1 6: The prevalence of tobacco use at ages 14-15 and 19 years
		(b) Indicate number of participants with missing data for each variable of interest	Table 1 Table 2
		(c) Summarise follow-up time (eg, average and total amount)	4; Study sample
Outcome data	15*	Report numbers of outcome events or summary measures over time	Table 1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2 Figure 3 Figure 4
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Figure 4
Discussion			
Key results	18	Summarise key results with reference to study objectives	10; Discussion
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13; Funding

*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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Predictors of electronic cigarette use among Swedish teenagers – a population-based cohort study

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Abstract

Objectives: The aim was to identify predictors of e-cigarette use among teenagers.

Design and setting: a prospective population-based cohort study of schoolchildren in northern Sweden.

Participants: In 2006, a cohort study about asthma and allergic diseases among schoolchildren started within the Obstructive Lung Disease in Northern Sweden (OLIN) studies. The study sample (n=2185) was recruited at age 7-8y and participated in questionnaire surveys at age 14-15y, and 19y. The questionnaire included questions about respiratory symptoms, living conditions, upper secondary education, physical activity, diet, health-related quality of life, parental smoking and parental occupation. Questions about tobacco use were included at age 14-15 and 19y.

Primary outcome: E-cigarette use at age 19y.

Results: At age 19y, 21.4% had ever tried e-cigarettes and 4.2% were current users. Among those who were daily tobacco smokers at age 14-15y, 60.9% had tried e-cigarettes at age 19y compared with 19.1% of never-smokers and 34.0% of occasional smokers (p<0.001). Among those who had tried e-cigarettes 28.1% were never smokers both at age 14-15 and 19y, and 14.4% were never smokers among the current e-cigarette users. In unadjusted analyses, e-cigarette use was associated with daily smoking, use of snus and having a smoking father at age 14-15y, as well as with attending vocational education, physical inactivity and unhealthy diet. In adjusted analyses, current e-cigarette use was associated with daily tobacco smoking at age 14-15y (OR 6.27 95%CI 3.12-12.58), attending a vocational art program (OR 2.22 95% CI 1.04-4.77), and inversely associated with eating a healthy diet (OR 0.74 95% CI 0.59-0.92).

Conclusions: E-cigarette use was associated with personal and parental tobacco use as well as with physical inactivity, unhealthy diet and attending vocational upper secondary education. Importantly,

almost one-third of those who had tried e-cigarettes at age 19 years had never been tobacco smokers.

Keywords: adolescents, electronic cigarettes, epidemiology, smoking, vaping

Strenghts and limitations of this study

- This paper presents data from a prospective cohort study with high response rates and few participants lost to follow-up
- Self-reported use of tobacco or e-cigarettes was not validated by objective measures
- E-cigarette use was measured only at the last follow-up

Introduction

In the last ten years, the use of electronic cigarettes (e-cigarettes) has increased rapidly among teenagers[1-3], but the increase seems to level off in some countries including England[1] and Sweden[4]. One explanation for their popularity may be that they are perceived as less harmful and less addictive than tobacco cigarettes[5-7]. Although the levels are considerably lower than in conventional cigarette smoke, e-cigarette aerosol does contain carcinogenic and toxic substances[8,9] and they can deliver similar nicotine levels as conventional cigarettes and thereby cause nicotine addiction[10,11].

Because e-cigarettes are portrayed as an alternative to tobacco smoking, studies of predictors for e-cigarette use have mostly evaluated the association with smoking conventional cigarettes[12,13]. For instance, e-cigarette use was more common among current smokers than former smokers[14,15] and younger smokers appear to be more prone to start using e-cigarettes than older smokers[15,16]. A major concern regarding e-cigarettes is that they also seem to appeal to non-smoking teenagers[17,18] and might serve as a gateway to initiation of tobacco smoking as well as other drugs[11,17,19]. However, another explanation for the association between e-cigarette use and tobacco smoking may be that these behaviors share many risk factors such as social disadvantage, addictive behaviors, low academic achievement and having family members or friends that smoke[20-24]. These shared characteristics may serve as a common liability for any tobacco or nicotine product[25,26], which implies

that the sequential order of product initiation is of less importance. Nevertheless, predictors of e-cigarette use need to be identified both among smoking and non-smoking teenagers but prospective studies are lacking. In Sweden, smoking is more common among women while the use of snus (smokeless, moist, grounded tobacco placed under the upper lip) and e-cigarettes is more common among men[14,27-29], but there are no epidemiological studies on sex differences in e-cigarette use among Swedish teenagers[4].

The aim of the present study was to identify predictors of e-cigarette use in a prospective population-based cohort study of teenagers in Sweden followed from 14-15 to 19 years of age.

Methods

Study sample

Within the Obstructive Lung Disease in Northern Sweden (OLIN) studies, a population-based paediatric cohort study has been ongoing since 2006. The starting point was a parental questionnaire survey inviting all children in first and second grade (age 7-8 years) in three municipalities of northern Sweden: Luleå, Piteå, and Kiruna[30-32]. The cohort was followed-up at age 14-15 years and 19 years. At age 19 years, the study sample consists of the 2,185 individuals that participated in all surveys, corresponding to 82% of the invited and 78% of the original cohort (n=2819). The study was approved by the Regional Ethical Review Board in Umeå, Sweden. At recruitment the parents gave consent for their child to participate. The participants gave written informed consent at the follow-up at 19 years.

Patient and Public Involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Questionnaire

The questionnaire surveys at age 14-15y and 19y were performed at school. The questionnaire included the International Study of Asthma and Allergies in Childhood (ISAAC) core questionnaire[33] with additional questions about asthma and allergic diseases including physician diagnoses, symptoms, use of medicine and heredity[30]. Other questions included possible risk factors such as living conditions, physical activity, diet, parental smoking and parental occupation. In the questionnaire at the age of 14-15 years, questions about smoking and use of snus were included[34] and at age 19 years, questions about e-cigarettes were added. At age 14-15 years, health-related quality of life (HRQoL) was assessed using the KIDSCREEN-10 questionnaire which consists of 10 items with responses on a five-point ordinal scale[35]. The crude values were transformed into a single score and poor HRQoL was defined as a value lower than the group mean score minus 0.5 standard deviation.

Definitions

At age 14-15 years and 19 years, respectively, tobacco use was defined based on the questions 'Do you smoke/use snus?' as *Never* if they smoked/used snus 'Never'; *Occasional,* if they smoked/used snus 'Almost never', 'Monthly' or 'Weekly'; and *Daily* if they smoked/used snus 'Almost daily' or 'Daily'. At age 19 years, the category Former smoker was also included in the analyses. Former smoker was defined as either self-reported former smoker in the questionnaire at age 19y, or reporting being an occasional or daily smoker at age 14-15y and non-smoker at age 19y.

At age 19 years, e-cigarette use was defined based on the question 'Do you use e-cigarettes?' as *Ever tried e-cigarettes* if they responded 'No, have quit', 'Have only tried', 'Use sometimes' or 'Use daily'; and *Current e-cigarette user* if they responded 'Use sometimes' or 'Use daily'.

In Sweden, the upper secondary school education offers three year programs that are vocational or preparatory for higher education (e.g. economics, natural science, social science or technology). The program is chosen at age 15 years and they attend the program until graduation at age 19 years. We divided the vocational programs into *work shop* (e.g. building and construction, electricity, energy, vehicle, transport or industrial technology), *service* (e.g. child and recreation, hotel and tourism, restaurant management, or health and social care), and *art* (theater, dance, or music).

Healthy diet was defined based on a score between 0-4 with one point each for: eating fish every week; eating a fruit every day; eating fast food less than every week; and drinking soda less than every week. These four items were chosen based on recommendations by the Swedish National Food Agency.

Physical activity was defined as regular participation in sports or physical activity, not including physical education at school

Parental socioeconomic status was based on parental occupation reported in a parentally completed questionnaire at age 7-8 years, defined according to the socio-economic classification by Statistics Sweden[36] and categorized into the following groups: manual workers in service, manual workers in industry, assistant non-manual employees, intermediate non-manual employees, self-employed, unemployed and professionals and executives.

Statistical analyses

Analyses were performed using the IBM SPSS statistics version 24 (IBM, Armonk, NY). Differences in proportions between groups were analysed by the Chi square test. A p-value <0.05 was considered statistically significant. Individuals with missing data in questions about exposure to parental smoking (2.7%), tobacco use at age 14-15y (0.97-1.1%) and 19y (1.0-1.7%), and e-cigarette use at age 19y (1.8%) were excluded from the analyses. Factors significantly associated with e-cigarette use in unadjusted analyses were included in adjusted logistic regression models. Sex was also included in

the analysis. The results were expressed as odds ratios (OR) with 95% confidence intervals (CI). The adjusted analyses were also performed among those who were never smokers and did not use snus at age 14-15 years. A representativeness analysis was performed comparing the n=2,185 individuals that participated in the follow-up surveys both at 14-15 years and 19 years with the n=634 individuals that did not participate in the follow-ups surveys. Participants and non-participants were compared regarding sex, parental smoking habits, single parent household and prevalence of asthma at recruitment.

Results

The prevalence of tobacco use at ages 14-15 and 19 years

At age 14-15 years, the majority of the adolescents were never smokers, 90.0% (Table 1). The prevalence of occasional smoking was 6.8% and 3.2% were daily smokers, with similar prevalence in girls and boys. Daily use of snus was significantly more common among boys than girls, 5.0% vs 0.8%, p<0.001.

At age 19 years, 61.8% were never smokers and 8.3% daily smokers. Occasional smoking was more common among boys than girls, 31.3% vs 25.6%, while daily smoking was more common among girls than boys, 9.3% vs 7.4% (p=0.021). Daily use of snus had increased to 14.4% and was still more common among boys.

The prevalence of e-cigarette use at age 19 years

At age 19 years, 21.4% (n=460) of the cohort had ever tried e-cigarettes, with a higher prevalence among boys than girls, 27.6% vs 15.1%, p<0.001, and 4.2% (n=90) were current e-cigarette users. The prevalence of dual use of e-cigarettes and conventional cigarettes was 1.7% (n=36), dual use of e-cigarettes and snus was 1.3% (n=28) while 0.5% (n=10) used all three products.

E-cigarette use at age 19 years in relation to tobacco use at age 14-15 years

Among those who were daily tobacco smokers at age 14-15 years, 60.9% (n=39) had tried e-cigarettes at age 19 years, compared with 34.0% (n=50) among occasional smokers and 19.1% (n=364) among never smokers (p<0.001). Of the daily smokers at age 14-15 years, 28.1% (n=18) were current e-cigarette users compared with 7.5% (n=11) among occasional smokers and 3.2% (n=61) among never smokers (Table 2). Of the current e-cigarette users at age 19 years, 14.4% reported being never smokers both at age 14-15 years and at 19 years (Figure 1). Corresponding proportion of never smokers among those who had tried e-cigarettes was 28.5%. Among those who were former smokers at age 19 years, 24.1% (n=7) had tried e-cigarettes but only one individual was a current user. At age 19 years, there were 13 individuals reported having quit using e-cigarettes. Of them, 10 were occasional smokers, 2 daily smokers, 1 never smoker but none of them was a former smoker.

The prevalence of e-cigarette use as well as current smoking at age 19 years increased with increasing number of tobacco smoking family members (Figure 2). Among those with two or more smoking family members, 33.1% had ever tried e-cigarettes and 8.4% were current users, compared with 18.7% and 3.3% among those with no smoking family members (p<0.001).

Predictors of e-cigarette use

Unadjusted analyses are presented in an online supplement, Table E1. Current e-cigarette use at age 19 years was associated with occasional and daily smoking, and use of snus at age 14-15 years. Further, it was associated with the vocational programs of work shop, service, and art using preparatory programs as reference category. E-cigarette use was also associated with poor HRQoL , having a smoking father and inversely associated with physical activity and eating a healthy diet.

In the adjusted analyses, current e-cigarette use remained significantly associated with daily smoking (OR 6.27 95% CI 3.12-12.58), the vocational program of art (OR 2.22 95% CI 1.04-4.77), and inversely associated with eating a healthy diet (OR 0.74 95% CI 0.59-0.92) (Figure 3).

In analyses stratified by sex, current e-cigarette use among the girls was associated with poor HRQoL at age 14-15 years (OR 2.92 95% CI 1.25-6.81), the vocational program of art (OR 3.13 95% CI 1.17-

8.34) and inversely associated with eating a healthy diet (OR 0.64 95% CI 0.45-0.91). Among the boys current e-cigarette use was significantly associated only with daily smoking (OR 5.37 95% CI 1.94-14.84).

Predictors of e-cigarette use among non-tobacco users

Adjusted analyses were also performed among those who were never smokers and did not use snus at age 14-15 years, n=1827. Current e-cigarette use at age 19 years was associated with male sex (OR 2.00 95% CI 1.06-3.77) and having a smoking father (OR 2.28 95% CI 1.19-4.39) (Figure 4).

Analyses of representativeness

The sex distribution did not differ between participants (n=2,185) and non-participants (n=634), male sex: 51.5% vs. 54.6%, p=0.177. However, compared with the participants, the non-participants more often had a smoking mother (16.2% vs. 26.7%, p<0.001), a smoking father (13.7% vs. 21.3%, p<0.001), lived in a single-parent household (10.5% vs. 19.7%, p<0.001), and reported having physician-diagnosed asthma (6.7% vs. 10.4%, p=0.004) at recruitment. Further, a comparison between the n=2185 participants and the n=213 that participated at age 14-15y but not at age 19y showed a similar pattern in the characteristics.

Discussion

In this population-based cohort study, daily smoking, use of snus and having a smoking father at age 14-15 years predicted e-cigarette use at age 19 years. Furthermore, e-cigarette use was more common among boys and less common among teenagers who were physically active and ate a healthy diet. Among never smokers and non-snus users at age 14-15 years, male sex and having a smoking father predicted e-cigarette use at age 19 years. Importantly, almost one-third of those who had tried e-cigarettes at age 19 years had never been smokers.

Biologically, teenagers are particularly susceptible to nicotine addiction and it has been shown that occasional smoking at a young age is associated with greater likelihood of daily smoking and future nicotine dependence[37,38]. Even occasional smoking is sufficient to develop abstinence symptoms[38] and may increase the likelihood of trying new nicotine delivery products out of curiosity[39,40]. Thus, we were not surprised that smoking conventional cigarettes and using snus predicted e-cigarette use in our study. Although the prevalence of dual use was low in our study, other studies have shown that the use of multiple tobacco and nicotine products has become more common particularly among young adults[41]. The different properties and legislation of cigarettes, snus and e-cigarettes enable the user to choose product depending on the situation. We found that one-fifth of never smokers and never snus users, respectively, at age 14-15 years had tried e-cigarettes four years later. Moreover, almost one-third of e-cigarette users had never been a tobacco user, which is a cause for concern as it has been shown that e-cigarette use is a predictor of becoming a tobacco smoker[17]. Finally, the teenagers in this cohort did not seem to use e-cigarettes as a smoking cessation method, as only one former smoker was a current e-cigarette user. Thus, due to the appeal of e-cigarettes among never smokers, our findings further undermine the claim that e-cigarettes are a useful harm reduction product.

One explanation for the strong appeal of e-cigarettes to non-smoking teenagers may be the plethora of flavors, including fruits, sweets and desserts[42,43]. In order to make e-cigarettes less appealing it has been suggested, for instance by the Food And Drug Administration (FDA) in the U.S. that flavors other than tobacco, mint and menthol should be banned[44]. The prominent taste of conventional cigarettes and most varieties of Swedish snus may avert teenagers from use. Consequently, e-cigarettes seem to appeal to new users that may not have initiated tobacco use otherwise, supporting the gateway theory[19].

In line with other studies, we found that e-cigarette use was more common in boys than girls[23,24,45]. One explanation may be that teenaged boys have a more risk-taking behavior than girls and therefore are willing to try a new nicotine delivery product. For a long time, tobacco smoking was more common among men than women in Sweden, but during the 1990s and 2000s it was more common among women[46]. It may be that e-cigarette use follows the same pattern as the traditional tobacco epidemic, with a higher uptake among men in the beginning followed by an increase among women. Among teenagers, social role modelling may contribute to the choice of tobacco product as smoking is more common among mothers and daughters, while snus use is more common among fathers and sons[28,29]. Unfortunately we did not ask for parental e-cigarette use, but we did find that e-cigarette use was associated with having a smoking father and that it was more common the more family members that smoked, suggesting that parental smoking habits play an important role for e-cigarette uptake.

We did not find any associations with parental socio-economic status, but e-cigarette use was more common among teenagers in vocational than preparatory upper secondary education. In Sweden, the vocational programs mainly lead to jobs within the industry and service, while many attending preparatory programs continue on to higher education. It is well known that smoking conventional cigarettes is associated with lower educational level, while studies of e-cigarette use have shown inconsistent results[14,47]. Nevertheless, our results indicate that the associations between lower educational level and smoking conventional or electronic cigarettes seen among adults is present already in early teenage in the choice of education. Moreover, e-cigarette use was less common among the teenagers who were physically active and ate a healthy diet. Tobacco use, physical inactivity and unhealthy diet as well as low educational level are known risk factors for public health diseases, for instance cardiovascular disease, and regrettably, the same individuals often recur in all of these high-risk groups[48,49], in accordance with the common liability theory[19,25]. Another interesting

finding was that e-cigarette use was associated with poor HRQoL, particularly among the girls. An association between HRQoL and tobacco smoking has been demonstrated among teenagers[34]. Thus, the predictors for e-cigarette use were to a large extent the same as for conventional cigarettes, which implies that the already available successful tobacco prevention measures only need minor modifications to also include e-cigarette use. Supporting teenagers to choose a healthy lifestyle without any tobacco or nicotine products is an important public health effort.

The strengths of the study include the prospective study design, with high initial participation rates and few individuals lost to follow-up. Among those lost to follow-up, there was a higher proportion of children having smoking parents than among those who participated in the survey at age 19 years. As having smoking parents and initiation of tobacco use in teenage is strongly correlated, we may have underestimated the prevalence of tobacco and e-cigarette use. On the other hand, most likely we have not overestimated the significance of the associations[50]. Tobacco and e-cigarette use was based on self-reports and not verified by objective measures such as level of cotinine. However, the prevalence of smokers, snus and e-cigarette users were in line with the prevalence in corresponding ages reported in Swedish national surveys[4], supporting the external validity of our results. Questions about diet and physical activity were included in the questionnaire at age 19y and thus represent cross-sectional associations with e-cigarette use. Another limitation is that the main focus of this cohort study is asthma and allergic diseases, and therefore we did not include questions about personality traits related to tobacco or nicotine product initiation, sensation seeking behavior, alcohol intake or other risk-taking behavior in the questionnaire.

In conclusion, daily smoking, use of snus and having a smoking father at age 14-15 years predicted e-cigarette use at age 19 years. Furthermore, e-cigarette use was associated with male sex, physical inactivity, eating an unhealthy diet and attending vocational upper secondary education. Alarmingly, almost one-third of those who had tried e-cigarettes at age 19 years had never been smokers or used

snus. Until the effects of e-cigarette use on respiratory and cardiovascular health have been fully elucidated, the rapid increase of e-cigarette use among teenagers needs to be curbed. In order to increase the efficacy of intervention efforts, the predictors and pattern of e-cigarette use among teenagers need to be studied in detail and our study contribute new knowledge in the field.

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Competing interests

None declared

Author contributions

LH participated in study design, data collection, performed the statistical analyses, drafted and revised the manuscript and approved the final manuscript. HB, CS, ML and MA contributed to the analyses and interpretation of data, revised the manuscript for important intellectual content and approved the final manuscript. ER is responsible for study conception and study design, participated in data collection, contributed to the analyses and interpretation of data, revised the manuscript for important intellectual content and approved the final manuscript. All authors are accountable for all aspects of the work.

Data sharing statement

No additional data available.

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Legends to figures

Figure 1. Smoking habits among e-cigarette users. The bars represent all those who had ever tried e-cigarettes and all current e-cigarette users at age 19 years, respectively.

Never smoker: never smoker at age 14-15 and 19y; Ever occasional smoker: occasional smoker at age 14-15 or 19y but not a daily smoker; Former smoker: either self-reported former smoker at age 19y or being a non-smoker or occasional smoker at 14-15y and non-smoker at 19y; Ever daily smoker: daily smoker at 14-15 or 19y.

Figure 2. The prevalence of ever and current e-cigarette use and current tobacco smoking at age 19 years in relation to number of smoking family members at age 14-15 years.

Figure 3. Risk factors for current e-cigarette use at age 19 years, analysed in an adjusted logistic regression analysis (including all factors listed in the figure) with the result expressed as odds ratios with 95% confidence intervals.

*Entered as a continuous variable (score 0-4)

**Upper secondary education, reference category: preparatory education

HRQoL: health-related quality of life

Figure 4. Risk factors for current e-cigarette use at age 19 years among the teenagers who were never-smokers and did not use snus at age 14-15 years, analysed in an adjusted logistic regression analysis (including all factors listed in the figure) with the results expressed as odds ratios with 95% confidence intervals.

* Entered as a continuous variable (score 0-4)

**Upper secondary education, reference category: preparatory education

Table 1. The prevalence of smoking and use of snus at age 14-15 years and 19 years, and e-cigarette use at age 19 years*.

	Girls		Boys		Difference by sex,	All	
	n	%	n	%	p-value	n	%
Parental smoking at age 14-15years							
Father smoker	129/1034	12.5	127/1093	11.6	0.544	256/2127	12.0
Mother smoker	115/1036	11.1	146/1092	13.4	0.111	261/2128	12.3
Tobacco use at age 14-15 years							
Never smoker	932/1053	88.5	1012/1108	91.3		1944/2161	90.0
Occasional smoker	81/1053	7.7	67/1108	6.0		148/2161	6.8
Daily smoker	40/1053	3.8	29/1108	2.6	0.083	69/2161	3.2
Never snus user	1036/1055	98.2	1034/1109	93.2		2070/2164	95.7
Occasional snus user	11/1055	1.0	19/1109	1.7		30/2164	1.4
Daily snus user	8/1055	0.8	56/1109	5.0	<0.001	64/2164	3.0
Tobacco use at age 19 years							
Never smoker	666/1044	63.8	662/1105	59.9		1328/2149	61.8
Former smoker	14/1044	1.3	15/1105	1.4		29/2149	1.3
Occasional smoker	267/1044	25.6	346/1105	31.3		613/2149	28.5
Daily smoker	97/1044	9.3	82/1105	7.4	0.021	179/2149	8.3
Daily snus user	65/1052	6.2	247/1111	22.2	<0.001	312/2163	14.4
E-cigarette use at age 19 years							
Ever tried/used e-cigarettes	158/1049	15.1	302/1096	27.6	<0.001	460/2145	21.4
Current e-cigarette user	36/1049	3.4	54/1096	4.9	0.084	90/2145	4.2

*Individuals with missing answers in the individual questions about tobacco use and e-cigarette use were excluded from the analysis.

Table 2. E-cigarette use at the age of 19 years in relation to smoking, use of snus and parental tobacco use at age 14-15 years*.

		Ever tried/used e-cigarettes			Current e-cigarette use		
		n	%	p-value	n	%	p-value
Smoking at age 14-15 years							
Never		364/1910	19.1		61/1910	3.2	
Occasionally		50/147	34.0		11/147	7.5	
Daily		39/64	60.9	<0.001	18/64	28.1	<0.001
Use of snus at age 14-15 years							
Never		405/2035	19.9		76/2035	3.7	
Occasionally		16/28	57.1		5/28	17.9	
Daily		31/61	50.8	<0.001	9/61	14.8	<0.001
Parental smoking at age 14-15 years							
Father smoker	No	374/1835	20.4		69/1835	3.8	
	Yes	72/253	28.5	0.003	20/253	7.9	0.002
Mother smoker	No	368/1832	20.1		73/1832	4.0	
	Yes	76/256	29.7	<0.001	16/256	6.3	0.093

*Individuals with missing answers in the individual questions about tobacco use and e-cigarette use were excluded from the analysis.

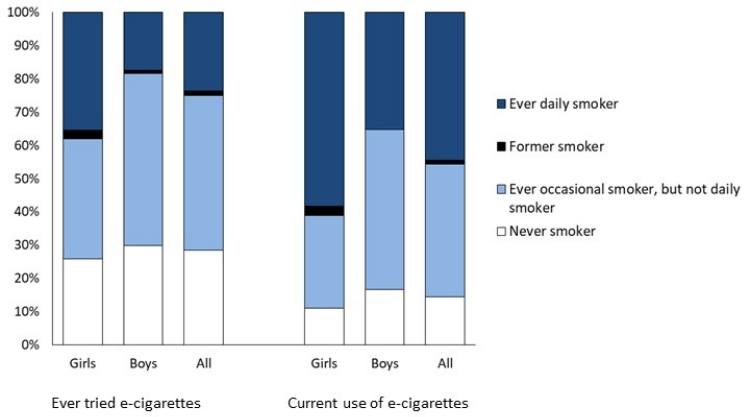

Figure 1. Smoking habits among e-cigarette users. The bars represent all those who had ever tried e-cigarettes and all current e-cigarette users at age 19 years, respectively.

Never smoker: never smoker at age 14-15 and 19y; Ever occasional smoker: occasional smoker at age 14-15 or 19y but not a daily smoker; Former smoker: either self-reported former smoker at age 19y or being a non-smoker or occasional smoker at 14-15y and non-smoker at 19y; Ever daily smoker: daily smoker at 14-15 or 19y.

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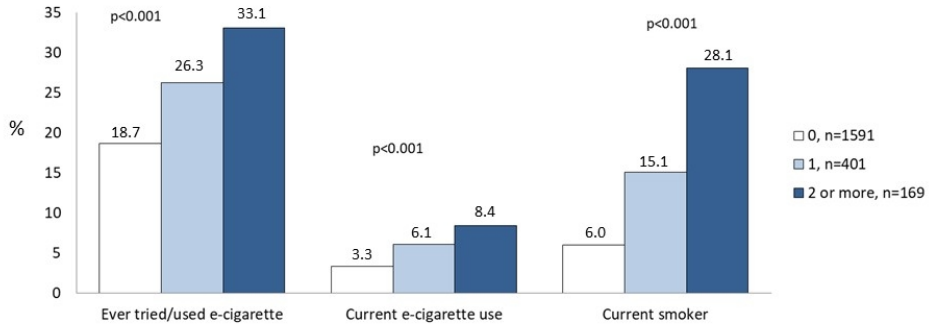

Figure 2. The prevalence of ever and current e-cigarette use and current tobacco smoking at age 19 years in relation to number of smoking family members at age 14-15 years.

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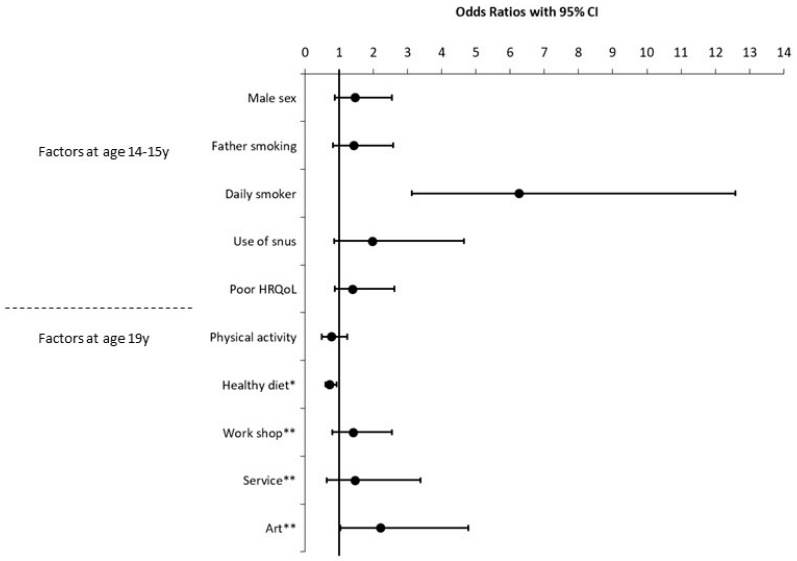

Figure 3. Risk factors for current e-cigarette use at age 19 years, analysed in an adjusted logistic regression analysis (including all factors listed in the figure) with the result expressed as odds ratios with 95% confidence intervals.

*Entered as a continuous variable (score 0-4)
**Upper secondary education, reference category: preparatory education
HRQoL: health-related quality of life

Figure 3. Risk factors for current e-cigarette use at age 19 years, analysed in an adjusted logistic regression analysis (including all factors listed in the figure) with the result expressed as odds ratios with 95% confidence intervals. *Entered as a continuous variable (score 0-4). **Upper secondary education, reference category: preparatory education. HRQoL: health-related quality of life

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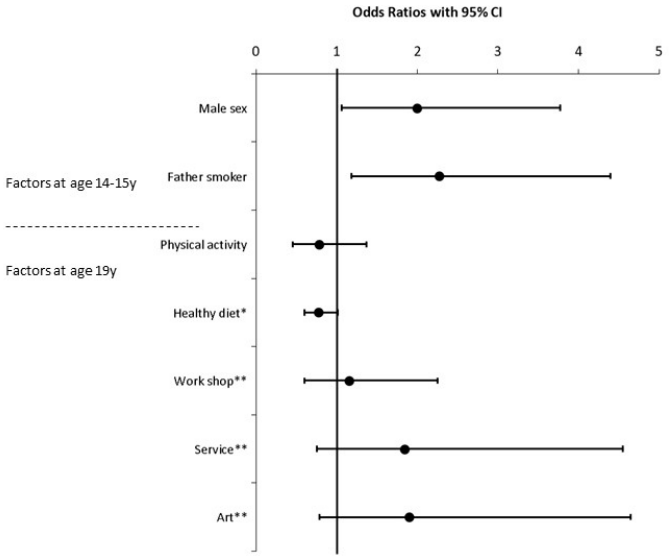

Figure 4. Risk factors for current e-cigarette use at age 19 years among the teenagers who were never-smokers and did not use snus at age 14-15 years, analysed in an adjusted logistic regression analysis (including all factors listed in the figure) with the results expressed as odds ratios with 95% confidence intervals.
* Entered as a continuous variable (score 0-4)
**Upper secondary education, reference category: preparatory education

Figure 4. Risk factors for current e-cigarette use at age 19 years among the teenagers who were never-smokers and did not use snus at age 14-15 years, analysed in an adjusted logistic regression analysis (including all factors listed in the figure) with the results expressed as odds ratios with 95% confidence intervals. * Entered as a continuous variable (score 0-4). **Upper secondary education, reference category: preparatory education

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Online supplement

Table E1. Factors associated with current e-cigarette use at age 19 years, analysed in unadjusted logistic regression analyses with the results expressed as odds ratios with 95% confidence intervals.

		OR	95% CI
Sex	Female	1.00	
	Male	1.46	(0.95-2.24)
Upper secondary school education	Preparatory	1.00	
	Work shop	2.68	(1.59-4.49)
	Service	2.15	(1.01-4.54)
	Art	2.22	(1.07-4.58)
Factors at age 14-15 years			
Father smoker	No	1.00	
	Yes	2.20	(1.31-3.68)
Mother smoker	No	1.00	
	Yes	1.61	(0.82-2.81)
Personal smoking habits	Never	1.00	
	Occasionally	2.45	(1.26-4.77)
	Daily	11.86	(6.50-21.65)
Use of snus	Never	1.00	
	Occasionally	5.60	(2.07-15.14)
	Daily	4.46	(2.12-9.39)
Parental socioeconomic status	Professionals and executives	1.00	
	Self-employed	1.03	(0.34-3.15)
	Intermediate non manual employees	1.18	(0.62-2.24)
	Assistant non-manual employees	1.07	(0.47-2.47)
	Manual workers in industry	1.78	(0.87-3.61)
	Manual workers in service	1.91	(0.92-3.98)
	Unemployed	Too few cases	
Single parent household	No	1.00	
	Yes	1.14	(0.58-2.25)
Current asthma at age 14-15 years	No	1.00	
	Yes	0.87	(0.43-1.76)
Factors at age 19 years			
Physical activity	No	1.00	
	Yes	0.56	(0.37-0.86)
Healthy diet	Entered as a continuous variable	0.64	(0.53-0.78)

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*) Indicate the study's design with a commonly used term in the title or the abstract	1 and 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4; Study sample
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4; Study sample
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4; Study sample
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4; Questionnaire 5; Definitions
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4; Questionnaire 5; Definitions
Bias	9	Describe any efforts to address potential sources of bias	6; Statistical analyses
Study size	10	Explain how the study size was arrived at	4; Study sample 6; Statistical analyses
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6; Statistical analyses
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6; Statistical analyses
		(*b*) Describe any methods used to examine subgroups and interactions	6; Statistical analyses
		(*c*) Explain how missing data were addressed	6; Statistical analyses
		(*d*) If applicable, explain how loss to follow-up was addressed	6; Statistical analyses
		(*e*) Describe any sensitivity analyses	NA

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4; Study sample 6; Statistical analyses 7-8; Analyses of representativeness
		(b) Give reasons for non-participation at each stage	7-8; Analyses of representativeness
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1 6: The prevalence of tobacco use at ages 14-15 and 19 years
		(b) Indicate number of participants with missing data for each variable of interest	Table 1 Table 2
		(c) Summarise follow-up time (eg, average and total amount)	4; Study sample
Outcome data	15*	Report numbers of outcome events or summary measures over time	Table 1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2 Figure 3 Figure 4
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Figure 4
Discussion			
Key results	18	Summarise key results with reference to study objectives	10; Discussion
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13; Funding

*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.