

The association of snus and smoking behaviour: a cohort analysis of Swedish males in the 1990s

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ABSTRACT

Background The European Union has banned sales of moist snuff (snus) in all member states, with the exception of Sweden. The ban is motivated by the potential adverse health effects of snus, but snus may also help people to avoid smoking or stop tobacco use. **Aims** The purpose of this study is to investigate the association between snus and smoking behaviour. **Measurements** The Swedish Survey of Living Conditions (ULF) health interview panel running from 1988/9 to 1996/7 was used to examine the gross and net flows between smoking and snus among Swedish males. Females were excluded from the analysis due to low snus prevalence. Contingency table models were used to investigate several hypotheses about the relationships between snus and smoking behaviour. **Findings** We found clear associations between the two habits. For the younger cohort (age 16–44 years), snus use contributed to approximately six smoking quitters per smoking starter attributable to snus. For the older cohort (age 45–84) there were slightly more than two quitters per starter. In terms of odds ratios, in the younger group smoking cessation attributable to snus was twice as common as smoking initiation, but in the older group the odds of starting smoking attributable to snus was 2.5 times higher than for quitting. **Conclusions** Snus contributed to the reduction of smoking among Swedish males in the 1990s. Snus had different effects among non-smokers and smokers in different age groups.

Keywords Moist snuff, smoking, snus, Sweden, tobacco behaviour.

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INTRODUCTION

During recent decades, the smoking rates in Sweden have declined substantially. Data from Statistics Sweden show that Sweden was the first country in Europe to reach the World Health Organization target of fewer than 20% of adults being daily smokers (19% in 1998). For 2006, Statistics Sweden reported a male daily smoking prevalence of 13.2% in the National Level of Living Survey, compared to 16.6% for females. However, in 2006, the prevalence of daily use of snus had reached almost 25% among males and 3% among females. Smoking has declined sharply and the use of snus has increased, especially among young people, in particular females. Some unpublished data from 2008, however, show a recent decline.

Data on the health risks of snus are relatively sparse, but research has increased in recent years. There is some evidence of an excess risk for pancreas cancer. The evidence about some other cancers is contradictory, i.e.

gastric cancer and oesophagus [1–4]. Swedish studies have generally failed to find elevated risks for ischaemic heart disease [5–9] and stroke [5,10], but elevated risks of some forms of fatal outcomes of stroke and myocardial infarction have been found [10,11], as well as an excess risk of hypertension [12]. It is reasonable to conclude that both tobacco habits are potentially dangerous. There is also wide consensus that the health risks of smoking are much greater than those of snus.

In light of this, the effects of snus on smoking behaviour matters. Does it lower the prevalence of smoking? Does it help smokers to quit? Does it deter potential smokers from starting? Or is it a gateway into smoking for young people?

The Swedish public debate on snus has been influenced by strong views and important financial interests. The snus proponents have focused on snus use as a way of quitting smoking or as a safer alternative to smoking for new tobacco users. The opponents of snus have, besides the direct adverse health effects, pointed to the possible

role of snus as a gateway into smoking. In addition, they have argued that the availability of smoked and smokeless tobacco products may create dual use and increase total tobacco consumption.

To date, most behavioural studies in Sweden seem to indicate that rather than being a gateway into smoking, snus is associated with less smoking and/or has served as a way out of smoking [13–23], but some evidence in the United States questions the possibility of extending the validity of these results beyond the case of Sweden [24]. In addition, there is little evidence on sex differences or on the role of snus during tobacco initiation among young people [13,23,25–27]. The European Union (EU) has banned the marketing of snus in all member states except for Sweden. An EU scientific committee concludes that there is not enough evidence to draw any conclusions on the effects of snus either on smoking cessation or initiation [13].

Evidence from randomized trials and cohort studies over time has been sparse. The present cohort study allows analyses of individuals' development of snus and smoking habits over 8 years in the late 1980s and early 1990s, the period during which Swedish males attained the World Health Organization (WHO) 20% target for smoking. While focusing on this specific historical context, the analysis may shed some light in general on the effects that a long-standing presence of snus in a population may have on tobacco smoking.

Study questions

Smoking initiation and cessation happens in two separate population groups, non-smokers and smokers. The presence of snus may contribute to elevated direct health risks and be a gateway into smoking for non-smokers while at the same time helping smokers to stop smoking. For non-smokers, snus may either serve as a gateway into or as an alternative to smoking. Any overall risk assessment of snus use in a society must consider:

- 1 the differential size of the two population groups;
- 2 the potentially different behavioural effects that snus use may have in different groups; and
- 3 the health risks of both forms of tobacco.

In this paper we focus on the behavioural effects, and specifically on the role of snus as a gateway or a way out of smoking. In order to arrive at a reasonable judgement, at least four different questions need to be answered:

- 1 Do snus users smoke less than non-snus users (and vice versa), or are snus users more likely to smoke (and vice versa)?
- 2 Does the use of one form of tobacco in one year affect the likelihood of using the other product in subsequent years?

- 3 Is the risk of smoke initiation higher among snus users?
- 4 Is the chance of smoking cessation enhanced by the presence of snus as an alternative?

MATERIALS AND METHODS

General approach

The Swedish Level of Living Survey (ULF) is an annual national survey performed by Statistics Sweden. It collects information on social conditions, including health, on a nationally representative sample of some 15 000 respondents collected over 2 years. The survey uses a sampling design where a fraction of the sample returns after 8 years. The survey has an annual part and a supplement which changes in 8-year waves and stays for 2 consecutive years. The annual survey contains questions about daily smoking, and the health supplement measures daily snus. We used the longitudinal part of the samples from 1988/9 and 1996/7 to obtain responses on the questions: 'Do you smoke daily?' and 'Do you use snus on a daily basis?' for the same males 8 years apart.

The socio-economic factors involved in smoking cessation were studied on parts of the same material, using the 1980/1 and the 1988/9 survey panel data [28]. Snus behaviour was not studied, but some descriptive results on gross flows were reported. The reported flows between categories were quite symmetrical: 5% of non-smokers started to smoke, 5% of non-smokers started to use snus, 5% of snus users started to smoke and 5% of smokers started to use snus. Simultaneous use dropped from 5 to 3%.

The data used for the present analysis consists of panel tables derived from 21 56 males between 16 and 84 years of age at the first interview who responded to both questions in both interviews. During the late 1980s and early 1990s, snus was still too rare among females (between 0.6 and 0.9%) to make an analysis of them reliable. Accordingly, the analysis is restricted to adult males.

Panel (cohort) tables of survey year (1988/9 or 1996/7) by daily use of snus by daily smoking (yes/no) were analysed with logistic models for contingency tables. Ample descriptions of the general methods for log-linear and logistic analysis of contingency table data are found in the literature [29–32], albeit used more rarely in epidemiology than logistic regression of non-grouped data. Methods for contingency table analysis adapted to causal and longitudinal modeling of panel (cohort) data are described by Duncan [33,34]. Using these methods, competing hypotheses on the relationship between snus and smoking were tested as sets of hierarchically related contingency table models and compared in terms of model fit.

Analyses of the whole population

The cross-sectional association between use of snus and smoking

The association between snus use and smoking was examined for each interview occasion separately to assess whether current snus users smoke more than non-users, or whether people tend to stick to one of the habits.

Time-lagged analysis: does use of one product lead to subsequent use of the other?

In order to decide whether use of one product affects the likelihood of using the other in a later year, we studied the cross-lagged associations between the tobacco habits in 1988/9 and 1996/7. The questions addressed were:

- 1 Was snus use in 1988/9 associated with smoking in 1996/7?
- 2 Was smoking in 1988/9 related to snus use in 1996/7?
- 3 If yes to both, which association was stronger?

This analysis reveals whether snus use had a stronger influence on smoking than smoking had on snus while controlling for the secular trends in each habit over time.

Separate analyses of non-smokers and smokers

In the next step we analysed the 1988/9 non-smokers and smokers separately. For non-smokers we examined the association of snus use in 1988/9 with future smoking in 1996/7. We also looked at whether snus was more prevalent in 1996/7 among former smokers than among current smokers or consistent non-smokers. If so, this would indicate that snus had been used as a replacement for smoking.

Time-lagged association models (like causal models in general) normally identify causation by temporal order on the assumption that causes precede their effects. In the current models, however, smoking is always regarded as the outcome, and snus use as the exposure. Because the question concerns the effect of snus, whether already used or whether acting as a possible future alternative for the individual, we regarded snus as a potential contributing factor to smoking behaviour regardless of which habit appeared first.

Separate logit regression analyses were performed for non-smokers and smokers in 1988/9. Smoking in 1996/7 was the outcome. We looked at the following questions:

- 1 For non-smokers in 1988/9: was smoking in 1996/7 more or less common among snus users?
- 2 For smokers in 1988/9: was non-smoking in 1996/7 associated with an uptake of snus between 1988/9 and 1996/7?

Because tobacco habits are usually established at young ages and relatively difficult for the individual to change, the association between the habits may differ between age groups. We therefore analysed the data separately for two broad age groups, 16–44 and 45–84 years, at the beginning of follow-up in 1988/9.

The final models were tested for stability across the potential confounding effects of socio-economic status. No socio-economic confounding or interaction was found, so the results from these analyses have not been reported.

A number of different hypotheses about the associations were tested. We used conventional model fit statistics comparing models according to established contingency table methods for hierarchical testing. Initially, four general models were tested:

- 1 independence (= 'snus does not explain smoking behaviour');
- 2 the saturated model (= 'every subgroup of snus users differs from every other in terms of smoking habits');
- 3 the 'ever user' model (= 'all snus users shared a common enhanced or decreased risk of smoking in 1996/7'); and
- 4 the 'dose-response' model [= 'the likelihood of smoking in 1996/7 depended on the number of recorded years of snus use (1 or 2)'].

The models were evaluated and compared hierarchically using the likelihood ratio test (L_2) according to methods described in the literature on contingency table analysis [29,32,35] Computations were performed using SAS version 9.1™ and GAUSS 4.0™.

RESULTS

Prevalence in the study cohort

The male prevalence of snus use in the entire sample increased slightly from 18% to 19% during the 8 years of follow-up, but there were opposite trends in different age groups. Snus increased from 26% to 30% in the younger cohort, while decreasing slightly from 13% to 12% in the older group.

Smoking decreased in both age groups. The prevalence in the sample decreased from 24% to 18% in the younger cohort and from 26% to 19% in the older group. The snus and smoking prevalences include those who used both products simultaneously. The mixed use of snus and smoked cigarettes decreased in both groups, from 4% to 3% in the younger group and from 3% to 2% in the older group. The cohort prevalence trends are affected by excess mortality among smokers, but similar changes were observed in the nationally representative cross-section samples collected in the same survey during the same time-period.

Question 1: what is the association between snus and smoking at a given point in time?

In the younger group snus users had slightly less than half the odds of smoking compared to non-snus users (Table 1), but no association was found in the older group. The results were similar across interview occasions.

A subgroup analysis of the 1996/7 data reveals the origin of these age differences. Making use of the information over time, we stratified the sample into different tobacco user groups in 1988/9 (non-users of tobacco, snus users, smokers and mixed users). We then examined the associations between habits in 1996/7 within each of these subgroups and for the age groups separately (Table 2). For all subgroups of tobacco users in 1988/9 the associations between snus use and cigarette smoking in 1996/7 were, in general, negative, albeit not all significant, and very similar across the two age groups.

The difference was seen only for those who did not use any tobacco in 1988/9. For them, there was no association between the two habits in 1996/7 in the younger group, but in contrast there was a very strong positive association in the older group (i.e. odds ratio (OR) larger than 13). As expected, in the older group a large proportion of non-tobacco users (765 of 789) also stayed away from tobacco in 1996/7, but a small group of 24 people (3%) started to use tobacco. Under independence we would have expected no simultaneous users in such a small group, but in fact two people started mixed use of smoking and snus. It may be questionable to pay atten-

tion to such a small number of people, but this resulted in a strong and statistically significant positive association.

The general results show that having one tobacco habit decreased the likelihood of having the other simultaneously.

Question 2: does one product lead to subsequent use of the other?

Young snus users in 1988/9 had lower odds of being smokers in 1996/7 than non-snus users, but there was no significant association in the older age group (Table 3). For the older age group smoking in 1988/9 increased the likelihood of using snus in 1996/7, but no such association was found in the younger group.

Separate analyses of smokers and non-smokers

Several questions remained:

- 3 Were those who only used snus in 1988/9 more likely to begin smoking than those who did not use tobacco at all?
- 4 Was it common for those who only smoked in 1988/9 to change to snus between 1988 and 1996?
- 5 Were those who used both tobacco forms in 1988/9 more likely to quit smoking than those who only smoked?

Logit analyses were performed for the 1988/9 smokers and non-smokers separately to address these questions (the basic data tables have been excluded here, but can be obtained from the first author).

Question 3: the risk of starting to smoke for non-smokers

Even though the model of overall independence ($df = 3$) failed to fit the data for only the older group ($L_{2(16-44)} = 6.89$, $P = 0.08$, $L_{2(45-64)} = 13.09$, $P = 0.00$), there were better-fitting models than independence for both age groups. Hence, the results indicate that smoking initiation was associated with previous snus use.

Table 1 Cross-sectional association between snus use and smoking in 1988/9 and 1996/7.

| Age group (years) | Year | Est. OR | 95% CI |
|-------------------|--------|---------|---------|
| 16–44 | 1988/9 | 0.52 | 0.4–0.8 |
| | 1996/7 | 0.43 | 0.3–0.7 |
| 45–84 | 1988/9 | 0.85 | 0.6–1.3 |
| | 1996/7 | 0.81 | 0.5–1.3 |

CI: confidence interval; OR: odds ratio.

Table 2 Cross-sectional association between snus and smoking in 1996/7 for different user subgroups in 1988/9.

| | Est. OR (95% CI) | |
|--------------|------------------|------------------|
| | 16–44 years | 45–84 years |
| 1988/9 | | |
| No tobacco | 0.94 (0.3–2.9) | 13.66 (2.7–70.2) |
| Only smoking | 0.14 (0.06–0.3) | 0.14 (0.05–0.4) |
| Only snus | 0.20 (0.06–0.7) | 0.19 (0.03–1.07) |
| Mixed users | 0.40 (0.08–2.0) | 0.54 (0.16–1.3) |

CI: confidence interval; OR: odds ratio.

Table 3 Time-lagged associations between tobacco habits.

| | | Est. OR | 95% CI |
|--|-------|-------------------------------------|-----------|
| | | Snus user in 1988/9 (baseline = no) | |
| Smoked in 1996/7 versus non-smokers | 16–44 | 0.52 | 0.33–0.80 |
| | 45–84 | 0.90 | 0.58–1.40 |
| | | Smoked in 1988/9 (baseline = no) | |
| Snus user in 1996/7 versus non-users of snus | 16–44 | 0.98 | 0.70–1.36 |
| | 45–84 | 1.57 | 1.09–2.27 |

CI: confidence interval; OR: odds ratio.

The large majority of the ever users of snuff did not differ from the non-snus population in their risk of initiating smoking. This was true for 79% (286 of 362) of those who reported using snus in at least one of the two interview waves.

There was, however, a positive association between snus use and smoking initiation for a small group of young snus quitters (6% of the snus users in the younger cohort). Non-smokers who quit snus use between interviews had an estimated OR of 4.1 of starting to smoke compared to other non-smokers (six observed cases compared to the expected 1.5). For the younger group of 1988/9 non-smokers, 15% of the smoking initiation may therefore be attributed to previous snus use.

In the older cohort, a larger group containing both snus beginners and snus quitters had a common elevated risk of starting smoking compared to non-snus users and consistent snus users. The estimated OR was 8.2, corresponding to an attributable fraction of 27%.

In summary, 10 of the 53 people who started to smoke could be attributed to snus use. This amounts to an average attributable fraction of 18%. If this were interpreted in causal terms it would correspond to roughly one of five smoking initiators starting to smoke because of snus.

Questions 4 and 5: the opportunity to stop smoking for smokers

In general, the chances to stop smoking were higher for snus users. As with smoking initiation, the associations

differed between different age groups. The models of overall independence, the two general models postulating either common effects for 'ever snus users' or the common dose-response models were all rejected.

The subgroup analyses reveal that younger consistent snus users and snus beginners had a greater chance of stopping smoking (OR = 5.5) than snus quitters and non-snus users. In the older group, only snus beginners had such an elevated chance of quitting (OR = 6.6).

In general, smoking cessation was much more common than smoking initiation. Smoking cessation attributable to snus use was more common in the younger age group, where 26 of the 84 quitters could be attributed to snus. This represents an attributable fraction of 31%, whereas in the older age group the fraction was only 9%, or 11 of 116 quitters. Hence, the association between snus use and changes in cigarette smoking behaviour was much stronger in the younger cohort.

Summary of results

In Tables 4 and 5, the results of the separate analyses of smokers and non-smokers are summarized for each age and snus user group.

For the younger cohort, snus use contributed to more than six smoking quitters per starter (Table 5; 26 versus 4). The proportion of attributable quitting was twice the proportion of attributable smoking initiations (31% versus 15%). For the older cohort, there were slightly more than two quitters per smoking initiator (11 versus 5), but in contrast to the younger group, the fraction of

Table 4 Estimated odds ratios of change in smoking behaviour for snus users (versus baseline: non-snus users) in two age groups.

| Age (years) | Snus change 1988–96? | Smoke stop | Smoke start |
|-------------|----------------------|-----------------|-----------------|
| 16–44 | Quitter | Not significant | 4.1 |
| | Beginner | 5.5 | Not significant |
| | Consistent snus user | 5.5 | Not significant |
| 45–84 | Quitter | Not significant | 8.2 |
| | Beginner | 6.6 | 8.2 |
| | Consistent snus user | Not significant | Not significant |

Table 5 Estimated potential effects of snus on change in smoking behaviour; attributable fractions and numbers.

| Age (years) 1988/9 | Snus use 1988/9–96/7 | Attributable fractions | |
|--|----------------------------------|------------------------|-------------|
| | | Smoke stop | Smoke start |
| 16–44 | Quitter | None | 15% |
| | Beginner or consistent snus user | 31% | None |
| 45–84 | Quitter | None | 18% |
| | Beginner | 9% | 5% |
| | Consistent snus user | None | None |
| Attributable number of persons in the sample ($n_{16-44} + n_{45-84} = n_{16-84}$) | | 26 + 11 = 37 | 4 + 5 = 9 |

smoking initiations attributable to snus was 2.5 times higher than for smoking cessation ($18\% + 5\% = 23\%$ versus 9%).

Tables 4 and 5 show that snus is associated differentially with smoking behaviour in different groups. In total, we observed 37 smoking quitters and nine smoking starters over and above what would have been expected if snus use had been unrelated to smoking. The more evenly distributed attributable fractions reflect the fact that smoke quitting was much more common than initiation during this period.

DISCUSSION

The main result from this study is that in the 1990s snus use was associated with a greater incidence of smoking cessation than smoking initiation, which was attributable mainly to the associations observed in young males. The generalization of this conclusion to other contexts depends on if, and to what extent, the associations are sensitive to the secular trends in tobacco habits.

The effects interacted with age. Changes in tobacco behaviour are probably less frequent in older age groups. It also seems likely that snus use had different effects in cohorts who grew up during different calendar time-periods, reflecting changes in popular attitudes towards cigarette smoking and snus.

Smokers who started using snus were much more likely than non-snus using smokers to quit smoking. This was also true for consistent snus users in the young cohort. Hence, it is reasonable to conclude that some smoking cessation in Swedish males can be attributed to snus use. On the other hand, snus quitters were more likely than non-snus users to start smoking. The association was stronger in the older age group, but the overall net effect was small, as this group represented very few people. In the older age group, snus starters were also more likely than non-snus users to start smoking. Hence, it is reasonable to attribute a part of the male smoking initiation to snus use. In summary, snus seems to reduce smoking in male smokers, but it may increase smoking somewhat among male non-smokers.

Other studies looking at the gateway effects of Swedish and (in one case) US snus have arrived at the conclusion that snus reduces rather than increases smoking prevalence [16–20,22], which agrees with our overall observation of the net trend in the 1990s. However, unlike others we studied the gross flows in detail leading to the detection of the differential role that snus had in different groups. Snus seems to serve both as a way out of smoking for many smokers and as a gateway into smoking for some non-smokers. This discovery was based on separating the population into smokers and non-smokers and

further breakdown of these population segments into different snus user groups. From a public health viewpoint this finding is important.

During the 1990s there was a secular decrease in smoking in the male population. In this context the observed associations between snus use and smoking contributed to considerably more smoking cessation than smoking initiation. We observed four to six times as many smoking quitters than people starting smoking attributable to snus. If the associations proved to be independent of the underlying secular decline in smoking, then an increasing secular trend would reverse the advantageous trade-off.

Advantages and limitations of the study

This is one of few studies where the behavioural patterns have been studied in cohort data over a long period focusing on the gateway function of snus. Hence, it provides more distinct observations leading to more empirically grounded detailed hypotheses about snus and smoking behaviour than before, among them that snus affects future smoking behaviour differently for current smokers and current non-smokers.

The very low prevalence of snus use among Swedish women means that we could not assess whether there was an interaction between sex and the role of snus. The strong increase in snus use among young females during the first years of the 2000s will make it possible to study this in more recent survey data.

The studied behaviour is probably culture- and gender-specific. As noted above, both the direct effects and the impact of snus on smoking may have been different in other countries (e.g. in the United States and Canada).

Our study does not answer questions about trends in snus use and smoking beyond 8 years. We do not know whether the people who gave up smoking in favour of snus stayed with snus in the long term, returned to smoking, added smoking to their snus use or quit tobacco altogether. These issues can be studied by collecting more recent follow-up data on the study cohort.

Declarations of interest

None.

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