


Oral lesions associated with daily use of snus, a moist smokeless tobacco product. A cross-sectional study among Norwegian adolescents

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ABSTRACT

Objective: Use of snus, a moist, smokeless tobacco product, may lead to local changes in the oral mucous membrane in the area where the snus is placed. It can also cause irreversible gingival retraction. This cross-sectional study aimed to investigate the relationship between use of snus, oral mucosal lesions (snus induced lesions) and gingival retractions among adolescents in Norway.

Material and Methods: All 18–20 years olds visiting public dental health clinics in the south-eastern region of Norway between October 2015 and December 2016 were invited to participate. All participants ($n = 1363$) filled in an electronic questionnaire before a clinical examination. Of these, 216 used snus daily.

Results: Snus induced lesions were observed in 79.2% of daily snus using participants. In adjusted regression analyses, the odds of having a more severe lesion as opposed to a less severe lesion were 1.12 times greater for each additional box of snus used in a month ($p < .01$). Women were 46% less likely to have a severe lesion than men ($p = .03$). Gingival retractions were observed in 18.4% of the participants. The odds for dental retraction were significantly higher by 34% for each year of snus use.

Conclusions: Most of the adolescents using snus had snus induced lesions, whereas approximately one-fifth had gingival retractions. The severity of the lesion and gingival retraction increased with the amount of snus boxes used and the duration of the snus use, respectively.

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Introduction

Snus, a moist smokeless tobacco product, is on the market in either loose or pouched form. When used, the product is commonly placed under the upper lip. Snus is banned in the European Union (EU); however, an exception exists for Sweden. There is no ban in Norway, a non-member of the EU. In Norway, snus consumption has increased substantially over the last 10–20 years [1]. At present, the use of snus is common among adolescents and young adults; 29% of men and 12% of women aged 16–24 years use snus daily [2].

Several adverse health outcomes, such as cancer, adverse effects on pregnancy, and cardiovascular events have been associated with the use of snus [3]. Use of snus may also lead to local changes in the oral mucosa, so-called snus induced lesions, in the area where the snus is placed [4]. These changes are commonly seen as white and/or red changes with or without furrows, which can be graded according to their clinical appearance [5]. Reversibility of the lesions are reported when the individual stops using snus [6,7]. However, one study reported that not all lesions disappeared six months after quitting, specifically among users of nicotine replacement therapy [8]. Use of snus can also cause irreversible retraction of the gingiva and may lead to local periodontal changes (loss of supporting tissue) in the area

where the snus is placed [9,10]. Thus, root cement and root dentin may be exposed, which may lead to tooth hyper sensibility. Although sparse data are available, previous studies have not shown any significant association between the use of snus and periodontal disease (general loss of dental supporting tissue) [11–13].

The high prevalence of use of snus among adolescents in Norway and the impact this may have on oral lesions is of concern. However, there is little knowledge about how gender, duration of use, type of snus (pouched or loose), and amount of snus used impact these oral outcomes. The dental service for adolescents up to 18 years of age is free of charge in Norway. Adolescents who regularly attend the dental health service may provide the dental health professionals with an opportunity to prevent and detect the use of tobacco products in general as well as the use of snus at an early age. However, a previous study in Norway reported that most dental professionals lacked knowledge about the impact of snus use on oral health [14]. Thus, prevalence data on oral mucosal lesions and gingival retractions is important to increase knowledge among the dental health professionals.

The aim of the study was to investigate factors associated with snus induced lesions and gingival retractions among adolescent daily snus users.

Materials and methods

The present study is a cross-sectional study of 18–20 years olds visiting public dental health clinics in the south-eastern region of Norway between October 2015 and December 2016. Nine dental clinics, both urban and rural, were included. The counties involved were Hedmark, Oppland, Østfold, and Oslo (as they were named before the Norwegian county administration reform in 2020). All clinicians (dentists and dental hygienists) working at the dental clinics agreed to participate in the study. Before the data collection, the clinicians were given a lecture on the clinical appearance of oral lesions, how to record all necessary information for the study in the computer software, and discussing the severity of oral lesions based on clinical photos of some selected patient cases.

All residents in Norway aged 20 years and younger are offered regular dental examinations and treatment in the public dental health service (PDS) in Norway. The service is free of charge for the age group 0–18 years, while the group aged 19–20 years has a 75% discount. All patients in the age group 18–20 years who visited the participating dental clinics during the recruitment period received an invitation to participate in the study concurrent with their regular dental examination in the PDS. The sample was not randomized but rather based on age and affiliation to the selected clinics (quota sample). All participants filled in an electronically pre-coded questionnaire (Easy Research, Oslo, Norway) before the clinical examination where they were asked at what age they started using snus, type of snus (loose or pouched), how often they used snus (sometimes/daily) and number of snus boxes used per month.

The clinicians employed at the dental clinics were instructed to examine the patients thoroughly with respect to snus induced lesions and some other clinical background variables. Snus induced lesions were graded according to Axell's scorings of severity (degree 1–4) [5]. Gingival retractions were graded as either present or non-present. The clinicians also recorded the participants' DMFT-values and collected information needed to calculate Simplified Oral Hygiene Index (OHI-S) [15]. According to the protocol of OHI-S, Debris Index and Calculus Index were collected from four posterior and two anterior teeth: the buccal surfaces of both upper first molars (tooth 16 and 26), the lingual surfaces of both lower first molars (tooth 36 and 46), the labial surface of the upper right first incisor (tooth 11) and the labial surface of the lower left first incisor (tooth 31). Each of these indexes is based on numerical determinations representing the amount of debris or calculus found on the preselected tooth surfaces (0: No debris or calculus present, 1: Debris/calculus covering less than one-third of the tooth surface, 2: Debris/calculus covering more than one third, but less than two thirds, of the exposed tooth surface. 3: Debris/calculus covering more than two-thirds of the exposed tooth surface). Debris and Calculus Index values were calculated by adding all scores and dividing by the number of surfaces scored. Finally, Simplified Oral Hygiene Index was calculated by the formula $OHI-S = Debris\ Index + Calculus\ Index$.

All collected clinical data were entered by the clinician or an assistant into an electronically questionnaire software (Easy Research, Oslo, Norway) while performing the oral examination

Statistical methods

Descriptive statistics in the form of medians (minimum, maximum) were used to describe all the numerical variables because the variables did not satisfy the normality assumption. We used the Mann–Whitney *U*-test and the Kruskal Wallis *H* test to compare median differences between the groups, respectively. Categorical variables were described using frequencies and percentages (proportions) and associations between groups were assessed using the Chi-square test.

Categories of our primary outcome, lesion severity, have a natural ordering from degree 0 (no lesion) to degree 4. Therefore, we investigated the association between lesion severity and patient level factors using the proportional odds model (POM), also called the ordered/ordinal logistic regression model. A characteristic feature of the POM is that the relationship between each pair of the categories of lesion severity is the same. This means that model estimates that describe the relationship between lesion severity degree 0 vs. degree 1, degree 2, and degree 3 combined are the same model estimates that describe the relationship between degree 0 and degree 1 combined vs. degree 2 and degree 3 combined, and so on. This assumption is known as the parallel regression assumption or the proportional odds assumption, hence the name of the model. We checked the proportionality assumption using the **omodel** command in Stata and concluded that the assumption was not violated. We also explored patient level factors that were associated with dental retraction, a binary measure for each patient, coded 1 if the patient experienced dental retraction or 0 if not, using a binary logistic regression model. The independent patient level variables that we considered were age in years, duration of snus use, number of snus boxes used in a month, DMFT, OHI-S, and gender (F/M).

The analyses of both lesion severity and dental retraction were preceded by two-step modeling. First, we fitted unadjusted models to assess patient level factors that were associated with the dependent variables. Second, in fitting the adjusted models, we purposefully selected independent variables ($p < .20$) from step 1. We also considered full models (models adjusted for all possible independent variables) and compared them to models purposefully fitted to the data using the Bayesian information criterion (BIC). The BIC states that the model with the lowest BIC is considered the best. All analyses were performed in StataSE 17 (StataCorp, College Station, TX, USA) and the significance level was set at $\alpha = 0.05$.

Ethical considerations

The study protocol for the present study was approved by the Regional Committee for Medical Research Ethics (ID:

2015/445). Written consent was obtained from all participants. Anonymity of the participants was ensured by Easy Research.

Results

A total of 1363 patients provided written consent to participate in the study and were examined clinically by a dentist or a dental hygienist. In accordance with the inclusion criteria of the study, all patients were aged 19–20 years. The sample constituted approximately one-third of all patients aged 18–20 years under the supervision of the participating clinics in 2016.

Only 216 of the 1363 participants used snus daily. These 216 individuals were used for the analyses in the present paper since the aim of the study was to evaluate risk factors for developing more severe oral lesions in individuals with daily exposure. Of the 216 daily snus users, 36.4% were female and 63.6% male. The median duration of snus use was 3.1 years. The majority of the participants used pouched snus (89.4%). Only one participant reported to use loose snus only, while 10.1% used both loose and pouched snus.

Snus induced lesions were observed in 172 (79.2%) of the snus users and graded for severity according to Axell [5]. Most of the snus induced lesions were of degree 1. No participants had snus induced lesions as severe as degree 4. The characteristics of the study participants in relation to the severity of the lesions are presented in Table 1. From the ordered logistic regression model, we observed that for each additional box of snus used in a month, the odds of having

a more severe lesion as opposed to a less severe lesion were 1.12 times greater ($p < .01$) (Model 2, Table 2). The results further showed a non-significant, 18% increase for each year of snus use for having a more severe lesion. In addition, our results showed that women were 46% less likely to have a severe lesion than men ($p = .03$).

The predicted probabilities of having a certain degree of lesion severity for men and women, based on the duration of snus use or number of snus boxes used in a month, are presented in Figure 1. Depending on the duration of snus use and number of snus boxes used in a month, our findings showed that men were more likely to have degree 2 and degree 3 lesions compared to women.

Gingival retractions were observed in 18.4% of the daily snus users, all in proximity to the upper incisors. Only four of these retractions were observed in participants where no snus induced lesion was visible. In approximately two-thirds of the cases, two or more teeth had retractions (Table 3). From the binary logistic regression model, we observed that the odds for dental retraction were significantly higher by 34% for each year increase in snus use duration (Table 4).

Discussion

Snus, a moist smokeless tobacco product, has become increasingly popular in the last decades among Norwegian adolescents of both genders [2]. Snus is consumed either in loose form or as premade pouches. Most often the snus is placed under the upper lip in contact with both the alveolar and labial oral mucosa. Localized clinical visible mucosal

Table 1. Characteristics of the study participants by lesion severity ($n = 216$ everyday snus users).

	Severity of snus induced lesions						<i>p</i> -Value
	No lesion ($n = 45$, 20.8%)	Degree 1 ($n = 106$, 49.0%)	Degree 2 ($n = 36$, 16.7%)	Degree 3 ($n = 29$, 13.4%)	Degree 4 ($n = 0$, 0.0%)	Total ($n = 216$)	
Gender: <i>n</i> (%)							.61
Female	20 (25.3)	38 (48.1)	11 (13.9)	10 (12.7)	–	79 (100.0)	
Male	25 (18.2)	68 (49.6)	25 (18.2)	19 (13.9)	–	137 (100.0)	
Snus use duration: median (range*)	3.1 (0.3, 7.7)	3.0 (0.3, 7.4)	3.4 (0.8, 6.9)	3.5 (1.0, 8.2)	–	3.1 (0.3, 8.2)	.19
Number of boxes per month: median (range*)	6.0 (2.0, 27.0)	8.0 (2.0, 25.0)	9.5 (4.0, 25.0)	13.0 (4.0, 41.0)	–	9.0 (2.0, 41.0)	<.01
DMFT: median (range*)	3.0 (0.0, 20.0)	3.0 (0.0, 16.0)	3.0 (0.0, 16.0)	3.0 (0.0, 15.0)	–	3.0 (0.0, 20.0)	.37
Simplified Oral Hygiene Index (OHI-S): median (range*)	0.3 (0.0, 6.0)	0.5 (0.0, 3.0)	0.3 (0.0, 3.0)	0.8 (0.0, 3.2)	–	0.5 (0.0, 6.0)	.16
Loose/pouched							.46
Pouched	43 (22.3)	93 (48.2)	32 (16.6)	25 (13.0)	–	193 (100.0)	
Loose and pouched	2 (8.7)	13 (56.5)	4 (17.4)	4 (17.4)	–	23 (100.0)	

*Range is defined as (minimum, maximum).

Table 2. Proportional odds ratios (PORs) with 95% CIs obtained from the ordered logistic regression model showing patient factors that were associated with snus lesion severity ($n = 216$).

Patient factors	Unadjusted		Adjusted ^a (BIC = 531.02)		Adjusted ^b (BIC = 502.47)	
	POR (95% CI)	<i>p</i> -Value	POR (95% CI)	<i>p</i> -Value	POR (95% CI)	<i>p</i> -Value
Gender (ref: male)						
Female	0.73 (0.43, 1.23)	.12	0.55 (0.31, 0.97)	.04	0.54 (0.31, 0.93)	.03
Snus use duration	1.22 (1.04, 1.45)	.02	1.19 (1.00, 1.41)	.05	1.18 (0.99, 1.40)	.06
Number of boxes	1.12 (1.07, 1.17)	<.01	1.12 (1.07, 1.18)	<.01	1.12 (1.07, 1.17)	<.01
DMFT	0.95 (0.89, 1.01)	.24	0.95 (0.88, 1.02)	.17		
Simplified Oral Hygiene Index (OHI-S)	1.11 (0.79, 1.57)	.56	0.92 (0.63, 1.34)	.65		
Loose/pouched (ref: pouched)						
Loose and pouched	1.60 (0.73, 3.49)	.24	1.02 (0.43, 2.41)	.97		

The adjusted model^a is a full model (adjusted for all independent variables) whereas adjusted model^b is based on variables purposefully selected ($p < .20$) from the unadjusted models. Based on the BIC, adjusted model^b fits the data better than adjusted model^a.

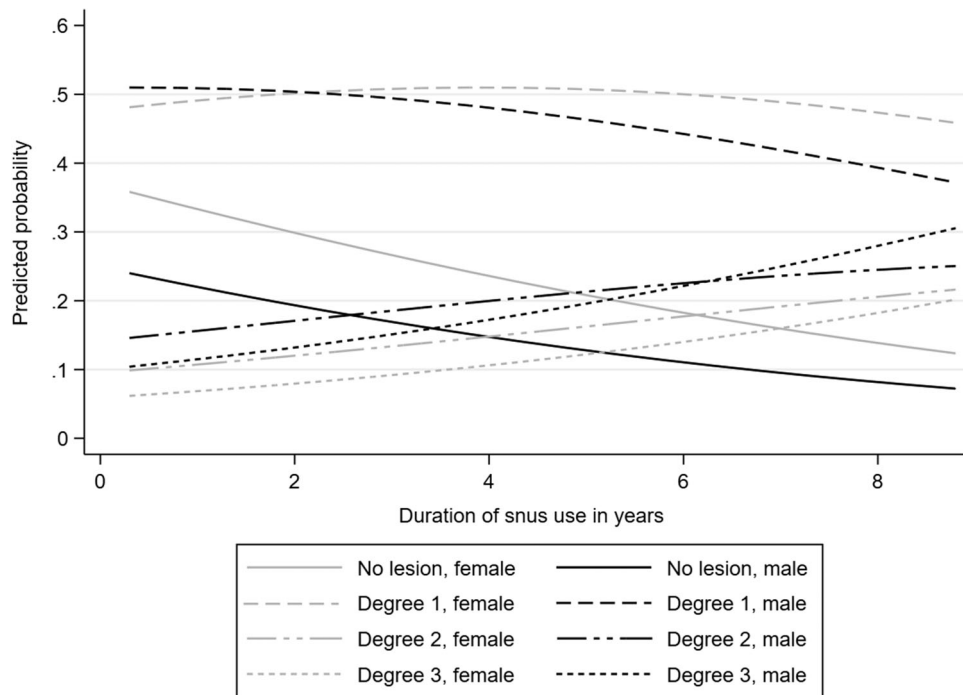


Figure 1. Predicted probabilities for lesion severity over a period of snus use by gender. The predicted probabilities of no lesions were lower for men than women, while the predicted probabilities for degree 1 and degree 2 were higher for men.

Table 3. Characteristics of the study participants by gingival retraction ($n = 216$ snus users).

	Gingival retraction		Total	<i>p</i> -Value
	Yes ($n = 40$)	No ($n = 176$)		
Gender: <i>n</i> (%)				.22
Female	18 (22.8)	61 (77.2)	79 (100.0)	
Male	22 (16.1)	115 (83.9)	137 (100.0)	
Snus use duration: median (range*)	3.8 (0.3, 8.2)	3.1 (0.3, 7.7)	3.1 (0.3, 8.2)	.03
Number of boxes per month: median (range*)	10.0 (2.0, 27.0)	8.0 (2.0, 41.0)	8.5 (2.0, 41.0)	.16
DMFT: median (range*)	3.5 (0.0, 15.0)	3.0 (0.0, 20.0)	3.0 (0.0, 20.0)	.50
Simplified Oral Hygiene index (OHI-S): median (range*)	0.7 (0.0, 3.0)	0.5 (0.0, 6.0)	0.5 (0.0, 6.0)	.15
Use of toothbrush				.11
Once per day/sometimes during the week/once a week	7 (11.7)	53 (88.3)	60 (100.0)	
\geq Twice a day	33 (21.2)	123 (78.8)	156 (100.0)	
Loose/pouched				.67
Pouched	158 (81.9)	35 (18.1)	193 (100.0)	
Loose and pouched	18 (78.3)	5 (21.7)	23 (100.0)	

*Range is defined as (minimum, maximum).

Table 4. Odds ratios (ORs) with 95% CIs obtained from the binary logistic regression model showing patient factors that were associated with gingival retraction ($n = 216$).

Patient factors	Unadjusted		Adjusted ^a (BIC = 223.45)		Adjusted ^b (BIC = 208.51)	
	OR (95% CI)	<i>p</i> -Value	OR (95% CI)	<i>p</i> -Value	OR (95% CI)	<i>p</i> -Value
Sex (ref: male)						
Female	1.54 (0.77, 3.09)	.22	1.63 (0.73, 3.63)	.23		
Snus use duration	1.33 (1.07, 1.66)	.01	1.37 (1.08, 1.73)	.01	1.34 (1.07, 1.69)	.01
Number of boxes	1.05 (0.99, 1.10)	.10	1.02 (0.96, 1.08)	.52	1.03 (0.97, 1.09)	.34
DMFT	0.99 (0.91, 1.08)	.83	0.97 (0.88, 1.08)	.59		
Simplified Oral Hygiene Index (OHI-S)	1.16 (0.77, 1.75)	.49	1.05 (0.66, 1.67)	.84		
Use of toothbrush (ref: \geq twice a day)						
Once per day/sometimes during the week/once a week	0.49 (0.20, 1.18)	.11	0.42 (0.16, 1.11)	.08	0.43 (0.16, 1.11)	.08
Loose/ pouched (ref: pouched)						
Loose and pouched	1.25 (0.44, 3.61)	.68	1.76 (0.55, 5.62)	.34		

The adjusted model^a is a full model (adjusted for all independent variables) whereas adjusted model^b is based on variables purposefully selected ($p < .20$) from the unadjusted models. Based on the BIC, model^b fits the data better than model^a.

changes, so called snus induced lesions, have been described to occur in the area where the snus is placed. In the current study, $\sim 80\%$ of current snus users had developed a snus

induced lesion. Previous studies have reported that snus induced lesions are a common finding [16,17]. The severity of mucosal changes have been described to depend on the

type of snus used, where those using the pouched form had less severe lesions [18]. In accordance with the findings in the present study, the amount of snus used has been reported to affect the clinical severity and histologic changes of the lesion more than the duration of use [18,19]. In addition to characteristics of use, the clinical and histological appearance of the lesions have been described to be affected by the nicotine content and pH of the snus [20,21].

The question whether long-term use of Swedish snus, a product that contains carcinogenic tobacco specific nitrosamines, may cause oral cancer has been a topic for several studies. However, few studies on oral cancer have had access to information regarding the exact subsite for cancer within the oral cavity, such as those located on the inside of the upper lip where the snus is most often placed. In a cohort study on snus induced lesions, three incident cases of oral cancer were reported during follow-up, two of the participants were concomitant smokers, and none of the cancer occurred at the site of the original lesion [7]. The authors reported a higher-than-expected oral cancer risk, but the study was underpowered to exclude a chance finding, still suggesting a 2.3-fold excess risk. In accordance, a Swedish case series among long-term users of snus, oral cancers were observed at the same locations as where the portions had been placed [22]. In a study by Axell et al., an incidence of 0.5 cases of oral cancer per 100,000 users of snus was suggested [23]. Oral cancer is a rare cancer, constituting 0.7–0.8% of all cancers in the Nordic countries [24], and relevant subsites are even rarer. We expect the excess risk of oral cancer associated with the use of snus to be relatively low from a public health perspective and challenging to estimate.

The use of snus has also been described to cause gingival retractions in the area where the snus is placed [9,10,18]. In the current study, 18.5% of daily snus users were observed to have gingival retractions on one or more teeth. As reported regarding the occurrence and severity of snus induced lesions, loose snus has been associated with a higher risk for gingival retractions [18]. Other factors, such as the amount of use and duration, have previously been shown to be of less importance [18]. However, in the present study, we observed a significantly increased risk for gingival retractions in relation to the duration of use, while the amount of use did not show a significant association. The finding that adolescents may develop irreversible gingival retractions after a relatively short-term use shows the importance of informing both patients and clinicians to avoid such permanent damages.

For the snus induced lesions, we observed an association between males and more severe mucosal changes compared to females. To our knowledge, this has not been described previously. One possible explanation for this could be related to the different content of nicotine in the snus product preferred by the two genders, as snus is available in different nicotine strengths. In addition, loose snus has been associated with more severe lesions compared to pouched forms. Loose snus was only reported to be used by male participants. Exclusive use of loose snus was only reported for one participant, and ~10% of the participants used both types. Thus, we combined the participants who used both loose

and pouched snus and the exclusive user of loose snus into one variable. Nevertheless, no significant association was observed between the type of snus used and the severity of lesion among the participants in the present study. In general, studies on the health effects of snus use in women are lacking, possibly due to the historic low prevalence of use among women in Sweden, where most studies so far have been conducted. Thus, our findings merit further investigation into the adverse health effects of snus on women.

The median age of the initiation of snus use in the current population has previously been reported to be 16 years of age [25]. In addition, it was reported that both parental snus use and smoking were associated with an increased risk of snus initiation, use, and amount of use. An increased risk of using snus was associated with male gender, no educational plans, or planning for further vocational education. The amount of snus used was higher for current snus users with a previous smoking history and among those planning for further vocational education [25]. The finding that both genders at an early age had gingival retractions, shows that prevention of snus use should begin at the elementary school level before the initiation of snus use occurs. This is an important message to dental health care professionals. However, in Norway, a majority of dentists and dental hygienists stated that they lacked sufficient knowledge about the impact of snus use on oral health [14]. The dental health service often sees patients at regular intervals and may have an opportunity to prevent use, engage in, and follow up patients that are dependent on nicotine- and/or tobacco products.

The primary weakness of our study is the cross-sectional design, where the use of snus, type, amount, and duration, was self-reported. We did not perform a calibration of the clinicians who examined the participants; however, we provided a lecture at the start of the study with each participating dental clinic, where the clinical appearance of oral lesions was taught, and the severity of oral lesions based on clinical photos of some selected patient cases were discussed. A strength of the current clinical and questionnaire-based study is that it included ~40% of all the patients aged 18–20 years under the supervision of the participating clinics in the year 2016. The recruited population consisted mainly of patients summoned for a recall examination. The population of participants covers both rural and urban areas; thus, we assume that our study population is representative of the general population of this age group and has a low risk of selection bias.

A majority of the adolescents using snus in the present study were observed to have snus induced mucosal lesions, whereas approximately one-fifth of the adolescents had gingival retractions. The findings show that the prevention of snus use should begin at an early age. Dental health care professionals could take an active role in the prevention of snus use, as symptoms occur early in the oral cavity.

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Author contributions

VA, SEK, RB, and HV conceived the study. IM assisted in the statistical analyses. All authors (SEK, VA, IM, RB, and HV) participated in writing the manuscript, and have read and approved the final version.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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