RESEARCH REPORT

ADDICTION   SSA

The relationship between smokeless tobacco (snus) and anxiety and depression among adults and elderly people. A comparison to smoking in the Tromsø Study

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Abstract

Aims: To (i) define the characteristics of snus users compared with non-users and smokers and (ii) define the relationship between snus use and self-reported anxiety and depression and compare it with the relation between smoking and anxiety and depression.

Design, setting and participants: A cross-sectional study based on data from the Norwegian population-based survey, the Tromsø Study (2015–16). A total of 32 591 people aged 40 years and older in the municipality of Tromsø were invited to attend. There were 21 083 respondents, giving a 65% attendance rate.

Measurements: Tobacco use was assessed by current and previous use of snus or cigarettes. Symptoms of anxiety and depression were measured using the Hospital Anxiety and Depression Scale (HADS).

Findings: Snus users were more often male, were younger and had higher income and higher alcohol consumption than smokers and non-users of snus. In a linear regression analysis, we found no significant association between current snus use and anxiety and depression after adjusting for background variables. However, there was a positive association between previous snus use and anxiety among males [adjusted beta = 0.258; 99% confidence interval (CI) = 0.023–0.492]. Regarding anxiety, the adjusted beta-coefficients for current smoking were 0.425 (99% CI = 0.184–0.666) for females and 0.303 (99% CI = 0.084–0.522) for males. Concerning depression, the adjusted beta coefficients for current smoking were 0.569 (99% CI = 0.358–0.780) for females and 0.281 (99% CI = 0.060–0.503) for males.

Conclusions: In Norway, current snus users differ from current smokers by having a higher socio-economic status and no detectable association with anxiety and depression. This suggests that the relationship between tobacco use and anxiety and depression is associated with the administration method.

KEYWORDS
Anxiety, depression, population study, smoking, snus use, smokeless tobacco

INTRODUCTION

There is a well-established association between cigarette smoking and anxiety and depression [1]. The prevalence of daily smoking in Norway was approximately 30% among females and 50% among males in the 1970s [2]. There was a steady decline in both sexes from the turn of the millennium, and daily smoking decreased to 9% of the population in 2019. While smoking prevalence has decreased, there has been a rise in daily use of the smokeless tobacco product 'snus' [2, 3].

There are many different types of smokeless tobacco. They contain different substances and nicotine levels, and are administrated in different ways. Some are sniffed into the nasal cavity (snuff), chewed (chewing tobacco) or placed behind the lip (dipping tobacco, snus). Snus is a moist oral snuff that comes either as a loose, ground tobacco or in small pouches much like tea bags. It is usually placed behind the upper lip. It is the most commonly used smokeless tobacco in Norway [2] and Sweden [4], but is not frequently used in other parts of the world. The sale of snus is prohibited in all European Union (EU) countries except Sweden [5]. In 2019 the US Food and Drug Administration announced that snus could be marketed as a tobacco product with fewer health risks than cigarettes [6].

The prevalence of daily snus use in Norway has doubled during the last decade and in 2019 was at 14% [2]. This rise in prevalence has been most pronounced among adolescents and young adults, especially women [2]. The number of daily snus users has surpassed the number of daily smokers in Norway. A possible reason for this trend could be that snus is cheaper, less prohibited, more discrete than cigarettes and is considered less harmful than cigarettes among Norwegian adolescents [7].

Few studies have investigated how smokeless tobacco in general and snus in particular is related to anxiety and depression, and several of these studies could not find any association [8–10]. However, a cross-sectional study on Norwegian adolescents found that snus users had more symptoms of depression compared to non-users of tobacco [3]. A prospective study on adolescent twins in Finland found that early-onset depressive disorders significantly predicted later use of smokeless tobacco [11]. It is difficult to compare the different results between countries due to demographic, judicial and cultural differences concerning the use of smokeless tobacco. Studies on snus should thus be based on populations such as Norway, where the prevalence of snus use is relatively high.

In a report on the health risks related to snus use [12], the Norwegian Institute of Public Health included only two studies concerning snus and psychiatric disorders [3, 13]. In both studies, the participants were adolescents and young adults. This illustrates the need for more research on snus and its relation to mental disorders in general, and particularly among adults and elderly people. Hence, the aims of the present study were to: (i) describe the characteristics of snus users versus non-users of snus and compare these to the characteristics of smokers versus non-smokers; and (ii) compare the relationship between snus use and self-reported anxiety and depression to the relationship between smoking and anxiety and depression.

METHODS

Participants

The Tromsø Study is a series of population-based cross-sectional studies conducted in the municipality of Tromsø in North Norway [14]. The Tromsø Study has been repeated in seven waves; the most recent wave (hereafter Tromsø 7) was conducted in 2015 and 2016, from which the data for the present study were taken. A total of 32 591 people from the age of 40 years and older were invited to attend. There were 21 083 respondents, giving a 65% attendance rate [15].

Measures

Dependent variables

Anxiety and depression
Symptoms of anxiety and depression were measured through the self-report instrument the Hospital Anxiety and Depression Scale (HADS) [16]. HADS has one subscale for anxiety (HADS-A) and one for depression (HADS-D). Each scale contains seven items, with four different answer alternatives scored 0–3. For each subscale, the total score ranges from 0 to 21. A higher score indicates higher levels of anxiety/depression. The seven HADS-A and the seven HADS-D items were used to make two continuous variables for the sum of the respondents' HADS-A and HADS-D scores. This was achieved by multiplying the mean score of non-missing items with seven (the number of subscale items) as a method of imputation. Cronbach's alpha was at 0.772 for HADS-A and 0.732 for HADS-D.

Explanatory variables

Sex and age
Sex was assessed through self-reported sex. Of the total 21 083 respondents, 11 074 (52.5%) were female and 10 009 (47.5%) were male. Age was measured through self-reported age as at 31 December 2015 in whole years. The attendants' ages ranged between 40 and 99 years, and the median age was 56 years.

Socio-economic status
Socio-economic status (SES) was measured through level of income and education. In Tromsø 7, income was defined as the household's total taxable income last year, and the attendants reported their income through intervals and not exact numbers. This was used to make a dichotomized variable for above and below median income. Education was measured through highest level of education completed. These values were used to make a dichotomized variable, with primary and secondary education labelled as lower education and any tertiary education labelled as higher education.

Alcohol consumption

Alcohol consumption was measured through a short version of the Alcohol Use Disorders Identification Test (AUDIT), AUDIT-C, which includes three items on alcohol consumption: frequency of alcohol consumption, average number of units consumed when drinking and frequency of consuming six units or more [17]. Each item has five alternatives, giving a score from 0 to 4. The total AUDIT-C score was calculated by summation of the three item scores. The total score ranged from 0 to 12, where higher score indicated heavier alcohol consumption.

Tobacco use

Tobacco use was assessed through the questions: 'do you/did you smoke daily?', 'do you smoke, or have you smoked sometimes, but not daily?', 'have you used or do you use snus or chewing tobacco?' and 'do you use, or have you used snus sometimes, but not daily?'. All four questions had the three response options: 'yes, now', 'yes, previously' and 'never'. The 25 possible combinations of the different patterns of snus use and smoking, shown with exact numbers and percentages, are presented in Supporting information, Table S1. As the sale and use of chewing tobacco has been almost non-existent in Norway during the last decades [18], the snus and/or chewing tobacco users were labelled as snus users. Snus users were categorized into 'never used', 'previous user' (daily or non-daily) and 'current user' (daily or non-daily). Smokers were categorized with the same labels as snus users. The snus user variable and the smoker variable were not mutually exclusive. For the variables for total years of snus use/smoking and number of snus portions/cigarettes used per week, all but current snus users/smokers were excluded. For the variables for time since cessation, all but previous snus users/smokers were excluded.

Missing data

There were 22 (0.1%) missing in the snus use variable and 244 (1.2%) missing in the smoking variable. Number of missing in each snus use and smoker subcategory are presented in Supporting information, Table S1. Regarding the HADS subscales, for those with four or more answered items in either subscale, missing items were imputed by multiplying the mean score of non-missing items with number of subscale items [19]. Those who had answered three items or fewer within one of the subscales were excluded from the corresponding subscale variable, resulting in 475 (2.3%) being excluded from HADS-A and 466 from HADS-D (2.2%). For the socio-economic variables, 898 (4.3%) were missing in the income variable and 378 (1.8%) missing in the education variable. Within the three items used for AUDIT-C, there were 131 (0.6%) missing from the 'drinking frequency' variable. In the 'number of alcohol units' variable, 1950 (9.2%) were missing. Of those missing, 82.4% had answered that they never drink in the first item of AUDIT-C. Within the 'frequency of six or more units' variable, 1151 (5.5%) were missing. Of those missing, there were 82.1% who never drink. For those who never drink and

had missing data from the second and/or third item, the missing data were recoded to the value zero [20]. This resulted in a total of 436 (1.8%) missing in the final AUDIT-C variable.

Statistical analyses

IBM SPSS version 26 for Windows was used to conduct the statistical analyses. Descriptive statistics of the different tobacco users were obtained using cross-tabs for ordinal variables and through compared means with analysis of variance (ANOVA) tests for continuous variables. *P*-values for the cross-tab analyses were obtained using Pearson's c^2 tests. For the compared means, ANOVA tests with *post-hoc* least significant difference (LSD) tests were used to find the *P*-values. Due to the large sample size, the significance level was set at $P < 0.01$ and 99% confidence intervals (CI) were used in the regression analyses. The analysis plan was not pre-registered, and the results should thus be considered exploratory.

Tobacco use was analysed in relation to socio-demographic variables (sex, age, income and education), alcohol consumption and symptoms of anxiety and depression. Tobacco use and background variables were analysed in relation to mean HADS-A and -D scores, separated by sex. Linear regression analyses separated by sex were used to assess the unstandardized beta-coefficients for socio-economic variables, alcohol consumption and different variables for tobacco use, with HADS-A and HADS-D scores as dependent variables. For the previous/current snus use/smoking categories, 'no use' was set as reference. The regression analyses were repeated with adjustments for age, income and alcohol consumption. We did not adjust for smoking in the regression analyses regarding snus use, as we saw that this had minimal effect on the outcome. This could be explained by few users of both snus and cigarettes (see Supporting information, Table S1). We checked for multicollinearity between the independent variables in the linear regression, and no variance inflation factors (VIFs) exceeded 1.3. Exact *P*-values from the analyses are presented in Tables 1–5.

Ethics

This research project has been approved by the Norwegian Reginal Committee for Medical and Health Research Ethics (REK case ref. 2019/1141). All respondents of Tromsø 7 gave an informed written consent, which could be withdrawn at any time.

RESULTS

Characteristics of snus users and smokers

Descriptive statistics for snus users and smokers are presented in Table 1. Regarding snus use, there were 18 036 (85.6%) never-users, 1359 (6.5%) previous users and 1666 (7.9%) current users. Within the

TABLE 1 Use of snus and smoking seen in relation to socio-demographic variables, alcohol consumption and self-reported symptoms of anxiety and depression measured through the Hospital Anxiety and Depression scale (HADS). Based on data from the seventh wave of the Tromsø Study (2015–16), n = 21 083

Variables		Snus use (daily and non-daily) (n = 21 061)						Smoking (daily and non-daily) (n = 20 839)					
		Never n = 18036 (85.6%)	Previous n = 1359 (6.5%)	Current n = 1666 (7.9%)	P-values			Never n = 7626 (36.6%)	Previous n = 9482 (45.5%)	Current n = 3731 (17.9%)	P-values		
					a	b	c				d	e	f
Socio-demographic variables													
Sex (female)	n (%)	10395 (57.5)	306 (22.5)	355 (21.3)	<0.001	<0.001	0.225	3983 (52.2)	4997 (52.7)	1958 (52.5)	0.275	0.409	0.417
Age (years)	Mean (SD)	58.42 (11.45)	51.51 (9.02)	50.01 (8.22)	<0.001	<0.001	<0.001	55.73 (11.63)	59.20 (11.44)	55.66 (9.89)	<0.001	0.750	<0.001
Income > median*	n (%)	7930 (46.1)	795 (59.9)	1030 (62.5)	<0.001	<0.001	0.073	4098 (55.6)	4179 (46.2)	1405 (39.3)	<0.001	<0.001	<0.001
Higher education†	n (%)	8523 (48.1)	772 (57.5)	857 (52.0)	<0.001	0.002	0.001	4541 (60.4)	4191 (45.1)	1317 (35.9)	<0.001	<0.001	<0.001
Alcohol consumption													
Current alcohol abstainer	n (%)	1571 (8.8)	67 (5.0)	50 (3.0)	<0.001	<0.001	0.004	832 (11.0)	589 (6.3)	214 (5.8)	<0.001	<0.001	0.161
AUDIT-C score (0–12 pts)‡	Mean (SD)	2.86 (1.79)	3.87 (1.89)	4.27 (1.88)	<0.001	<0.001	<0.001	2.65 (1.72)	3.14 (1.82)	3.62 (2.01)	<0.001	<0.001	<0.001
Symptoms of anxiety and depression													
HADS-A score (0–21 pts)	Mean (SD)	3.20 (2.90)	3.62 (2.93)	3.60 (2.95)	<0.001	<0.001	0.832	3.86 (2.80)	3.22 (2.85)	3.71 (3.24)	0.003	<0.001	<0.001
HADS-D score (0–21 pts)	Mean (SD)	2.81 (2.72)	3.13 (2.92)	2.91 (2.78)	<0.001	0.168	0.025	2.63 (2.65)	2.82 (2.68)	3.30 (3.00)	<0.001	<0.001	<0.001

SD = standard deviation.

*Total taxable household income last year > 750 k NOK;

†tertiary education, such as college or university;

‡a three-item version of the Alcohol Use Disorders Identification Test (AUDIT).

Difference between the snus categories:

a difference between no and previous snus use;

b difference between previous and current snus use;

c difference between no and current snus use.

Difference between the smoking categories:

d difference between no and previous smoking;

e difference between no and current smoking;

f difference between previous and current smoking.

TABLE 2 Mean scores of the Hospital Anxiety and Depression Subscale (HADS) subscales for anxiety (HADS-A) and depression (HADS-D) seen in relation to socio-demographic variables, alcohol consumption and tobacco use. Possible score for both subscales is 0–21 points. Based on data from the seventh wave of the Tromsø Study (2015–16, n = 21 083; females only n = 11 074, 52.5%)

Variables	n (%)	HADS-A Mean (SD)	P-values	HADS-D Mean (SD)	P-values
Socio-demographic variables					
Age (years)			< 0.001		0.054
40–49	3378 (30.5)	4.09 (3.14)		2.66 (2.81)	
50–64	4665 (42.1)	3.57 (3.09)		2.56 (2.70)	
> 65	3031 (27.4)	2.84 (2.74)		2.71 (2.52)	
Income			0.487		< 0.001
< Median[a]	5888 (56.5)	3.54 (3.16)		2.91 (2.82)	
> Median[a]	4528 (43.5)	3.58 (2.92)		2.24 (2.44)	
Education			< 0.001		< 0.001
Lower[b]	5376 (49.4)	3.41 (3.08)		2.79 (2.75)	
Higher[c]	5498 (50.6)	3.67 (3.02)		2.48 (2.62)	
Alcohol consumption					
AUDIT-C score (0–12 pts)[d]			< 0.001		< 0.001
< Cut-off[e]	5578 (51.6)	3.30 (3.04)		2.74 (2.78)	
> Cut-off[e]	5234 (48.4)	3.78 (3.04)		2.50 (2.56)	
Tobacco use					
Daily or non-daily snus use			< 0.001		0.271
Never	10395 (94.0)	3.49 (3.04)		2.63 (2.69)	
Previous	306 (2.8)	4.16 (3.23)		2.87 (2.80)	
Current	355 (3.2)	4.24 (3.35)		2.57 (2.63)	
Snus portions used per week[f]			0.982		0.881
1–4	91 (26.8)	4.22 (3.40)		2.66 (2.61)	
5–9	137 (40.3)	4.31 (3.61)		2.61 (2.75)	
> 10	112 (32.9)	4.25 (3.03)		2.48 (2.51)	
Daily or non-daily smoking			< 0.001		< 0.001
Never	3983 (36.4)	3.30 (2.96)		2.43 (2.59)	
Previous	4997 (45.7)	3.52 (2.98)		2.57 (2.59)	
Current	1958 (17.9)	4.04 (3.37)		3.20 (3.04)	
Cigarettes smoked per week[g]			0.005		< 0.001
1–4	423 (22.6)	4.05 (3.21)		2.74 (2.65)	
5–9	604 (32.2)	3.74 (3.16)		3.02 (2.92)	
> 10	846 (45.2)	4.33 (3.57)		3.60 (3.26)	

SD = standard deviation.
[a]Median total taxable household income is at 750 k NOK;
[b]primary or secondary education;
[c]tertiary education, such as college or university;
[d]a three-item version of the Alcohol Use Disorders Identification Test (AUDIT);
[e]cut-off scores are set at ≥ 3 points for females;
[f]if current snus user;
[g]if current smoker.

smoking categories, there were 7626 (36.6%) never-smokers, 9482 (45.5%) previous smokers and 3731 (17.9%) current smokers. There were fewer women among previous snus users (n = 306; 22.5%) and current users (n = 355; 21.3%) than among non-users (n = 10 395;

57.5%; P < 0.001). There were equally as many women and men within the non-smokers (n = 3983; 52.2%), previous smokers (n = 4997; 52.7%) and current smokers (n = 1958; 52.7%). The non-users of snus were older [mean age = 58.42 years; standard deviation (SD) =

TABLE 3 Mean scores of the Hospital Anxiety and Depression Subscale (HADS) subscales for anxiety (HADS-A) and depression (HADS-D) seen in relation to socio-demographic variables, alcohol consumption and tobacco use. Possible score for both subscales is 0–21 points. Based on data from the seventh wave of the Tromsø Study (2015–16, n = 21 083; males only, n = 10 009, 47.5%)

Variables	n (%)	HADS-A		HADS-D	
		Mean (SD)	P-values	Mean (SD)	P-values
Socio-demographic variables					
Age (years)			< 0.001		0.073
40–49	3054 (30.5)	3.55 (2.81)		3.10 (2.89)	
50–64	4110 (41.1)	3.04 (2.76)		2.99 (2.75)	
> 65	2845 (28.4)	2.18 (2.30)		3.14 (2.67)	
Income			0.867		< 0.001
< Median[a]	4541 (46.5)	2.96 (2.87)		3.51 (2.98)	
> Median[a]	5228 (53.5)	2.97 (2.57)		2.68 (2.52)	
Education			0.009		< 0.001
Lower[b]	5176 (52.6)	2.89 (2.75)		3.17 (2.81)	
Higher[c]	4655 (47.4)	3.04 (2.68)		2.95 (2.72)	
Alcohol consumption					
AUDIT-C score (0–12 pts)[d]			< 0.001		0.375
< Cut-off[e]	4706 (47.8)	2.73 (2.66)		3.09 (2.80)	
> Cut-off[e]	5129 (52.2)	3.16 (2.74)		3.04 (2.75)	
Tobacco use					
Daily or non-daily snus use			< 0.001		0.169
Never	7641 (76.4)	2.80 (2.66)		3.06 (2.74)	
Previous	1053 (10.5)	3.46 (2.82)		3.21 (2.95)	
Current	1311 (13.1)	3.42 (2.81)		3.00 (2.81)	
Snus portions used per week[f]			0.031		0.440
1–4	243 (19.4)	3.08 (2.88)		3.01 (3.00)	
5–9	484 (38.6)	3.38 (2.93)		3.13 (2.82)	
> 10	526 (42.0)	3.64 (2.69)		2.90 (2.72)	
Daily or non-daily smoking			< 0.001		< 0.001
Never	3643 (36.8)	2.85 (2.59)		2.86 (2.70)	
Previous	4485 (45.3)	2.88 (2.65)		3.10 (2.74)	
Current	1773 (17.9)	3.34 (3.04)		3.40 (2.96)	
Cigarettes smoked per week[g]			0.196		0.002
1–4	401 (23.5)	3.56 (3.14)		2.98 (2.74)	
5–9	372 (21.8)	3.17 (2.81)		3.33 (2.81)	
> 10	934 (54.7)	3.34 (3.10)		3.60 (3.06)	

SD = standard deviation.
[a]Median total taxable household income is at 750 k NOK;
[b]primary or secondary education;
[c]tertiary education, such as college or university;
[d]a three-item version of the Alcohol Use Disorders Identification Test (AUDIT);
[e]cut-off scores are set at ≥ 4 points for males;
[f]if current snus user;
[g]if current smoker.

11.45] than previous users (mean = 51.51; SD = 9.02) and current snus users (mean = 50.01; SD = 8.22; P < 0.001). Previous smokers were older (mean = 59.20; SD = 11.44) than non-smokers (mean = 55.73; SD = 11.63) and current smokers (mean = 55.66; SD = 9.89; P < 0.001).

Non-users of snus had a lower proportion of people with above median income (n = 7930; 46.1%) than previous users (n = 795; 59.9%) and current users (n = 1030; 62.5%; P < 0.001). Non-smokers had a higher share of above median income (n = 4098; 55.6%) than previous

TABLE 4 Linear regression with scores of the Hospital Anxiety and Depression scale (HADS) subscales for anxiety (HADS-A) and depression (HADS-D) as dependent variables. Unstandardized beta-coefficients, unadjusted and adjusted.[a] Based on data from the seventh wave of the Tromsø Study (2015–16, n = 21 083; females only, n = 11 074, 52.5%)

Variables	HADS-A score (unadjusted)			HADS-A score (adjusted[a])			HADS-D score (unadjusted)			HADS-D score (adjusted[a])		
	Beta	99% CI	P-values	Beta	99% CI	P-values	Beta	99% CI	P-values	Beta	99% CI	P-values
Socio-demographic variables												
Age (years)	−0.045	(−0.051, −0.038)	< 0.001				0.005	(−0.001, 0.011)	0.018			
Income[b]	−0.013	(−0.054, 0.028)	0.419				−0.230	(−0.265, −0.194)	< 0.001			
Higher education[c]	0.256	(0.103, 0.408)	< 0.001				−0.313	(−0.447, −0.179)	< 0.001			
Alcohol consumption												
AUDIT-C score[d]	0.169	(0.122, 0.216)	< 0.001				−0.078	(−0.120, −0.036)	< 0.001			
Tobacco use												
Previous snus use[e]	0.667	(0.210, 1.124)	< 0.001	0.408	(−0.054, 0.871)	0.023	0.243	(−0.161, 0.647)	0.122	0.330	(−0.078, 0.738)	0.037
Current snus use[e]	0.751	(0.325, 1.177)	< 0.001	0.222	(−0.208, 0.653)	0.183	−0.061	(−0.436, 0.315)	0.677	−0.028	(−0.407, 0.350)	0.848
Previous smoking[e]	0.222	(0.058, 0.385)	< 0.001	0.211	(0.039, 0.383)	0.002	0.145	(0.002, 0.287)	0.009	0.180	(0.031, 0.330)	0.002
Current smoking[e]	0.742	(0.519, 0.964)	< 0.001	0.425	(0.184, 0.666)	< 0.001	0.777	(0.581, 0.974)	< 0.001	0.569	(0.358, 0.780)	< 0.001

CI = confidence interval.

[a]Adjusted for age, income and alcohol consumption;

[b]total taxable household income in 2014;

[c]tertiary education, such as college or university, lower education set as reference;

[d]a three-item version of the Alcohol Use Disorders Identification Test (AUDIT), possible score 0–12 points;

[e]daily or non-daily, no use set as reference.

TABLE 5 Linear regression with scores of the Hospital Anxiety and Depression scale (HADS) subscales for anxiety (HADS-A) and depression (HADS-D) as dependent variables. Unstandardized beta-coefficients, unadjusted and adjusted.[a] Based on data from the seventh wave of the Tromsø Study (2015–16, n = 21 083; males only; n = 10 009, 47.5%)

Variables	HADS-A score (unadjusted)			HADS-A score (adjusted[a])			HADS-D score (unadjusted)			HADS-D score (adjusted[a])		
	Beta	99% CI	P-values	Beta	99% CI	P-values	Beta	99% CI	P-values	Beta	99% CI	P-values
Socio-demographic variables												
Age (years)	−0.048	(−0.054, −0.042)	< 0.001				0.004	(−0.002, 0.011)	0.070			
Income[b]	−0.013	(−0.054, 0.028)	0.419				−0.230	(−0.265, −0.194)	< 0.001			
Higher education[c]	0.145	(0.002, 0.287)	0.009				−0.224	(−0.370, −0.079)	< 0.001			
Alcohol consumption												
AUDIT-C score[d]	0.128	(0.091, 0.164)	< 0.001				−0.010	(−0.047, 0.028)	0.510			
Tobacco use												
Previous snus use[e]	0.663	(0.435, 0.892)	< 0.001	0.258	(0.023, 0.492)	0.005	0.150	(−0.086, 0.387)	0.101	0.166	(−0.077, 0.410)	0.079
Current snus use[e]	0.623	(0.415, 0.831)	< 0.001	0.138	(−0.079, 0.355)	0.102	−0.060	(−0.273, 0.154)	0.471	−0.061	(−0.284, 0.163)	0.484
Previous smoking[e]	0.028	(−0.124, 0.180)	0.634	0.211	(0.078, 0.392)	< 0.001	0.236	(0.079, 0.394)	< 0.001	0.163	(−0.001, 0.328)	0.010
Current smoking[e]	0.487	(0.281, 0.693)	< 0.001	0.303	(0.084, 0.522)	< 0.001	0.539	(0.330, 0.748)	< 0.001	0.281	(0.060, 0.503)	0.001

CI = confidence interval.

[a]Adjusted for age, income and alcohol consumption;

[b]total taxable household income in 2014;

[c]tertiary education, such as college or university. Lower education set as reference;

[d]a three-item version of the Alcohol Use Disorders Identification Test (AUDIT), possible score 0–12 points;

[e]daily or non-daily, no use set as reference.

smokers (n = 4179; 46.2%) and current smokers (n = 1405; 39.3%; P < 0.001). Previous snus users had more people with higher education (n = 772; 57.5%) than non-users (n = 8523; 48.1%) and current users (n = 857; 52.0%; P < 0.001). Non-smokers had higher education (n = 4541; 60.4%) than previous smokers (n = 4191; 45.1%) and current smokers (n = 1317; 35.9%; P < 0.001). Regarding alcohol consumption, the AUDIT-C score was higher among previous snus users (mean = 3.87; SD = 1.89) and current users (mean = 4.27; SD = 1.88) compared to non-users (mean = 2.86; SD = 1.79; P < 0.001). Non-smokers had the lowest AUDIT-C score (mean = 2.65; SD = 1.72) compared to previous smokers (mean = 3.14; SD = 1.85) and current smokers (mean = 3.62; SD = 2.01; P < 0.001).

The relationship between snus use and anxiety and depression compared to smoking and anxiety and depression

Mean HADS-scores for the three snus categories and the three smoking categories, 'never used', 'previous user' and 'current user', are presented in Table 1, while the mean scores for the 25 different tobacco use combinations are presented in Supporting information, Tables S2 and S3. The mean HADS-A scores for previous (mean = 3.62; SD = 2.93) and current snus users (mean = 3.60; SD = 2.95) were higher than among non-users (mean = 3.20; SD = 2.90; P < 0.001). Current smokers had higher HADS-A score (mean = 3.71; SD = 3.24) than both non-smokers (mean = 3.09; SD = 2.80) and previous smokers (mean = 3.22; SD = 2.85; P < 0.001). Previous snus users had a higher mean HADS-D score (mean = 3.13; SD = 2.92) than non-users (mean = 2.81; SD = 2.72; P < 0.001). Current smokers had higher HADS-D score (mean = 3.30; SD = 3.00) than previous smokers (mean = 2.82; SD = 2.68) and non-smokers (mean = 2.63; SD = 2.65; P < 0.001). Mean HADS scores seen in relation to socio-demographic variables, alcohol consumption and tobacco use, separated by sex, are presented in Tables 2 and 3. The distribution of exact HADS-A and -D scores within the general female and male population and among female and male current snus users and smokers are shown in Supporting information, Figs S1 and S2.

Linear regression analyses with HADS-A and -D scores as dependent variables are presented in Tables 4 and 5. The unstandardized beta-coefficients, both unadjusted and adjusted for age, income and alcohol consumption for females only (n = 11 074), are presented in Table 4 and males only (n = 10 009) in Table 5. Non-users were set as reference for the previous/current snus users/smokers. See Tables 4 and 5 for 99% CIs.

There was a significant positive association between previous snus use and HADS-A before and after adjustment for males (adjusted beta = 0.258, P = 0.005), but not for females (adjusted beta = 0.408, P = 0.023). There was a positive and significant association between current snus use and previous HADS-A score before adjustment for both females (unadjusted beta = 0.751, P < 0.001) and males (unadjusted beta = 0.623, P < 0.001), but not after adjustment for either females (adjusted beta = 0.222, P = 0.183) or males

(adjusted beta = 0.138, P = 0.102). Regarding current smoking and HADS-A score, there was a significant positive association before and after adjustment for both females (adjusted beta = 0.425, P < 0.001) and males (adjusted beta = 0.303, P < 0.001). There was no detectable association between current snus use and HADS-D scores before and after adjustment for either females (adjusted beta = −0.028, P = 0.848) or males (adjusted beta = −0.062, P = 0.484). The association between current smoking and HADS-D score was positive and significant before and after adjustment for both females (adjusted beta = 0.569, P < 0.001) and males (adjusted beta = 0.281, P < 0.001). See Supporting information, Tables S4 and S5 for adjusted and unadjusted beta-coefficients for total time of use, amount used and time since cessation.

DISCUSSION

In this cross-sectional study of adults and elderly in the general population of Tromsø in North Norway, current snus users were more often male, younger, had higher income and higher levels of alcohol consumption than current smokers and non-users of snus. We could not detect a significant relationship between current snus use and anxiety and depression after adjustments for relevant covariates. There was a significant, positive association between current smoking and anxiety, and depression was strong and remained significant for both females and males after adjusting for relevant covariates.

The prevalence of current snus use within the study population was similar to the corresponding age group in the general Norwegian population. We also found that current snus users were younger than the current smokers and non-users of tobacco, which corresponds well with snus being most prevalent among adolescents and young adults. One-fifth of the current snus users in this study were female, which reflected the sex distribution among snus users in the general population when the survey was conducted [2].

The current snus users had a higher income than previous and non-users of snus. The literature on snus use and SES in northern Europe is inconsistent, as some studies have found an association between snus use and low SES [21–23] while others have described snus users as a group with generally high SES [24, 25]. Current smokers had the lowest income and education compared to previous and non-smokers. This reflects previous findings on the relationship between smoking and low SES [26–28].

Current snus users had higher levels of alcohol consumption compared to previous and non-users of snus, which reflects previous studies that have found a positive relationship between snus use and alcohol consumption [3, 8, 21, 26, 29]. A study from 2017, based on the population from the fifth wave of the Tromsø Study in 2001, found an association between occasional smoking and snus use [30]. The characteristics of the occasional smokers in this study were quite similar to the daily snus users in our study, as they were younger, had higher education and higher alcohol consumption than other participants.

Before adjustment for covariates, there was a significant correlation between previous and current snus use and anxiety for both females and males. After adjustment for age, income and alcohol consumption, this association was only detectable among male previous snus users. Regarding depression, there was no detectable association between either current or previous snus use among either females or males. Some studies on smokeless tobacco and/or snus and its relation to anxiety and/or depression have reported non-significant findings [8–10], while some northern European studies have found a significant relationship between smokeless tobacco/snus and depressive symptoms [3, 11].

There was a significant association between both previous and current smoking and anxiety and depression, after adjustment for covariates, among both sexes. This finding reflects earlier studies that have found an association between smoking and anxiety [31–36] and smoking and depression [35–38]. The relationship between smoking and anxiety and depression seems to be somewhat established [1]. However, the biological mechanism of this relationship remains uncertain: is it due to the impact of nicotine or other chemicals in the cigarettes or to a propensity to addictive behaviour? As snus contains many of the same chemical constituents as cigarettes, and because we could not detect any association between current snus use and anxiety and depression, this may point away from a directly chemical relationship between tobacco use and anxiety and depression. However, this issue has been discussed in previous studies on tobacco use and its relation to different mental disorders, and some have found that the associations between nicotine dependence and mental disorders are specific for different methods of administration [39]. Future studies should be careful to differentiate between the different methods of administrating nicotine and tobacco products available.

One of the strengths of this study was the large sample size and the high prevalence of current smoking and current snus use. A sufficient sample size and prevalence of tobacco use were necessary to detect any possible relationships between current smoking/snus use and anxiety and/or depression. However, snus studies in countries where snus use is infrequent can also be informative, as it may be the most vulnerable who use snus. A limitation in the present study is selection bias, as the response rate of Tromsø 7 was at 65%. There is a possibility that those participants suffering from severe anxiety and/or depression are less likely to attend a long survey compared to those with no mental health issues. If this is the case, our results might underestimate the true relationships between both smoking and snus use and anxiety and depression. As the design of the present study is cross-sectional, we could not describe any causal linkages between tobacco use and anxiety and depression, nor could we state anything regarding the direction of the associations described. Additionally, we have not taken into further consideration the possibly unknown confounding in the significant associations we detected after adjustment for relevant covariates, which we could have solved by including E-values in our analyses [40].

In conclusion, the results of the present study show how current snus users and current smokers strongly differ from one another regarding both socio-economic variables and symptoms of anxiety and depression. We found that the snus users had generally high SES, and we found no significant association between current snus use and symptoms of anxiety and depression. We have replicated previous studies that have described cigarette smoking and its relation to low SES and higher levels of anxiety and depression. This indicates that the relationship between tobacco use and mental disorders, such as anxiety and depression, is associated with the method of administration. If the mode of nicotine administration was insignificant one might expect a stronger relationship between snus use and anxiety and depression, as with smoking. This suggests that previous findings on cigarette smoking cannot be fully extrapolated to snus users, and further emphasizes the need for more research on snus use and the harms and risks associated with it.

DECLARATION OF INTERESTS
None.

AUTHOR CONTRIBUTIONS
Pia Bondø: Conceptualization-Equal; Resources-Lead; Writing – original draft-Lead. **Anne Høye:** Conceptualization; supervision. **Maja-Lisa Løchen:** Resources; supervision. **Jorgen G. Bramness:** Conceptualization; formal analysis; methodology; project administration; resources; supervision.

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