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Patterns of snus and cigarette use: a study of Norwegian men followed from age 16 to 19

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ABSTRACT

Background The use of moist snuff (snus) in young Norwegians is increasing, while smoking rates are declining. It is not clear whether snus facilitates smoking.

Objective To assess whether 16-year-old men who were never-smokers, but snus users in 2001, had an increased risk of smoking 3 years later.

Methods In a prospective school-based cohort study, 1440 men, who responded to questionnaires in 2001 and 2004, were included in the analyses. The participation rate was 89% in 2001 and 50% in 2004. Multinomial logistic regression models were used to assess the OR of snus users, smokers and dual users of cigarettes and snus, compared with non-tobacco users at baseline, to be smokers at follow-up.

Results Snus use at baseline was associated with increased odds of dual use at follow-up when the outcome was (1) current dual use versus no tobacco (OR 3.49, 95% CI 1.8 to 6.8) and when the outcome was (2) current dual use versus no smoking but including snus-only use (OR 1.88, 95% CI 1.1 to 3.3). Baseline snus users who were dual users at follow-up seemed to prefer using snus daily and cigarettes occasionally. Use of snus only at baseline was not associated with increased odds of smoking only at follow-up, after adjusting for known risk factors.

Conclusions Young men who only used snus at baseline had an increased risk of being dual users at follow-up. Snus use may therefore facilitate smoking.

The smokeless tobacco (ST) marketed in Norway is a not-fermented moist tobacco product, which is held behind the upper lip, known as snus. Since 2000, the daily use of snus increased from <5% to 25% among young men and from almost nothing to 8% among young women. In 2010, an additional 8%–10% among both genders used snus occasionally. During this period, smoking rates in Norway have declined. In 2010, 12% of young adults (16–24 years) smoked daily and 14% occasionally. Hence, snus use is now more common than smoking among young men.[1]

Research reports concerning the health effects of ST are conflicting; however, most researchers agree that ST is less harmful than cigarettes on an individual basis.[2 3] There is less agreement on the health consequences of ST use at the population level. Some studies indicate that ST is likely to produce a net health benefit through replacing smoking, while others find it unlikely that increased use of ST will give any substantial health benefits when dual use of cigarettes and snus is taken into account.[4 5] A crucial question is whether ST could lead to smoking, especially among young people. Some studies among young adults and adolescents from the USA and Sweden conclude that ST use alone is not a significant risk factor for the later use of cigarettes,[6–8] while other studies have reported that ST use increases the probability of taking up smoking in adolescent and young adult men.[9–12]

Whether ST use facilitates smoking may depend on the definitions of the outcome and current tobacco use and whether risk factors other than ST are included in the models. Conflicting results may also be due to heterogeneity between populations, where attitudes to, and availability of, cigarettes and ST may influence the likelihood of transition between the tobacco types. Regulations of use, such as smoking bans in Norwegian restaurants and bars from 2004, may also affect the transition between tobacco products. The question if snus use may increase the risk of taking up smoking is also referred to as the 'gateway hypothesis'.[7 9] Two recent reviews concluded that more knowledge is needed to determine whether ST use leads to smoking.[2 13]

The purpose of this study was to investigate whether 16-year-old men who were never-smokers, but snus users, at baseline had an elevated risk of smoking 3 years later, after adjustment for known risk factors for smoking.

METHODS

Baseline and follow-up survey

All 10th graders (16-year-olds) in Oslo County were invited to participate in the youth part of the Oslo Health Study during 2000–2001. A corresponding health study was performed in the predominantly rural county Hedmark in 2000–2001. In both counties nearly all public and private schools participated. The survey was performed during school hours, and standardised explanations were given by trained personnel.[14] In total, 5750 pupils participated at baseline, 89% of all pupils in participating schools in the 2001 cohort, 3811 in Oslo and 1939 in Hedmark. The follow-up study was carried out in 2004, mainly at schools in Oslo and as a postal survey in Hedmark, with procedures as in the baseline study. All upper secondary schools in Oslo participated, and the 13th graders were given a questionnaire during school class. Baseline study participants who agreed to participate at follow-up, but were not enrolled in school at age 19, were invited to participate by mail. Two reminders were sent to non-respondents.[15]

Study population

Only men were selected for the present study because <1% of the women were snus users (totally 30% using tobacco) at baseline and 7% at

follow-up (totally 41% using tobacco). Figure 1 describes the retention rate for both study counties. Loss to follow-up was associated with non-Western ethnicity, postal survey compared with school-based and low educational ambitions.[16]

Main outcome variables

Smoking and snus use were assessed by questions that separated never-, former and current users, where current use was recorded as occasional or daily use. Questions were similar at baseline and at follow-up: 'Do you smoke, or have you ever been smoking?' (tick one box only). The four response categories were: no, never; yes, but I have quit; yes, occasionally and yes, every day. The question about snus was worded 'Do you use, or have you ever been using snus, chewing tobacco or similar products?' with the same response categories as for smoking. In the analyses, four mutually exclusive groups were categorised into: daily or occasional snus use, but no smoking; daily or occasional smoking, but no snus use; dual use of snus and cigarettes and no current tobacco use, including former tobacco users. There were missing values for one or both questions on smoking and snus use for 2.3% of participants at baseline and 0.6% at follow-up.

Other variables

Table 1 describes the sample characteristics. Household smoking at baseline was assessed with the following question: 'Do any of the people you live with smoke?' with five answer categories: mother, father, sibling, others and nobody. A comparable question about snus was not asked. Cultural background was classified according to parents' country of birth, self-reported by adolescents at baseline. Muslim cultural background was addressed because it affects the use of tobacco, with high smoking prevalence among adolescent men.[17] The pupils' consideration of their family economy was assessed by asking if their family, compared with other families in Norway, were probably 'very well off', 'well off', 'in the middle' or 'short of money'. Socioeconomic status has been shown to be negatively associated with adolescent smoking, while less is known about snus use.[18–20]

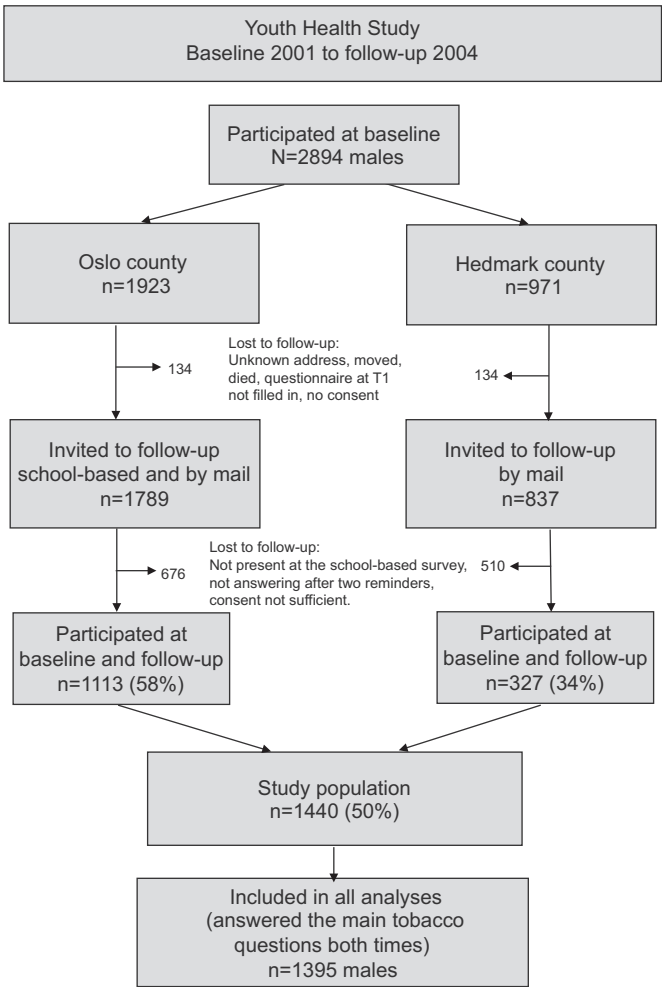

Figure 1 Flow chart of the youth health study.

Statistical analysis

The impact of baseline snus use on smoking at follow-up was assessed in multinomial logistic regression (mlogit), where maximum-likelihood multinomial logit models were fitted using STATA, V. 10.0. The model was a modification of a binary logistic regression model, with a nominal outcome variable with more than two levels. The effect size from the STATA output is RR ratio, which may be interpreted as OR.[21] Two models with different outcome variables of current tobacco use at follow-up were used: (1) snus-only use, smoking-only and dual use, regressed against no tobacco use and (2) smoking-only and dual use, regressed against no smoking but possible use of snus. Hence, in the second model, the reference group contained also the snus users. Both models assessed the OR of snus users, smokers and dual users, compared with non-tobacco users at baseline, of becoming smokers at follow-up. The same baseline tobacco variable with mutually exclusive groups of snus-only, smoking-only and dual use were used in both models as dummy variables. The same models were also carried out with a more detailed outcome variable of current tobacco use at follow-up: occasional snus only, daily snus only, occasional smoking only, daily smoking only and with the four corresponding values of dual use (see table 2, detailed). In the detailed analyses, small groups led to some limitations in the interpretation of the results.

From known baseline risk factors for tobacco use as shown in table 1, those associated with tobacco use both at baseline and at follow-up were included in the models as possible confounders. In the final models, only the confounding variables were kept. A multiplicative interaction term 'smoking by snus use' at baseline was included in the preliminary analyses. To get interpretable ORs, we used dummy variables for baseline tobacco use. Similarly, the significance of the interaction of tobacco with alcohol use, sexual experience and family economy was assessed.

RESULTS

Characteristics of participants

Participants' mean age at baseline was 15.9 years (range 14.7–17.4 years) and 18.7 years at follow-up. At baseline, 6% used snus, 13% smoked, 10% were dual users and 71% were tobacco free (table 1). The use of tobacco was higher among those invited to follow-up but not attending (1186 men). The prevalence of snus use was the same in both groups, but among those not attending, 18% smoked, 14% were dual users and only 61% were tobacco free. A higher percentage of cohort participants compared with non-participants had parents who were married or cohabiting, had good or very good family economy and were planning an academic study course.

Bivariate analyses

Use of tobacco did not vary by age but was higher among those who had divorced parents, were planning a vocational education

Table 1 Baseline characteristics by use of tobacco among 16-year-old men* †

	Total, N (%)	Snus, but no smoke, n (%)	Smoke, but no snus, n (%)	Dual use, n (%)	No tobacco, n (%)	p Value
	1395 (100)	90 (6)	175 (13)	144 (10)	986 (71)	
Age, years						
Below median (mean 15.6)	701 (100)	43 (6)	80 (11)	65 (9)	513 (73)	
Above median (mean 16.1)	694 (100)	47 (7)	95 (14)	79 (11)	473 (68)	
Total	1395 (100)	90 (6)	175 (13)	144 (10)	986 (71)	<0.220
County						
Oslo	1078 (100)	73 (7)	136 (13)	105 (10)	764 (71)	
Hedmark	317 (100)	17 (5)	39 (12)	39 (12)	222 (70)	
Total	1395 (100)	90 (6)	175 (13)	144 (10)	986 (71)	<0.502
Parents' marital status						
Married/cohabiting	1012 (100)	64 (6)	109 (11)	101 (10)	738 (73)	
Divorced, separated etc	378 (100)	24 (6)	66 (17)	43 (11)	245 (65)	
Total	1390 (100)	88 (6)	175 (13)	144 (10)	983 (71)	<0.005
Parents' country of birth						
Norway	1175 (100)	84 (7)	147 (13)	129 (11)	815 (69)	
Country with majority of Muslims	132 (100)	3 (2)	18 (14)	4 (3)	107 (81)	
Other foreign countries	80 (100)	2 (3)	8 (10)	10 (13)	60 (75)	
Total	1387 (100)	89 (6)	173 (12)	143 (10)	982 (71)	<0.009
Educational plans						
Academic studies	808 (100)	53 (7)	84 (10)	75 (9)	596 (74)	
Upper secondary school, general studies	78 (100)	5 (6)	11 (14)	10 (13)	52 (67)	
Upper secondary school, vocational studies	252 (100)	16 (6)	47 (19)	38 (15)	151 (60)	
One year of upper secondary school or other plans	52 (100)	4 (8)	9 (17)	5 (10)	34 (65)	
Undecided	194 (100)	11 (6)	23 (12)	16 (8)	144 (74)	
Total	1384 (100)	89 (6)	174 (13)	144 (10)	977 (71)	<0.013
Perceived family economy						
In between/short of money	411 (100)	13 (3)	52 (13)	46 (11)	300 (73)	
Well off	809 (100)	59 (7)	97 (12)	82 (10)	571 (71)	
Very well off	163 (100)	18 (11)	23 (14)	16 (10)	106 (65)	
Total	1383 (100)	90 (7)	172 (12)	144 (10)	977 (71)	<0.021
Family smoking						
No family member smokes	722 (100)	42 (6)	69 (10)	58 (8)	553 (77)	
Father or mother smokes	322 (100)	27 (8)	35 (11)	33 (10)	227 (70)	
Father and mother smoke	137 (100)	7 (5)	24 (18)	9 (7)	97 (71)	
Siblings and/or others smoke	209 (100)	14 (7)	47 (22)	44 (21)	104 (50)	
Total	1390 (100)	90 (6)	175 (13)	144 (10)	981 (71)	<0.0001
Alcohol use						
Have never been drunk	694 (100)	11 (2)	35 (5)	3 (0.4)	645 (93)	
Have been drunk once or more	695 (100)	78 (11)	139 (20)	140 (20)	338 (49)	
Total	1389 (100)	90 (6)	174 (13)	143 (10)	983 (71)	<0.0001
First sexual experience by 10th grade or sooner						
No	1147 (100)	73 (6)	116 (10)	87 (8)	871 (76)	
Yes	228 (100)	17 (7)	58 (25)	55 (24)	98 (43)	
Total	1375 (100)	90 (7)	174 (13)	142 (10)	969 (70)	<0.0001

*Total number of participants is <1395 if the given variable had missing data.
†p Value: test for independence between the socio-demographic and the tobacco variable at baseline.

course or perceived family economy 'very well off'. High total prevalence of tobacco use among adolescents with parents born in Norway and among those in perceived affluent families were mainly due to higher rates of snus use. Adolescents' snus use was higher if one of the parents smoked. Smoking and dual use was higher in families where siblings smoked. Alcohol users were often also tobacco users. Tobacco users were over-represented among adolescents with early sexual experience and high alcohol consumption (table 1).

Among the snus-only users at baseline, 37% maintained their snus use at follow-up, 11% switched to be smokers only and 28% became dual users at follow-up (table 2, aggregated). Adolescents using snus only at baseline were more likely to be tobacco free at follow-up (24%) than smokers and dual users (14%–15%, respectively). The total prevalence of tobacco use increased from 29% at baseline to 48% at follow-up and at the same time the proportion of daily users increased. Analyses of occasional versus daily tobacco use among adolescents (table 2, detailed) showed that 56% of the baseline dual users used at least one product daily. The corresponding proportion was 68% at follow-up. Only a small proportion of dual users were daily users of both products (8% at baseline and 5% at follow-up).

Regression analyses

In the first multinomial model, snus-only use at baseline was not associated with increased odds of smoking only at follow-up (OR 1.66, 95% CI 0.7 to 3.8) (table 3). The odds for snus users to be dual users at follow-up was elevated (OR 3.49, 95% CI 1.8 to 6.8) compared with being tobacco free. The OR to continue as snus-only users at follow-up was 5.50, 95% CI 3.0 to 10.3.

Table 2 Current tobacco use among men at baseline (2001) and at follow-up (2004)

Tobacco use at follow-up	No tobacco	Snus only	Smoke only	Dual use	All
Tobacco use at baseline					
Aggregated view					
No tobacco	659 (67)	113 (12)	114 (12)	100 (10)	986 (100)
Snus only	22 (24)	33 (37)	10 (11)	25 (28)	90 (100)
Smoke only	25 (14)	12 (7)	75 (43)	63 (36)	175 (100)
Dual use	21 (15)	25 (17)	23 (16)	75 (52)	144 (100)
All	727 (52)	183 (13)	222 (16)	263 (19)	1395 (100)

Tobacco use at follow-up		Snus only		Smoke only		Dual use				
	No tobacco	Occasionally	Daily	Occasionally	Daily	Both occasionally	Occasional smoke, daily snus	Daily smoke, occasional snus	Both daily	All
Tobacco use at baseline										
Detailed view										
No tobacco	659	70	43	73	41	44	23	30	3	986
Occasional snus only	20	15	11	8	2	5	8	3	1	73
Daily snus only	2	2	5	0	0	2	4	1	1	17
Occasional smoke only	20	4	6	20	20	15	9	16	3	113
Daily smoke only	5	2	0	7	28	2	3	14	1	62
Both occasionally	16	7	8	3	3	12	13	1	0	63
Both occasional smoke and daily snus	2	0	4	0	1	0	8	1	2	18
Both daily smoke and occasional snus	2	0	2	1	15	3	4	24	1	52
Both daily	1	1	3	0	0	0	1	3	2	11
All	727	101	82	112	110	83	73	93	14	1395

Unadjusted analyses, n (%).

Baseline smokers had high odds of remaining smokers or becoming dual users at follow-up, but the odds for switching from smoking only to snus only was not significant. Baseline dual users had high odds of still being dual users at follow-up, while the OR to become smokers only was 5.19 (95% CI 2.6 to 10.4) and the OR for changing from dual use to snus only was 4.02 (95% CI 2.0 to 7.9) (table 3).

The second multinomial model with the same baseline tobacco variable as in table 3, but with the outcome reference 'no smoking', including the snus-only users, is presented in table 4. We found no elevated risk of baseline snus users becoming smokers only (OR 0.86, 95% CI 0.4 to 1.8), but baseline snus use was associated with increased odds of dual use at follow-up (OR 1.88, 95% CI 1.1 to 3.3). The OR for baseline smokers to remain smokers (OR 13.31, 95% CI 8.2 to 21.6) or to become dual users (OR 10.74, 95% CI 6.6 to 17.6) was high. Baseline dual users had high odds of remaining dual users (OR 9.28, 95% CI 5.7 to 15.2) or becoming smokers only (OR 3.29, 95% CI 1.8 to 6.0).

In a supplementary analysis (not shown), we performed multinomial models with the outcome variable separated into occasional and daily tobacco use. These models essentially confirmed the results from tables 3 and 4.

Corresponding to table 3, baseline snus users had no increased odds of becoming either occasional or daily smokers at follow-up, but an OR of 4.85, 95% CI 2.3 to 10.2, of becoming occasional snus users, and an OR of 6.70, 95% CI 3.0 to 14.8, of becoming daily snus users. Dual users originating from baseline snus use seemed to be daily snus users and occasional smokers (OR 7.42, 95% CI 2.9 to 18.7) rather than the opposite, daily smokers and occasional snus users (association not significant). Baseline dual users had increased odds of being dual users at follow-up, as well as daily smokers (OR 13.05, 95% CI 5.7 to 29.7) or daily snus users (OR 6.84, 95% CI 3.1 to 15.3).

Furthermore, baseline smokers had high odds to be both occasional (OR 9.05, 95% CI 4.7 to 17.6) and daily (OR 29.86, 95% CI 15.2 to 58.6) smokers at follow-up but no increased OR to become snus users. Baseline smokers had high odds to be dual users of both products occasionally at follow-up (OR 7.07, 95% CI 3.3 to 15.2), to be dual users of daily snus and occasional smoking (OR 7.64, 95% CI 3.1 to 18.7) and of daily smoking and occasional snus use (OR 29.20, 95% CI 13.6 to 62.8).

Corresponding to table 4, baseline snus users had no increased OR to be either occasional or daily smokers at follow-up. Also in this model, baseline snus use was associated with dual use of daily snus and occasional smoking at follow-up (OR 3.54, 95% CI 1.5 to 8.3), whereas no association was found with dual use of daily smoking and occasional snus use. Again, baseline smoking was associated with all kinds of dual use at follow-up. Baseline dual users had increased odds to be daily smokers (OR 7.94, 95% CI 3.7 to 16.9) at follow-up, as well as all kinds of dual users.

The interaction term between smoking and snus use was incorporated in the models with the inclusion of tobacco dummy variables. No other interaction terms were statistically significant.

DISCUSSION

Baseline snus users had increased odds for taking up smoking in addition to continuing their snus use. There was no trend, however, of switching from use of snus alone to cigarettes alone. Baseline smokers only carried a high risk of remaining smokers at follow-up but were not more likely than baseline non-users of tobacco to use snus as the only tobacco product at follow-up. The odds for dual users at baseline to remain dual users or smokers were high. Baseline dual users were more likely than baseline non-users of tobacco to become users of snus only. Finally, baseline snus users who were dual users at follow-up had increased odds of being daily

Table 3 Male tobacco use versus no tobacco use at follow-up (2004) according to baseline risk factors, multinomial logistic regression* †

	Current snus-only use vs no tobacco at follow-up 2004		Current smoking only vs no tobacco at follow-up 2004		Current dual use vs no tobacco at follow-up 2004	
N=1361	Unadjusted OR (95% CI)	Full model OR (95% CI)	Unadjusted OR (95% CI)	Full model OR (95% CI)	Unadjusted OR (95% CI)	Full model OR (95% CI)
Current tobacco use at baseline 2001						
No tobacco	Ref	Ref	Ref	Ref	Ref	Ref
Snus-only use	8.68 (4.88 to 15.43)	5.5 (2.95 to 10.25)	2.73 (1.26 to 5.92)	1.66 (0.73 to 3.80)	7.00 (3.78 to 12.96)	3.49 (1.79 to 6.82)
Smoking only	2.89 (1.41 to 5.95)	1.53 (0.71 to 3.31)	18.00 (10.86 to 29.83)	15.94 (9.20 to 27.59)	16.85 (10.07 to 28.21)	12.59 (7.19 to 22.06)
Dual use	6.33 (3.39 to 11.83)	4.02 (2.04 to 7.93)	6.57 (3.51 to 12.29)	5.19 (2.60 to 10.38)	22.62 (13.34 to 38.37)	15.38 (8.49 to 27.87)
Previous smoking						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.71 (0.98 to 3.00)	1.01 (0.54 to 1.89)	1.93 (1.15 to 3.22)	2.96 (1.69 to 5.19)	2.01 (1.25 to 3.24)	2.87 (1.67 to 4.95)
Previous snus use						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	3.23 (1.79 to 5.84)	2.55 (1.32 to 4.92)	3.10 (1.76 to 5.48)	1.04 (0.53 to 2.05)	2.92 (1.70 to 5.04)	1.24 (0.64 to 2.39)
Perceived family economy						
In between/ short of money	Ref	Ref	Ref	Ref	Ref	Ref
Well off	1.92 (1.28 to 2.90)	1.8 (1.17 to 2.77)	0.87 (0.62 to 1.22)	0.95 (0.65 to 1.37)	1.42 (1.02 to 1.97)	1.58 (1.08 to 2.32)
Very well off	2.46 (1.39 to 4.37)	1.99 (1.08 to 3.66)	1.12 (0.66 to 1.90)	1.07 (0.60 to 1.91)	1.97 (1.21 to 3.19)	1.84 (1.05 to 3.22)
Alcohol use						
Have never been drunk	Ref	Ref	Ref	Ref	Ref	Ref
Have been drunk once or more	4.43 (3.11 to 6.30)	2.54 (1.69 to 3.82)	3.13 (2.28 to 4.30)	1.36 (0.92 to 2.01)	6.21 (4.50 to 8.57)	2.01 (1.35 to 2.99)
First sexual experience by 10th grade or sooner						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.92 (1.19 to 3.07)	1.17 (0.70 to 1.96)	3.47 (2.33 to 5.17)	1.94 (1.23 to 3.05)	4.07 (2.81 to 5.89)	1.82 (1.18 to 2.82)

*Multiplicative interaction between smoking and snus use is taken into account by current dual use of tobacco.
†The baseline variables age, parents' marital status, county, parents' country of birth, pupils' educational plans and family members smoking did not influence the association between tobacco use at baseline and at follow-up and were left out.

snus users and occasional smokers, while baseline smokers had increased odds to be all kinds of dual users at follow-up.

Strengths and limitations

Our study has several strengths: it has a high participation rate at baseline and includes adolescents in both urban and rural areas. Furthermore, the baseline study was performed prior to the segregation of adolescents into theoretical and practical school courses. Another strength is that established risk factors for smoking could be adjusted for, and models included 'previous smoking' and 'previous snus use' at baseline, which were acting as powerful factors in the multivariate analyses.

One limitation of our study is the participation rate of 50%. However, as smoking and established risk factors for smoking

Table 4 Male tobacco use versus no smoking at follow-up (2004) according to baseline risk factors, multinomial logistic regression* †

	Current smoking only vs no smoking (tobacco free and snus-only use) at follow-up 2004		Current dual use vs no smoking (tobacco free and snus-only use) at follow-up 2004	
N=1370	Unadjusted OR (95% CI)	Full model OR (95% CI)	Unadjusted OR (95% CI)	Full model OR (95% CI)
Current tobacco use at baseline 2001				
No	Ref	Ref	Ref	Ref
Snus-only use	1.28 (0.63 to 2.58)	0.86 (0.40 to 1.81)	3.31 (1.96 to 5.59)	1.88 (1.06 to 3.33)
Smoking only	13.87 (8.89 to 21.61)	13.31 (8.20 to 21.60)	12.92 (8.19 to 20.40)	10.74 (6.56 to 17.57)
Dual use	3.67 (2.13 to 6.32)	3.29 (1.79 to 6.04)	12.77 (8.33 to 19.57)	9.28 (5.68 to 15.17)
Previous smoking				
No	Ref	Ref	Ref	Ref
Yes	1.69 (1.04 to 2.75)	2.92 (1.71 to 4.97)	1.78 (1.14 to 2.79)	2.84 (1.72 to 4.70)
Alcohol use				
Have never been drunk	Ref	Ref	Ref	Ref
Have been drunk once or more	2.37 (1.74 to 3.21)	1.15 (0.79 to 1.67)	4.62 (3.38 to 6.31)	1.72 (1.18 to 2.51)
First sexual experience by 10th grade or sooner				
No	Ref	Ref	Ref	Ref
Yes	2.98 (2.06 to 4.33)	1.82 (1.20 to 2.76)	3.46 (2.46 to 4.87)	1.72 (1.16 to 2.55)

*Multiplicative interaction between smoking and snus use is taken into account by current dual use of tobacco.
†The baseline variables age, parents' marital status, family economy, county, parents' country of birth, pupils' educational plans, previous snus use and family members smoking did not influence the association between tobacco use at baseline and at follow-up and were left out.

were relatively more common among non-participants at follow-up, the transition from snus use to smoking or dual use would most probably have been equally or more pronounced among the non-participants. We think the difference between participants and non-participants in our study probably did not lead to bias, as transitions between snus and smoke, not the absolute prevalence, were of interest in this study.

As the amount of tobacco used was not asked in our study, we did not have the opportunity to separate light from heavy users. Both light and heavy users may be hidden behind the category 'daily use', and the diversity within 'occasional use' should also be further explored in future studies. The appropriate way of asking youth has to be considered in light of the un-established tobacco use habits in the youngest age groups and weighted against the tendency to skip difficult questions. Uncertainty related to the classification of 'occasional' and 'daily' tobacco use among young people[22] was taken into account by grouping occasional and daily users together in the categories 'snus users', 'smokers' or 'dual users' in the main analyses in our study. The validity of adolescent self-reported tobacco use has been demonstrated, even when higher discrepancy was found among those reporting non-daily use.[23] Among the dual users in our study, the majority were daily users of at least one substance, which corresponds well with a recently proposed definition of dual use as daily use of one substance and at least weekly use of the other.[24]

Another limitation in our study is the inclusion of men only. The epidemiology of snus use shows large gender differences.[1] Also, the results may be valid only for countries that are similar to Norway because the attitudes to the different tobacco products, their availability and regulations of use differ between countries.

Our follow-up survey was carried out in spring 2004, and later the same year, the ban on cigarette smoking in restaurants and bars was introduced in Norway. In a comparable survey today, this ban would possibly have influenced the results. In particular, young smokers might have a higher tendency to quit all tobacco or to switch to snus alone, as smoking has become more inconvenient. Future tobacco use should be assessed in larger study groups than ours, including women, and with good measures of all kinds of tobacco use, for being able to elucidate details relevant changes.

Modelling of smoking behaviour

Previous smoking was an important factor in this study. Even at the baseline age of 16, nearly one-tenth reported previous smoking. When not adjusting for the variable 'previous smoking', baseline snus-only users had a significantly higher odds of switching to smoking only at follow-up, but when adjusting for this smoking experience, the result was changed. This is in line with Kozlowski *et al*,[7] but Severson *et al*[10] found ST use to increase the odds among adolescent men for taking up regular smoking, when including only those reporting no lifetime smoking at baseline. In any case, previous smoking points out as an important factor that should always be addressed when transitions from snus use to smoking is discussed. Timberlake used a method of matching pairs of users and non-users of ST with the same behaviour risk profile, also taking lifetime smoking into account.[8] Our result was in line with Timberlake, finding that snus-only use did not facilitate smoking only, though the analytic methods were different.

The choice of reference group for the outcome variable influenced our study findings. No use of tobacco at follow-up was the 'gold standard' reference, but we also used non-smokers as reference at follow-up. We wanted to study transitions between snus use and smoking, regardless of whether the adolescents were snus-only users at follow-up because use of snus alone is a smaller health problem compared with smoking. A clear definition of the reference group of the outcome variable has not always been given in studies, which is a problem for comparability and interpretation of the results. Recent reviews discussed how different definitions and models lead to different answers to the question of whether ST use increases the risk of smoking initiation.[2 13]

Dual use of cigarettes and snus

In our study, dual tobacco use at baseline increased the odds to be a daily snus user or a daily smoker at follow-up. The odds of remaining a dual user at follow-up was high. As we found baseline snus use to increase the odds of ending up with dual use, an important question is whether young adult dual users may become smoke free or tobacco free later. As dual users who were previously snus-only users often use snus as their main product at follow-up, the health hazards may be less serious, but the likelihood of quitting tobacco not necessarily higher than among dual users with cigarettes as their main product. Among Swedish adolescents, dual users constituted a high-risk group for tobacco dependence and tobacco-related harms.[6 25] In the USA, dual users planned to quit less often than those who smoked cigarettes exclusively, 42% of dual users had no plans to quit smoking the next 6 months and most of them reported ST use in locations with restrictions on smoking.[26] A summary of Scandinavian epidemiological tobacco studies found higher prevalence of dual use among adolescents than among adults, suggesting that many tobacco users are trying both products, before settling for one in adulthood.[13] Nevertheless, adolescents using both snus and cigarettes are at high risk of remaining in tobacco dependence, as Scandinavian snus has nicotine content comparable to cigarettes and is by no means easier to quit.[3 27 28]

The overall prevalence of tobacco use was high among the men studied, with nearly half using tobacco at follow-up. When data were collected for this study, women had a high prevalence of smoking but very low prevalence of snus use. In the years following this study, prevalence of daily or occasional use of snus has increased in both genders, to around 16% in young women.[1] This implies a high prevalence of nicotine dependency in the generation now entering adulthood, even though smoking rates are declining. Dual use of snus and cigarettes seems to be gaining ground, and the prevalence is high among the young men in our study. The prevalence of daily tobacco use was 11% in our cohort at baseline in 2001 and 14% among 15-year-old Norwegian men in 2005.[29] This may indicate that total use of tobacco products is not declining, even though smoking rates among adolescents decreased between 2000 and 2005. A comparison to other studies is difficult, as most studies report smoking and snus use separately. Preventive measures against use of both tobacco types are needed to avoid an increasing proportion of young adults becoming addicted to nicotine and thus ready to use any available product. Prevention efforts and help with tobacco cessation should have a dampening effect on the increasing proportion of snus users unable to quit. Future studies should assess all kinds of tobacco use, in large study groups, and with longer follow-up, for being able to elucidate relevant changes in this phase of the tobacco epidemic.

CONCLUSIONS

We found that snus-only use in early adolescence was associated with the increased risk of taking up occasional smoking in

What this paper adds

- Male adolescents using snus only were at risk of entering young adulthood as dual users of occasional smoking and daily snus use.
- Male adolescents using snus only did not carry an increased risk of smoking only in young adulthood.
- Male adolescent dual users carried high risk of entering adulthood as dual users, daily smokers or daily snus users.

addition to snus in late adolescence. Snus-only use at baseline was not associated with the risk of becoming smokers only. Our results indicate an increasing proportion of both snus users and dual users among young adults and highlight the need for preventive efforts and professional interventions for snus users who want to quit.

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