

Do never smokers make up an increasing share of snus users as cigarette smoking declines? Changes in smoking status among male snus users in Norway 2003–15

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ABSTRACT

Aims To examine how the relative size of six groups of male ever snus users (current and former users of snus who were current, former or never cigarette smokers) varied over time in Norway, and how these groups differ with regard to important measures of tobacco behaviour. **Design** Repeated cross-sectional nationally representative surveys of tobacco use. The association between survey year and the six categories of ever snus use was examined using cross-tabulation and multinomial logistic regression. Differences in tobacco behaviour across snus use categories were examined using logistic and ordinary least squares (OLS) regression. **Setting** Norway, 2003–15. **Participants** A total of 2067 males aged 15–79 years. **Measurements** The categories of ever snus use represented all six combinations of cigarette smoking (current, former or never) among current and former users of snus. The variables measuring tobacco behaviour were: order of product uptake (snus or cigarettes first), mean cigarette consumption, reduction from daily to occasional smoking, intention to quit cigarettes, future smoking identity and use of snus in latest quit attempt. **Findings** During the period 2003–15, the relative share of current snus users who had never smoked, and current snus users who were former smokers, increased. The share of dual users, and smokers who were former snus users, decreased. Among men who reported life-time experience with both products, a large majority had initiated their tobacco use with cigarettes. The average number of cigarettes smoked weekly was lower among dual users compared with current smokers who were former snus users or had never used snus. **Conclusions** During the period 2003–15 in Norway, which has a mature snus market, even though smoking has declined and the relative size of the category of never-smokers among male users of snus has increased, the majority of snus users are still former or current smokers.

Keywords Nicotine alternatives, public health, smokeless, snus, tobacco, tobacco harm reduction.

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INTRODUCTION

In his visionary paper in *Addiction* in 1991, the tobacco behavioural scientist Michael Russell asserted that alternative delivery systems of nicotine could make the virtual elimination of cigarettes a realistic future target [1]. However, Russell maintained that the quit smoking effect from new delivery systems would be limited to a specific historical stage in the phasing-out of cigarette smoking. According to Russell, it was the potential of new nicotine delivery systems as long-term alternatives to cigarettes for youth susceptible to smoking that would be their most important contribution in the cigarette endgame.

Working in an era before some of the alternative nicotine delivery products such as low-nitrosamine snus were available, Russell held an optimistic view towards such products. In the contemporary tobacco harm reduction discourse, attitudes are split [2–6]. Opponents are particularly concerned about the uptake of snus or e-cigarettes among non-smokers compared to smokers, and how the user configuration of such products may change as the number of smokers continues to decline.

Observational and experimental studies suggest that the availability of snus influences smoking cessation. Empirical evidence from Norway and Sweden—where the use of snus is common—demonstrates that snus is the most frequently used method for stopping smoking after

unassisted quit attempts [7–12]. Evidence also shows that former smokers make up the largest segment of snus users [13,14], that snus use is associated with higher quit rates compared to not using snus [15,16] and that snus might be more effective for smoking cessation than pharmaceutical nicotine [11,17,18].

Through its role in smoking cessation, evidence suggests that snus has contributed to the decline in smoking in Sweden and Norway, particularly among males, who are far more likely to use this product than females [15,19–22]. However, although the majority of snus users today have had prior experience with cigarette smoking, there is a growing concern that future snus use will consist increasingly of people who have no experience with cigarettes [23–25].

The first aim of this paper is to examine the size and temporal variations of six groups of ever snus users (current or former users who were current, former or never smokers) during the period 2003–15 in Norway—a country with a mature snus market.

Our second aim is to examine if these six groups differ with regard to measures of tobacco use that are important for population health. For comparison, we also included smokers who have never used snus.

METHODS

Sample

Our study population included male ever users of snus who had participated in annual cross-sectional surveys of tobacco behaviour conducted in Norway from 2003 to 2015. The total number of male respondents was 8157 and age ranged from 15 to 79 years with a mean of 44.4. Of these, 2067 were ever snus users (see Table S1 in the Supporting information for descriptive statistics). Females were not included because the uptake of snus in females has occurred at a much lower rate and is still concentrated among young adult women.

The surveys and interviews were carried out by Statistics Norway. For each year, a simple random sample of 2000 (3000 in 2015) respondents was drawn from the National Population Register by Statistics Norway and interviews were carried out by telephone [26,27]. The mean response rate for the period was 62.1%.

Measures

Regarding snus use, respondents were asked if they used snus daily, occasionally or not at all. Respondents without current (daily or occasional) use were asked if they had used snus previously. These questions were used to identify our study population of ever snus users—males who currently or formerly used snus.

For smoking status, respondents were asked: ‘Do you smoke?’. Respondents answering ‘yes’ were then asked if they smoked daily or occasionally. Current smokers were defined as those who smoked cigarettes daily or occasionally.

Respondents who answered that they did not smoke at the time of the survey were asked if they had smoked daily or occasionally earlier in their life-time. Respondents answering ‘no’ were categorized as never smokers. Respondents reporting ‘yes’ were identified as former smokers.

Based on the questions above, we were able to identify six groups of ever snus users through combinations of current (daily or occasional) or former use of snus and current/former/never use of cigarettes. The six groups were (1) current snus users who were current smokers (dual users), (2) current snus users who were former smokers, (3) current snus users who had never smoked, (4) former snus users who were current smokers, (5) former snus users who were former smokers and (6) former snus users who had never smoked. We also identified a contrasting group of men who currently smoked, but who had never used snus (7).

Tobacco use was measured by seven items. Dual users and current smokers were asked to state the average number of cigarettes consumed per day (for daily smokers) or per week (for occasional smokers). Frequencies among daily smokers were multiplied by seven and combined with frequencies among occasional smokers.

Dual users and current smokers were then asked if they had an intention to stop smoking within the next 6 months. Possible answers were ‘yes’ and ‘no’.

Dual users and current smokers who smoked occasionally were also asked if they had previously smoked daily.

Respondents with prior regular use or current regular use of both products were asked: ‘Which tobacco product did you start to use first—snus or cigarettes?’. Response categories were ‘cigarettes first’, ‘snus first’ and ‘about the same time’ (within 3 months). Respondents were dummy-coded as either ‘snus first’ or ‘cigarettes first’.

Men who had had a life-time experience with both products were also asked if they had used snus at their latest quit attempt (if any). Possible answers were ‘yes’ and ‘no’.

Finally, all respondents were asked if they viewed themselves as smokers 5 years into the future. Response categories were: ‘definitely yes’, ‘probably yes’, ‘probably not’ and ‘definitely not’.

Analyses

To address our first aim, we calculated the fraction and 95% confidence intervals of men in each snus use category across four time-periods (2003–05, 2006–08, 2009–11 and 2012–15) (Table 1). Possible linear temporal trends

Table 1 The percentage and 95% confidence intervals of respondents in each of the six ever snus user groups across four periods, Norwegian men 15–79 years, 2003–15.

	Dual users of snus and cigarettes (I)	Current snus users, former smokers (II)	Current snus users, never smokers (III)	Former snus users, current smokers (IV)	Former snus users, former smokers (V)	Former snus users, never smokers (VI)	Total	n
2003– 2005	33.0 (28.8–37.2)	14.5 (11.4–17.7)	16.0 (12.7–19.2)	22.4 (18.7–26.1)	8.9 (6.4–11.5)	5.2 (3.2–7.2)	23.3 (21.5–25.1)	482
2006– 2008	25.6 (21.5–29.6)	22.9 (19.0–26.8)	15.9 (12.5–19.3)	13.9 (10.7–17.1)	15.2 (11.9–18.6)	6.5 (4.2–8.8)	21.6 (19.8–23.4)	446
2009– 2011	24.3 (20.2–28.5)	23.4 (19.3–27.5)	21.0 (17.0–24.9)	9.2 (6.4–11.9)	13.5 (10.2–16.8)	8.7 (6.0–11.4)	20.1 (18.4–21.8)	415
2012– 2015	18.9 (16.1–21.8)	25.1 (22.0–28.3)	24.9 (21.7–28.0)	8.1 (6.2–10.1)	11.2 (8.9–13.5)	11.7 (9.4–14.1)	35.0 (33.0–37.1)	724
Total	24.7 (22.9–26.6)	21.8 (20.0–23.6)	20.1 (18.4–21.8)	12.9 (11.5–14.4)	12.0 (10.6–13.4)	8.5 (7.3–9.7)	100	–
Linear trend ^a	–5.0 (–7.1 to –2.9)	3.8 (1.6–6.0)	6.2 (3.8–8.6)	–12.2 (–15.4 to –9.0)	–0.8 (–4.0 to 2.3)	10.1 (6.1–14.0)	–	–
n	511	451	415	267	248	175	–	2067

^aCalculated from a multinomial logistic regression model where year was entered as a continuous variable with 1-year intervals. Coefficients show percentage change with 1-unit change in year (semi-elasticities).

in the relative size of each of the snus use categories were examined using a multinomial regression model with the six snus use categories as dependent variable. Independent variables were year (continuous with 1-year intervals), age (continuous with 1-year intervals), education (four categories: 'primary', 'secondary', 'tertiary' and 'other') and geographical region (six categories). The slope coefficient was presented as percentage change with 1-unit change in year (semi-elasticities).

To address our second aim, we constructed a set of regression models to examine the seven measures of tobacco behaviour across the six groups of ever snus users and among current smokers without experience with snus (Table 2).

The following seven measures of tobacco behaviour were recoded into dummy variables and treated as dependent variables in the set of logistic regression models: 'used cigarettes before snus', 'used snus before cigarettes', 'had intentions to quit cigarettes within 6 months', 'would definitely be smoke-free in 5 years', 'had reduced from daily to occasional smoking' and 'used snus in latest quit attempt'. The average number of cigarettes per week was modelled using ordinary least squares (OLS) regression.

Independent variables were identical to those used in the multinomial regression model described above, but included an additional variable identifying the six categories of snus use and the contrasting group of never snus users/current smokers. Coefficients and 95% confidence intervals were reported as marginal mean probabilities multiplied by 100 (proportions).

All data analysis was performed in Stata version 13.

RESULTS

In this nationally representative sample of 8157 male Norwegians, our study population of ever snus users comprised 2067 individuals (25.3%), while our contrasting group of never snus users/current smokers included 1411 respondents (17.3%) (for descriptive statistics, see Table S1 in the Supporting information).

The percentage of current snus users/never smokers among ever snus users increased from 16.0% in 2003–05 to 24.9% in 2012–15 (Table 1, column III). The underlying linear trend showed a 6.2% increase per year during the period. The annual increase in the percentage of never smokers who were former snus users (column VI) was somewhat higher (10.1%). However, this segment comprised only 11.7% of ever snus users in the latest period. In sum, never smokers (columns III and VI) made up 36.6% (11.7 + 24.9%) of ever users of snus in 2012–15, an increase from 21.2% in 2003–05.

The percentage of dual users among ever snus users decreased from 33.0 to 18.9% from 2003–05 to 2012–

15 (column I). The percentage of current snus users who had quit smoking increased from 14.5 to 25.1%, but this increase occurred mainly between the first and second periods (column II). The segment of men who had quit both snus and cigarettes remained stable over time, and comprised only 11.2% by the end of the study period (column V). Another relatively small group was current smokers who had quit using snus (8.1% in 2012–15). This was the group with the highest relative annual change (–12.3%) (column IV).

When we examine the seven measures of tobacco behaviour within groups, we find that in the four groups where respondents reported life-time experience with both products (Table 2, columns I, II, IV and V), a majority ranging from 67.6 to 77.4% had initiated their tobacco use with cigarettes. Only between 19.6 and 29.8% had started with snus.

The average number of cigarettes smoked weekly was significantly lower among dual users (57.0, column I) than among never snus users/current smokers (80.9, column VII) and current smokers who had quit snus (79.6 column IV).

Moreover, a significantly higher proportion of dual users (29.7%) reported that they had reduced from daily to occasional smoking than was the case among never snus users/current smokers (14.6%) and among current smokers who at the time of the survey had quit snus (17.2%).

No significant differences were observed in the proportion who answered that they had intentions to stop smoking within the next 6 months between dual users (45.8%, column I) and never snus users/current smokers (43.1%, column VII). However, a significantly higher proportion of dual users (43.8%) reported that they would definitely be smoke-free in 5 years' time compared to never snus users/current smokers (32.2%) and current smokers who had quit snus (32.2%, column IV).

A total of 75.4% of dual users had used snus in their latest quit attempt (column I). Among current snus users who had succeeded in stopping smoking completely (column II), 82.7% reported that snus was used in their final quit attempt.

DISCUSSION

Our study has shown that in a country with a mature snus market, the majority of snus users still derive from the smoking population, even if smoking has been declining rapidly. By the end of our study period, never smokers made up just above one-third of the respondents who had been using snus on a regular basis either currently or previously. However, we also observed a marked increase in the

Table 2 Order of product uptake, smoking intensity, intentions to quit, presumed future smoking status and use of snus in latest quit attempt. Marginal mean probabilities and 95% confidence intervals. Norwegian men aged 15–79 years, 2003–15.

	Ever snus users							Never snus users	
	Dual users of snus and cigarettes (I)	Current snus users, former smokers (II)	Current snus users, never smokers (III)	Former snus users, current smokers (IV)	Former snus users, former smokers (V)	Former snus users, never smokers (VI)	Current smokers (VII)		
Used cigarettes before snus	70.3 (66.5–74.1)	67.6 (63.4–71.7)	–	77.2 (71.2–83.2)	77.4 (71.9–82.9)	–	–	–	–
Used snus before cigarettes	25.7 (22.1–29.4)	29.8 (25.7–33.8)	–	21.1 (15.2–26.9)	19.6 (14.4–24.8)	–	–	–	–
Average number of cigarettes per week	57.0 (51.5–62.5)	–	–	79.6 (72.0–87.1)	–	–	–	80.9 (77.6–84.3)	–
Reduced from daily to occasional smoking	29.7 (25.8–33.7)	–	–	17.2 (12.7–21.7)	–	–	–	14.6 (12.8–16.4)	–
Intentions to quit cigarettes within 6 months	45.8 (41.5–50.1)	–	–	47.9 (42.0–53.9)	–	–	–	43.1 (40.5–45.7)	–
Definitely smoke free in 5 years	43.8 (39.6–48.1)	86.0 (82.9–89.2)	94.7 (92.6–96.8)	32.2 (26.7–37.7)	90.3 (86.7–94.0)	96.0 (93.1–98.9)	32.2 (29.8–34.6)	–	–
Used snus in latest quit attempt	75.4 (71.0–79.9)	82.7 (78.3–87.1)	–	30.1 (23.9–36.3)	48.0 (40.6–55.3)	–	–	–	–

fraction of never smokers among ever snus users during the study period of 12 years.

Consequently, as smoking declines—due partly to the availability of snus—the relative share of never smokers among snus users is likely to continue to increase. If so, the main effect of snus in tobacco harm reduction will be increasingly in reducing smoking initiation, while its effect on smoking cessation may eventually diminish, as pointed out by Russell in 1991 in relation to alternative nicotine delivery devices [1].

As observed in other studies [15], an increase in snus use has taken place in parallel with a decline in smoking among young adults in Norway. The inverse and very high correlation between snus use and cigarette smoking could be interpreted in line with Russell's predictions. Thus, the availability of snus might have produced a shift in tobacco preferences and contributed to lower smoking initiation among young adults, particularly males.

Snus use among former smokers

In line with previous studies [14,17], our data demonstrate that former smokers make up a sizable and increasing segment among ever snus users (Table 1, columns II and V). This increase apparently contradicts Russell's assumption that the quit-smoking effect from new delivery systems of nicotine would diminish over time. An explanation might be that the rapid increase in snus use in Norway started less than 2 decades ago, and coincided with a ban on all indoor smoking in public places. This means that men who replaced cigarettes with snus are still relatively young, still count among former smokers and that it will take some time before they disappear from the study population. When this cohort effect eventually decreases, the fraction of former smokers among snus users may diminish, in line with Russell's prediction.

It is important to note that former smokers who are current or former snus users did not necessarily stop smoking because they used snus. Among former smokers who also had quit snus at the time of the survey, only 48.0% (Table 2, column V) reported that snus was the method they had used when finally quitting smoking. However, among former smokers who continued to use snus, 82.7% reported that snus was used at the final quit attempt (column II). These findings suggest that the fraction of former smokers among snus users can only indicate the role of snus in smoking cessation.

However, our data suggest that snus might have served as an exit from cigarettes for a number of smokers. Given the share of ever snus users who were former smokers, and the large difference in health risks associated with these products, the anticipated transition from cigarettes to snus might have made a significant positive contribution to the public health effect.

Additional use of snus among smokers

There was no difference in intention to quit smoking in the next 6 months between dual users of snus and cigarettes and smokers who had never used snus (Table 2, columns I and VII). This is consistent with findings from Sweden [28], and more recently from the United States [29]. However, expectancies of being smoke-free 5 years into the future were significantly more prevalent among dual users compared to never snus users/current smokers (columns I and VII). Thus, we observed no empirical evidence in support of delayed smoking cessation among dual users in our study.

Consistent with observations in Sweden [12], it has been argued that alternative harm reduction strategies other than smoking cessation, such as smoking reduction, have been important motives for additional snus use in Norway. In line with this, approximately one-third of dual users reported that they had changed smoking status from daily to occasional smokers, in contrast to only one in six among never snus users/current smokers (Table 2, columns I and VII). However, given the cross-sectional nature of the data, it cannot be discerned if the switch from daily to occasional smoking occurred before or after initiation of snus use among dual users.

A systematic review of health risks related to dual use from 2014 concluded that dual users of cigarettes and snus smoke fewer cigarettes, on average, than do never snus users/current smokers [30]. Findings in two papers published after that date have been inconsistent [31,32].

There is also some evidence that unsuccessful attempts to quit smoking using snus lead to reduced smoking intensity [11,18,33]. Our study showed that a majority (75.4%) of dual users had, in fact, used snus in their latest quit smoking attempt, and that dual users consumed on average fewer than 23.9 cigarettes per week than never snus users/current smokers (Table 2, columns I and VII). However, the health gain from reduced cigarette consumption is modest [34].

In sum, our data indicate that additional snus use among smokers is not likely to impact negatively upon public health compared to exclusive cigarette use. Moreover, for a wide variety of health end-points, evidence does not suggest any special hazard associated with dual use of snus and cigarettes compared to smoking only, according to a systematic review [30].

Former snus use among current smokers

The fastest-declining group in our study population comprised respondents who have quit snus, but were current smokers at the time of the survey. This combination might imply that snus had served as a gateway to smoking. However, the order of product uptake in this group does not

support such an interpretation. Instead, a majority (77.2%) had started their tobacco use with cigarettes (Table 2, column IV). If a gateway mechanism existed, it would be operating only among the 21.1% in this group who reported that snus was their first product.

Moreover, neither smoking intensity nor intention to quit within the short or long term in this group differ from never snus users, current smokers. Therefore, when assessing the overall public health effect from snus, the decline in size of this segment probably does not play an important role.

The tipping-point

What proportion of never-smokers relative to smokers among users of an alternative nicotine product would mark the tipping-point from a possible net gain to a possible net loss for public health? This question is of contemporary interest, particularly in a context where nicotine delivery products other than snus (i.e. electronic cigarettes) are growing in popularity.

To answer this question we need to have information about the configuration of snus users over time, as we have tried to identify in our study. In addition, we need information about the relative risk difference between snus and cigarettes. According to qualitative assessments of risks by groups of tobacco researchers, low-nitrosamine smokeless tobacco products pose less than one-tenth the risk of cigarettes [35,36].

Using relative risk estimates, Gartner *et al.* [37] assessed the potential for net population-level harm given different rates of snus uptake by current smokers, ex-smokers and people who have never smoked. According to their model, 14–25 individuals who have never smoked would need have to started using snus to offset either the health gain from every tobacco user who uses snus rather than cigarettes or the health gain from every smoker who switches to snus. According to our data, the number of snus users who were former smokers was relatively large, while the number of never smokers among snus users, although increasing, is far from being of the order of magnitude suggested by Gartner *et al.*

However, in an imaginary situation where the prevalence of smoking has declined to a minimum, any public health benefit from the availability of snus will depend upon the ratio between (a) snus users who in the absence of snus would have become smokers and (b) snus users who, in the absence of snus, would have remained completely tobacco-free.

Follow-up studies of snus initiation among non-smokers with and without traits for smoking susceptibility at baseline could shed some light on this. Currently, results from cross-sectional studies indicate that primary snus users [11] overlap to some degree with smokers as well as

non-smokers with regard to susceptibility characteristics [38–43]. This suggests that a certain fraction of those who used snus before cigarettes would have become smokers even if snus was not available. Conversely, it also suggests that a certain fraction of never smoking snus users would probably have remained tobacco-free in the absence of snus. Our aim is to address these questions in future research with a prospective design.

Strengths and limitations

In evaluating our study findings, some strengths and limitations should be noted. Strengths that lend confidence to our findings include a population-based methodology, a robust data pool ($n = 8157$), an acceptable and relatively stable response rate (average 62.1%) and standardized measures of tobacco behaviour.

However, all behavioural characteristics were based upon self-report and may be affected by under- or over-reporting, or misclassification due to imperfect recall. Note also that the questions used to define former use were not identical for snus and cigarettes. The study findings are probably also product-, culture- and diffusion stage-specific, and the generalizability of our results to other populations might be limited.

Our study focused only on males, as the uptake of snus in females has occurred at a much lower rate and is still concentrated among young adults. Future studies should assess trajectories of use of snus and other nicotine-containing products among women and girls.

In addition, differences between groups in the distribution of age or education could undermine our findings. To control for this, we calculated marginal mean probabilities of being in each cell of Table 1 using the same multinomial regression model used to calculate temporal trends (not shown). Results were nearly identical with the percentages reported in Table 1. We also checked for possible temporal variations in the seven measures of tobacco behaviour by calculating the percentage change in each measure with a 1-unit change in year in each group (not shown). The result showed little, if any, change over time (at most 3.5% per year).

There have been some attempts to quantify the public health effects from snus use [44], and more recently use of e-cigarettes [45,46], using simulation models with a variety of constructed scenarios of user patterns.

To understand the complex calculus of the overall population health impact of snus one has to operationalize the complex states and transitions that must be examined simultaneously and dynamically over time. Our data derive from cross-sectional studies, and therefore raise concerns about selection bias and unmeasured or insufficiently controlled confounders, precluding causal inference. However, given the lack of prospective data to uncover the overall

population-level effects of snus on tobacco use behaviour and health outcomes, cross-sectional data can shed some light on these processes. The fact that our results are based on real-world observations should be considered a strength.

CONCLUSION

In Norway, with a mature snus market, even though smoking has been declining rapidly and the relative size of never-smokers among users of snus has increased, the majority of snus users are still those who have been smokers.

Declaration of interests

KEL has served as an unpaid expert witness in five court cases for private and governmental committees against the tobacco industry. TFV has been an unpaid advisor to Norwegian Health authorities for questions relating to changes in tobacco use. In addition to her University post, LB holds the CRUK BUPA Chair in Beverley Research for Cancer Prevention at Cancer Research UK.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1 Descriptive statistics, men 15–79 years, 2003–15.

Table S2 Coding of snus status groups.

Table S3 Output from regression models for Table 1.