

Symptoms of nicotine dependence in a cohort of Swedish youths: a comparison between smokers, smokeless tobacco users and dual tobacco users

Ann Post¹, Hans Gilljam¹, Ingvar Rosendahl², Sven Bremberg¹ & Maria Rosaria Galanti¹

Department of Public Health Sciences, Karolinska Institute, Stockholm, Sweden¹ and STAD, Center for Dependence Disorders, Stockholm County Council, Stockholm, Sweden²

ABSTRACT

Aims To determine whether symptoms of nicotine dependence, addiction and withdrawal symptoms differ between exclusive smokers, exclusive snus (moist snuff) users and dual users. **Design** A cross-sectional survey of a cohort subsample. **Setting** County of Stockholm, Sweden. **Participants** Current exclusive smokers ($n = 466$), exclusive snus users ($n = 209$) and dual users ($n = 144$), mean age 17.6 years. **Measurements** Self-reported life-time experience of nicotine dependence and withdrawal symptoms in periods of discontinued tobacco use. Selected items from the modified Fagerström Tolerance Questionnaire (mFTQ), the Hooked on Nicotine Checklist (HONC) and the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV). **Findings** The odds ratio of endorsing each of four mFTQ items as well as the HONC item investigating the risk of feeling addicted to tobacco was two to five-fold higher for exclusive snus users and for dual users compared to exclusive smokers. One DSM-IV item (difficult to refrain from use) was elevated among dual users compared to smokers. Dual users reported the highest prevalence of any withdrawal symptom in contrast to exclusive snus users, who reported a lower risk of withdrawal symptoms compared to exclusive smokers. **Conclusions** Smokeless tobacco users show symptoms of nicotine dependence at least as frequently as cigarette smokers. Symptoms of nicotine dependence and of withdrawal during quit attempts are particularly frequent in the subgroup of users who combine smokeless tobacco with smoking.

Keywords Addiction, adolescents, nicotine dependence, nicotine withdrawal, smoking, smokeless tobacco, snus.

Correspondence to: Ann Post, Department of Public Health Sciences, Division of Social Medicine, PO Box 17070, SE-104 62 Stockholm, Sweden. E-mail: ann.post@ki.se

Submitted 10 April 2009; initial review completed 1 July 2009; final version accepted 27 October 2009

INTRODUCTION

Recent studies indicate that the uptake of smoking in youth is followed by a rapid development of nicotine dependence (ND) [1]. Adolescent smokers report withdrawal symptoms early after initiation correlated with the frequency of smoking [2]. Nicotine dependence is associated with repetitive and compulsive use and development of tolerance, and during periods of interrupted use craving appears to be the most frequent of withdrawal symptoms [3]. When abstaining from tobacco, adolescent smokers report withdrawal symptoms similar to those experienced by abstaining adult smokers [4]. While there are several studies of adolescent ND associated with smoking, progression to dependence in young smokeless tobacco users has attracted little attention

[5]. One of the reasons behind this inadequate knowledge may be the lack of suitable instruments to assess ND from smokeless tobacco, although some attempts have been made with adult populations [6,7], such as The Fagerström Test for Nicotine Dependence for smokeless tobacco users (FNTD-ST) [8]. In Sweden the use of snus (the traditional Swedish type of moist oral snuff) is widespread among male adolescents, and appears to be linked to rapid escalation of tobacco use, especially when used in combination with cigarettes (dual use) [9,10].

In order to compare occurrence of symptoms of ND among adolescent smokers, smokeless tobacco users and dual users, we analysed information collected within the frame of a longitudinal study carried out in Stockholm, Sweden.

METHODS

The Ethical Board of the Huddinge University Hospital approved the study.

Study population

The BROMS (Children's Smoking and Environment in the Stockholm County) Cohort Study, supported by the Stockholm County Council, was initiated in 1998 in order to identify determinants of uptake of cigarettes and snus. The baseline population consisted of a sample of 3020 children attending the fifth grade (at age 11 years) of compulsory school in the Stockholm region. Data were collected from 1998 to 2005, yielding one baseline and six follow-up surveys. Details on the study population and participation rates have been published previously [11]. Of the adolescents recruited at baseline, 2621 (86%) participated in the survey carried out during the second year after compulsory school [mean age 17.6 years, standard deviation (SD) 0.34]. Among participants, 819 (31%) reported using any type of tobacco at least monthly (current tobacco users); therefore, they (exclusive smokers $n = 466$, exclusive snus users $n = 209$ and dual users $n = 144$) represent the analytical sample in this study.

Data collection

The survey instrument was a self-completed questionnaire sent to the participants' homes and returned by pre-paid mail. The questionnaire included questions on health behaviours, psychosocial characteristics and the use of tobacco and alcohol. In particular, the instrument used in the sixth follow-up survey included selected items for the assessment of nicotine dependence and information on withdrawal symptoms after discontinuation of smoking or snus use [12]. As indicators of nicotine dependence we used selected items from the Modified Fagerstöm Tolerance Questionnaire (mFTQ) [13], the Hooked on Nicotine Checklist (HONC) [1] and the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) [14] (shown in Appendix S1). These items were chosen based on the highest achieved response rate during a pilot study carried out the year before this survey (unpublished data).

Measurements

Tobacco use and alcohol consumption

Current tobacco use was assessed through the questions 'do you smoke/use snus at present?', with alternatives 'not at all', 'less than once a month', 'every month, but less than one cigarette/snus dip per week', 'each week, but less than one cigarette/snus dip per day' and 'at least one cigarette/snus dip per/day'. Reported tobacco use at least once a month was categorized as current use. Subjects

reporting at least weekly use (regular users) were asked about average number of cigarettes or snus dips per week. Categories of exclusive smokers and exclusive snus users were identified by at least current monthly use of either product and dual users were defined as at least current monthly use of cigarettes and snus. The number of previous quit attempts was assessed by the question 'how many times have you attempted to quit smoking/snus use?' with response alternatives 'never', 'once', 'twice' or 'three or more times'. Age at initiation of tobacco use was based on the year when the subject first reported having smoked one whole cigarette and/or used snus.

Alcohol drinking was investigated through the question 'how often do you use to drink any of the following alcoholic beverages?' (beer 2.5%, beer $\geq 3.5\%$, wine, liquor and stronger alcoholic drinks), with response alternatives: no use or less than monthly; one to three times a month; one to two times per week or more often.

Socio-economic variables

Among the socio-demographic characteristics of the subjects, the following were investigated: current cohabitation categorized into 'with parents' or 'other' (this later included the alternatives 'with friends', 'with partner' and 'independent living'); current occupation ('student', 'employed' or 'other'); and parental education, based on the highest achieved education attended by either parent at the time of the baseline survey (categorized as: elementary school, senior high school, college or higher).

Symptoms of ND

All questions exploring symptoms of ND were relative to life-time experience, with wording adapted to include snus use and response alternatives adapted to non-daily use. Four items were included from the original mFTQ seven-item scale: time to first use in the morning; cigarette or snus dip hardest to give up; refraining from use in forbidden areas; and use of tobacco even when ill (Appendix S1). The following criteria relative to the DSM-IV were investigated: difficulty to refrain from using tobacco; used tobacco despite decided not to; and avoiding or reducing activities in order to use tobacco (Appendix S1). We also investigated the presence of the following withdrawal symptoms on occasions when tobacco was discontinued: craving, upset or tense, impaired concentration, depressed mood, irritability and anger, muscular pain, restlessness, increased appetite/weight, heart palpitations, nausea, anxiety and sleep disturbances. Finally, two items from the HONC were included, i.e. failed quit attempts and feeling addicted to tobacco [15]. All variables were dichotomized into binary scoring as follows: first cigarette/dip in the morning <30 minutes versus later; cigarette or snus dip hardest to give up (first in the

morning versus other); difficult to refrain when tobacco is prohibited (very or somewhat difficult versus not difficult); and use even when ill (always or quite often versus other). Withdrawal scores and the HONC items were also used as binary variables (yes versus no).

Data analysis

Data analyses were conducted using SPSS version 10.0.5 for Windows (SPSS Inc., Chicago, IL, USA) and Stata/SE version 10.0 for Windows (StataCorp, College Station, TX, USA); the χ^2 test was used to compare proportions in univariate analyses. Kruskal–Wallis, Kolmogorov–Smirnov and Wilcoxon's signed ranks tests were used to test for differences between medians. Logistic regression was used to adjust for potential confounders in multivariate analyses. Odds ratios (OR) and corresponding 95% confidence intervals (CI) were estimated as measures of cross-sectional association between pattern of current tobacco use (exclusive cigarette smoking, exclusive snus use or dual use) and life-time prevalence of ND symptoms. Factor analysis (principal factor) with an orthogonal rotation was used as a means to summarize the information on withdrawal symptoms. Regression scoring was used to create individual scores for the factors retained by the model. The level for statistical significance was set conventionally at 5% ($P < 0.05$).

RESULTS

Current tobacco use differed significantly by gender. Among girls ($n = 407$), 89.4% were exclusive smokers,

while among boys ($n = 412$) 24.8% were exclusive smokers, 47.0% were exclusive snus users and 28.2% were dual tobacco users. Only 6.9% of girls combined the use of cigarette and of snus (Table 1). Socio-demographic characteristics did not differ significantly between the three groups of users, but current alcohol use did. Dual users reported drinking every week or more often (42.7%) than exclusive smokers (26.7%) or exclusive snus users (22.2%).

Dual users were characterized by earlier age at onset of tobacco use compared to smokers and exclusive snus users. Median age at initiation of each product in dual users differed significantly, yet no significant differences appeared between age at initiation of either cigarette or snus compared to the corresponding age in the groups of exclusive users (not shown). Dual users had higher snus consumption than exclusive snus users despite concurrent cigarette use, but lower cigarette consumption than exclusive smokers. Exclusive snus users had a lower frequency of prior quit attempts compared to both exclusive smokers and dual users (Table 2).

All three groups of current tobacco users reported some symptoms of nicotine dependence in their life-time, but the extent of these reports differed between groups (Table 3). After adjustment for gender, age at onset of tobacco use and parental education, the OR of endorsing each of the four mFTQ items was higher for all exclusive snus users but two, and up to five times higher for dual users compared to exclusive smokers.

Of the three DSM-IV items (difficult to refrain from use, use despite decided not to and neglected activities)

Table 1 Demographic characteristics of the study sample.

	<i>Exclusive smokers</i> total = 466 n (%)	<i>Exclusive snus users</i> total = 209 n (%)	<i>Dual users</i> total = 144 n (%)	<i>Study sample</i> total = 819 n (%)	<i>P</i>
Gender					<0.05
Male	102 (21.9)	194 (92.8)	116 (80.6)	412 (50.3)	
Female	364 (78.1)	15 (7.2)	28 (19.4)	407 (49.7)	
Parental education ^a					>0.05
Compulsory school	63 (13.7)	23 (11.0)	18 (12.6)	104 (12.8)	
Senior high school	179 (39.0)	94 (45.0)	70 (48.9)	343 (42.2)	
College	218 (47.3)	92 (44.0)	55 (38.5)	365 (45.0)	
Current occupation					>0.05
Student	419 (90.7)	193 (92.3)	123 (85.4)	735 (89.7)	
Employed	16 (3.5)	9 (4.3)	8 (5.6)	33 (4.0)	
Other	27 (5.8)	7 (3.4)	13 (9.0)	47 (5.8)	
Current cohabitation					>0.05
With parents	418 (89.7)	195 (94.6)	131 (91.0)	744 (90.8)	
Other	48 (10.3)	11 (5.4)	13 (9.0)	72 (8.8)	
Self-reported current alcohol use					<0.05
No use or less than monthly	103 (22.3)	65 (31.4)	20 (14.0)	188 (23.2)	
1–3 times/month	235 (51.0)	96 (46.4)	62 (43.3)	393 (48.5)	
1–2 times/week or more often	123 (26.7)	46 (22.2)	61 (42.7)	230 (28.3)	

^aAt baseline.

Table 2 Profiles of tobacco use according to product used currently.

	Exclusive smokers <i>n</i> = 466		Exclusive snus users <i>n</i> = 209		Dual users <i>n</i> = 144		<i>P</i>
Age at onset of tobacco use ^a							
25th centile	12.8		12.8		11.9		
					Cig.	Snus	
					12.2	12.6	
Median	13.7		14.4		13.1		<0.05 ^b
					Cig.	Snus	
					13.6	13.9	
75th centile	15.0		15.4		14.3		
					Cig.	Snus	
					14.7	15.2	
Current consumption: cigarettes/week ^c							
25th centile	20				0		
Median	40				20		<0.05 ^d
75th centile	70				65		
Current consumption of snus: dips/week ^c							
25th centile			21		20		
Median			50		60		<0.05 ^d
75th centile			70		90		
Current daily tobacco use	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Cigarettes	214	45.9			40	27.8	
Snus			154	73.7	101	70.1	
Recency of tobacco use							
On the survey day	262	56.3	169	80.8	133	92.4	<0.05
Past 7 days	175	37.7	34	16.3	11	7.6	
Past 30 days	28	6.0	6	2.9	0	0	
Number of quit attempts of tobacco use							
No attempts	123	27.0	71	35.3	32	22.5	<0.05
One	84	18.5	59	29.4	30	21.1	
Two	93	20.4	30	14.9	21	14.8	
Three or more	155	34.1	41	20.4	59	41.5	

^aFirst whole cigarette or first dip. ^bKruskal–Wallis test for difference between medians. ^cAmong weekly users. ^dKolmogorov–Smirnov, two-sample test for equality of distribution.

only the risk of the first was elevated among dual users compared to smokers. Exclusive snus users endorsed each of the DSM-IV symptoms as often as smokers, after adjustment for potential confounders. Of the two HONC items only the risk of feeling addicted to tobacco was elevated significantly among exclusive snus users and dual users compared to smokers (Table 3). A total of 87% of all current tobacco users had endorsed any symptoms of ND in their life-time.

Dual users had a two- to fourfold higher OR of most withdrawal symptoms during periods of discontinued tobacco use compared to smokers. In all groups, craving was the most frequently reported symptom. Exclusive snus users reported withdrawal symptoms with frequency generally very similar to exclusive smokers (Table 4).

Factor analysis results (not shown) revealed that the 12 withdrawal symptoms loaded on two factors, which together explained about one-third of the total variance. Nine symptoms, mainly of psychological nature, loaded preferentially on the first factor: craving, upset or tension,

impaired concentration, depressed mood, irritability and anger, restlessness, increased appetite/weight, anxiety and sleep disturbances. The remaining three symptoms, mainly of physical nature (muscular pain, heart palpitations, nausea), loaded preferentially on the second factor. A comparison of factor scores between the three groups of tobacco users revealed a higher score for psychological symptoms among dual users ($P < 0.001$) and a lower score among exclusive snus users ($P < 0.05$) compared to the mean score of the whole group. Factor scores for the physical symptoms did not differ between the three groups of tobacco users.

DISCUSSION

In this study of adolescents a significantly higher proportion of dual users and of exclusive snus users reported life-time symptoms of ND compared to exclusive cigarette smokers. Also, withdrawal symptoms in periods of reduced or discontinued use were reported more

Table 3 Symptoms of nicotine dependence among current tobacco users according to product currently used, odds ratios (OR) and 95% confidence interval (CI) of endorsing the most unfavourable symptom for snus users or dual users, compared to exclusive smokers.

Symptoms of nicotine dependence	n (%)	Time to first tobacco in the morning ≤ 30 min	Hardest to give up 1-st in the morning	Difficult to refrain when forbidden	Use even when ill	Strong need/difficult to think of anything else	Use although decided not to	Neglect important activities	Failed quit attempts	Felt addicted to tobacco
		F	F	F	F	D	D	D	H	H
Exclusive smokers (reference)	77 (21.6)	118 (32.5)	163 (35.7)	112 (26.6)	266 (58.6)	343 (75.2)	94 (20.6)	290 (78.8)	313 (68.6)	
Exclusive snus users versus smokers	79 (45.1)	74 (42.3)	78 (38.6)	95 (53.4)	106 (52.2)	105 (54.1)	28 (13.8)	93 (66.4)	157 (77.7)	
OR ¹ (CI)	2.5 (1.4-4.4)	1.9 (1.1-3.2)	1.6 (1.0-2.6)	4.1 (2.4-6.9)	1.3 (0.8-2.1)	0.7 (0.4-1.1)	0.9 (0.5-1.7)	1.1 (0.6-2.0)	2.6 (1.5-4.5)	
Dual users versus smokers	65 (49.2)	65 (49.2)	73 (52.5)	88 (64.7)	104 (72.7)	103 (75.2)	34 (23.8)	87 (75.0)	128 (89.5)	
OR ¹ (CI)	2.5 (1.4-4.3)	2.0 (1.2-3.4)	2.1 (1.3-3.5)	4.9 (2.9-8.3)	2.4 (1.4-4.1)	1.4 (0.8-2.5)	1.1 (0.6-2.0)	1.3 (0.7-2.5)	5.0 (2.4-10.1)	

OR¹: adjusted for gender, age at tobacco onset and parental education; F: Modified Fagerstöm Tolerance Questionnaire (mFTQ); D: Diagnostic and Statistical Manual of Mental Disorders (DSM IV); H: Hooked on Nicotine Checklist (HONC).

Table 4 Life-time experience of withdrawal symptoms reported by current tobacco users during periods of discontinued use.

Craving	n (%)	Nervous/upset	Difficulty in concentrating	Unhappiness/sadness	Irritation/anger	Muscular pain	Restlessness	Hunger/weight gain	Heart palpitations	Nausea/vomiting	Anxiety/tension	Difficulty in sleeping	Any symptom
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Exclusive smokers (reference)	307 (80.8)	204 (54.1)	204 (54.3)	110 (29.6)	207 (55.3)	7 (1.9)	279 (73.8)	107 (28.8)	16 (4.3)	6 (1.6)	100 (27.0)	98 (26.3)	347 (74.5)
Exclusive snus users versus smokers	124 (77.0)	69 (42.9)	86 (53.4)	24 (15.0)	83 (51.9)	3 (1.9)	93 (57.8)	35 (21.7)	12 (7.5)	3 (1.9)	29 (18.1)	45 (28.5)	135 (64.6)
OR ¹ (CI)	1.3 (0.7-2.5)	1.0 (0.6-1.8)	1.4 (0.8-2.5)	1.0 (0.5-2.0)	1.6 (0.9-2.7)	0.4 (0.1-2.7)	0.7 (0.4-1.2)	1.7 (0.9-3.4)	3.6 (1.1-11.7)	0.2 (0.0-3.2)	1.0 (0.5-1.9)	1.5 (0.8-2.8)	1.1 (0.7-1.8)
Dual users versus smokers	101 (87.1)	63 (54.8)	87 (75.0)	23 (20.2)	78 (67.2)	2 (1.8)	92 (80)	35 (30.4)	12 (10.5)	3 (2.6)	34 (29.6)	40 (35.1)	111 (77.1)
OR ¹ (CI)	2.1 (1.0-3.4)	1.3 (0.8-2.3)	3.0 (1.6-5.4)	1.0 (0.5-2.0)	2.3 (1.3-4.2)	0.3 (0.3-2.9)	1.8 (1.0-3.5)	1.7 (0.9-3.3)	3.9 (1.3-11.4)	1.4 (0.2-12.8)	1.6 (0.9-3.0)	1.5 (0.8-2.7)	1.7 (1.0-3.0)

Odds ratio (OR)¹: adjusted for gender, age at tobacco onset and parental education; CI: confidence interval.

frequently by dual users than by either exclusive smokers or exclusive snus users. Finally, more than 80% of the snus users and dual users reported use on the very same day of the survey compared to 56% of smokers, probably indicating a more advanced stage of progression towards regular use.

Approximately nine of 10 adolescents had experienced any of the ND items, including withdrawal symptoms, in their life-time. Dual users and exclusive snus users reported more frequent ND symptoms from the modified mFTQ compared to exclusive smokers. They also reported feeling addicted to tobacco more often than smokers, with dual users reporting a fivefold higher prevalence OR compared to exclusive smokers. However, the life-time prevalence of three criteria for ND in the DSM-IV did not differ between the groups.

A slightly different picture emerged concerning withdrawal symptoms. While dual users reported the highest frequency of almost all symptoms, exclusive snus users generally reported similar frequency to exclusive smokers. It should also be noted that snus users reported a lower frequency of quit attempts. The typology of withdrawal symptoms (whether reflecting prevalently psychological distress or physical distress) was not different between the three groups of users.

Some differences in response to the items assessing dependence and withdrawal symptoms can probably be explained by the topography of smokeless tobacco use. A dip of snus is held in place between the lip and the gum without chewing or spitting. This makes it relatively easy to conceal and therefore possible to use where tobacco use is forbidden (e.g. in schools). Also, the risk of adverse health effects, both short- and long-term, is lower with snus than with cigarettes [16]. Therefore, the low perceived health risk may be a possible explanation for the low frequency of quit attempts among exclusive snus users compared to smokers.

A previous analysis of this cohort of youths showed that dual users had a high-risk profile of consumption compared to exclusive users of either snus or cigarettes [10]. Also, recent data from a cross-sectional study indicated a higher grade of ND among young adult smokers using more than one tobacco product [17]. The order of initiation of products in this longitudinal study indicated that the risk to proceed to current use was lowest among exclusive snus users and highest among experimenters of both product [18]. In this sample socio-demographic characteristics were similar, but dual users reported earlier initiation of any tobacco and also higher frequency of alcohol consumption compared to the exclusive users. This profile of substance use has been reported previously among Swedish adolescents and suggests the presence of a subgroup of adolescents that is particularly vulnerable to substance use progression [19].

To our knowledge, this is the first study comparing profiles of ND among adolescent smokeless tobacco users with those of adolescent cigarette smokers. Previous studies suggest that smokeless tobacco users are exposed to high nicotine doses [20,21]. Indeed, these levels can be sustained for a much longer time than among smokers [22]. The slower decline in nicotine plasma levels may be due to a nicotine depot effect in the mucous membrane of the mouth, as this tissue can release nicotine for a longer time after the product is removed [23]. This may explain why the severity of withdrawal symptoms is somewhat lower among adult smokeless tobacco users [24]. If habitual adolescent users of smokeless tobacco are exposed to similar doses as adults it can explain the higher prevalence of dependence despite the lower frequencies of withdrawal symptoms compared to exclusive smokers in our study.

A major limitation of this study is that we did not employ a complete instrument for the assessment of nicotine dependence. Comparisons are therefore limited to single items or group of items belonging to different scales. However, the evaluation of full scales using multiple items to measure withdrawal symptoms did not yield more reliable or accurate measurements than the reduced scales [25,26]. It should also be noted that the development of instruments to assess ND among smokeless tobacco users is still under way [7,8]. Snus users in this study reported low frequency of quit attempts or urge to use tobacco when not allowed. This indicates that, in pursuing more efficient instruments to assess ND among smokeless tobacco users, efforts are needed to disentangle the effect of topography of product use from that of the addictive properties of the product as such.

Another major limitation is that symptoms of ND were investigated based on life-time experience. This choice was motivated by the young age of this study population, with few addicted users and probably few past quit attempts. As all participants in the study were current users of tobacco, it is likely that their reports reflect relatively recent experiences. In fact, adolescents' recall of events occurring more than 1 year ago is inconsistent, although older adolescents show better recall than younger adolescents [27,28]. On the other hand, the concurrent assessment of withdrawal symptoms or other symptoms of ND would require much more sophisticated media, not suitable to be employed in large-scale epidemiological studies. The strengths of the study include the sample size, high participation rate and detailed history of both cigarette smoking and snus use.

The findings in this study support the conclusion that smokeless tobacco in adolescence has a potential to induce nicotine dependence which is at least as high as for cigarette smoking. It also reveals a high frequency of symptoms of nicotine dependence and of withdrawal

during quit attempts among the subgroup of young users who combine smokeless tobacco with smoking. In order to unravel whether this finding indicates subgroup vulnerability or differential addictive properties of combined tobacco use, further longitudinal studies are warranted, with refined assessment of personality traits and psychopathological symptoms preceding tobacco use.

Declarations of interest

None.

Acknowledgements

The study has been funded by the Stockholm County Council and the Swedish Research Council, Grant no. 345-2002-3515.

References

- DiFranza J. R., Rigotti N. A., McNeill A. D., Ockene J. K., Savageau J. A., Cyr D. S. *et al.* Initial symptoms of nicotine dependence in adolescents. *Tob Control* 2000; **9**: 313–19.
- O'Loughlin J., DiFranza J., Tyndale R. F., Meshefedjian G., McMillan-Davey E., Clarke P. B. S. *et al.* Nicotine-dependence symptoms are associated with smoking frequency in adolescents. *Am J Prev Med* 2003; **25**: 219–25.
- Shadel W. G., Shiffman S., Niaura R., Nichter M., Abrams D. B. Current models of nicotine dependence: what is known and what is needed to advance understanding of tobacco etiology among youth. *Drug Alcohol Depend* 2000; **59**: S9–22.
- Eissenberg T., Balster R. L. Initial tobacco use episodes in children and adolescents: current knowledge, future directions. *Drug Alcohol Depend* 2000; **59**: S41–60.
- Holm H., Jarvis M. J., Russell M. A., Feyerabend C. Nicotine intake and dependence in Swedish snuff takers. *Psychopharmacology (Berl)* 1992; **108**: 507–11.
- Boyle R. G., Jensen J., Hatsukami D. K., Severson H. H. Measuring dependence in smokeless tobacco users. *Addict Behav* 1995; **20**: 443–50.
- Ferketich A. K., Wee A. G., Shultz J., Wewers M. E. A measure of nicotine dependence for smokeless tobacco users. *Addict Behav* 2007; **32**: 1970–5.
- Ebbert J. O., Patten C. A., Schroeder D. R. The Fagerström Test for Nicotine Dependence–Smokeless Tobacco (FTND-ST). *Addict Behav* 2006; **31**: 1716–21.
- Galanti M. R., Rosendahl I., Post A., Gilljam H. Early gender differences in adolescent tobacco use—the experience of a Swedish cohort. *Scand J Public Health* 2001; **29**: 314–17.
- Ingvar Rosendahl K., Rosaria Galanti M., Gilljam H. Trajectories of smokeless tobacco use and of cigarette smoking in a cohort of Swedish adolescents: differences and implications. *Nicotine Tob Res* 2008; **10**: 1021–7.
- Post A., Galanti M. R., Gilliam H. School and family participation in a longitudinal study of tobacco use: some methodological notes. *Eur J Public Health* 2003; **13**: 75–6.
- Hughes J. R. Effects of abstinence from tobacco: valid symptoms and time course. *Nicotine Tob Res* 2007; **9**: 315–27.
- Prokhorov A. V., Pallonen U. E., Fava J. L., Ding L., Niaura R. Measuring nicotine dependence among high-risk adolescent smokers. *Addict Behav* 1996; **21**: 117–27.
- American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, 4th edn. Washington, DC: American Psychiatric Association; 1994.
- DiFranza J. R., Savageau J. A., Rigotti N. A., Fletcher K., Ockene J. K., McNeill A. D. *et al.* Development of symptoms of tobacco dependence in youths: 30 month follow up data from the DANDY study. *Tob Control* 2002; **11**: 228–35.
- Arabi Z. An epidemic that deserves more attention: epidemiology, prevention, and treatment of smokeless tobacco. *South Med J* 2007; **100**: 890–4.
- Timberlake D. S. A latent class analysis of nicotine-dependence criteria and use of alternate tobacco. *J Stud Alcohol Drugs* 2008; **69**: 709–17.
- Galanti M. R., Rosendahl I., Wickholm S. The development of tobacco use in adolescence among 'snus starters' and 'cigarette starters': an analysis of the Swedish 'BROMS' cohort. *Nicotine Tob Res* 2008; **10**: 315–23.
- Galanti M. R., Wickholm S., Gilljam H. Between harm and dangers. Oral snuff use, cigarette smoking and problem behaviours in a survey of Swedish male adolescents. *Eur J Public Health* 2001; **11**: 340–5.
- Post A., Gilljam H., Rosendahl I., Meurling L., Bremberg S., Galanti M. R. Validity of self reports in a cohort of Swedish adolescent smokers and smokeless tobacco (snus) users. *Tob Control* 2005; **14**: 114–7.
- Bauman K. E., Koch G. G., Bryan E. S., Haley N. J., Downton M. I., Orlandi M. A. On the measurement of tobacco use by adolescents. Validity of self-reports of smokeless tobacco use and validity of cotinine as an indicator of cigarette smoking. *Am J Epidemiol* 1989; **130**: 327–37.
- Benowitz N. L. Nicotine and smokeless tobacco. *CA Cancer J Clin* 1988; **38**: 244–7.
- Henningfield J. E., Fant R. V., Tomar S. L. Smokeless tobacco: an addicting drug. *Adv Dent Res* 1997; **11**: 330–5.
- Hatsukami D. K., Gust S. W., Keenan R. M. Physiologic and subjective changes from smokeless tobacco withdrawal. *Clin Pharmacol Ther* 1987; **41**: 103–7.
- West R., Ussher M., Evans M., Rashid M. Assessing DSM-IV nicotine withdrawal symptoms: a comparison and evaluation of five different scales. *Psychopharmacology (Berl)* 2006; **184**: 619–27.
- Hughes J. R., Hatsukami D. Signs and symptoms of tobacco withdrawal. *Arch Gen Psychiatry* 1986; **43**: 289–94.
- Eppel A., O'Loughlin J., Paradis G., Platt R. Reliability of self-reports of cigarette use in novice smokers. *Addict Behav* 2006; **31**: 1700–4.
- Stanton W. R., McClelland M., Elwood C., Ferry D., Silva P. A. Prevalence, reliability and bias of adolescents' reports of smoking and quitting. *Addiction* 1996; **91**: 1705–14.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1 Questions from Modified Fagerström Tolerance Questionnaire.

Please note: Wiley-Blackwell is not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.