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Who are the young users of tobacco products? Prevalence and characteristics of Danish adolescents who have either smoked cigarettes, used alternative tobacco products, or used both

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Abstract

Aims: We examined characteristics (smoking in social relations, binge drinking, and well-being measures) of Danish 13-year-olds in relation to their tobacco use patterns. Ever use of cigarettes exclusively, ever use of alternative tobacco products (ATPs; e-cigarettes, snus, or waterpipe) exclusively, and use of both cigarettes and ATPs were studied. **Methods:** We used self-reported data from students at 46 Danish schools in 2017 comprising 2,307 students (response rate = 86%). Multi-level logistic regression analyses were used to examine the associations between student characteristics and the odds for having ever used any tobacco products, smoked cigarettes exclusively, used ATPs exclusively, or used both cigarettes and ATPs compared with never use of

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any tobacco products. Unadjusted estimates and estimates adjusted for gender were reported. **Results:** A significant minority of youth (13.2%) had used one or more tobacco products. Of these, 2.0% had exclusively smoked cigarettes, 7.2% had exclusively used ATPs, and 4.0% had used both. Findings showed that all included characteristics (families' and friends' smoking, binge drinking, and well-being characteristics) were associated with using any tobacco product; however, students with friends who smoked, had been binge drinking, and had low well-being at home had notably higher odds for having both smoked cigarettes and used ATPs compared to the other tobacco use patterns. **Conclusion:** ATPs were popular among Danish adolescents compared with conventional cigarettes. Thus, prevention efforts among adolescents should not merely focus on the health risks of conventional cigarette smoking but also on ATPs. Students with diverse tobacco use patterns were similar on various characteristics. However, findings indicate that adolescents who had used both conventional cigarettes and ATPs constitute a more risk-averse group in special need of prevention efforts. Gender did not markedly influence the results. These findings may help future strategies aiming at the youngest adolescents at risk of using tobacco products.

Keywords

adolescents, characteristics, cigarettes, e-cigarettes, smoking, snus, tobacco use, waterpipe

Cigarette smoking constitutes a critical public health issue worldwide and is still the single most preventable risk factor of morbidity and mortality in Denmark and across the world (Eriksen et al., 2016; National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health, 2014). Especially among adolescents, smoking uptake has increasingly gained public health and political attention as adolescents experimenting with smoking early in life are more at risk of developing conventional smoking habits in adulthood (Chassin et al., 1990; Pisinger et al., 2005). In many countries, including Denmark, the smoking prevalence among adolescents has decreased during the past decades (Azzopardi et al., 2019). However, this decline seems to have stagnated among Danish adolescents in recent years (Rasmussen et al., 2018) and conversely, some measures indicate an increasing trend in smoking uptake among some groups of Danish youth (Hoffmann et al., 2018), while others indicate a recent modest decline (Brink & Stage, 2021; The Danish Health Authority, 2021).

Concurrently, a new market of alternative tobacco products (ATPs) has been introduced and these products (e.g., e-cigarettes, snus, and waterpipe) seem to gain increasing popularity among youth (Goniewicz et al., 2014; Kinnunen et al., 2016; Rasmussen et al., 2018). Here, ATPs refer to non-cigarette tobacco products and comprise, e.g., e-cigarettes, smokeless tobacco (including snus), and waterpipe/hookah. However, while trends in cigarette smoking over the past decades have been well-documented (e.g., Azzopardi et al., 2019; Hoffmann et al., 2018; World Health Organization, 2019), the use of ATPs separately or concurrently has been less established – especially among the youngest users of these products. In Denmark, numbers for using waterpipes among 13-year-olds are dated back to 2005 (Jensen & Kvern-rød, 2008) and no Danish numbers exist for snus use among this age group. Nonetheless, in the last decade, studies worldwide indicate an upward trend in the use of ATPs among youths (Ali et al., 2016; Geidne et al., 2016; Jawad et al., 2018; Kinnunen et al., 2016; Lundberg et al., 2019; Zhu et al., 2013). For

example, in Norway and Sweden, snus is commonly used among adolescents compared with conventional cigarettes (Lundberg et al., 2019) and e-cigarette use is most prevalent in the US (Zhu et al., 2013).

Tobacco regulations in Denmark have been quite lenient for years compared with other Nordic countries (e.g., Iceland, see also Kristjansson et al., 2020). However, within the past decades, tobacco use among youth has gained increasing attention from Danish politicians. In 2007, indoor smoking at schools was banned, and in 2012, the ban was extended to smoking on school premises; so that schools with a main uptake of pupils below 18 years of age should be smoke-free both indoors and outdoors. After this, regulations stayed quite stable until a significant debate in 2018 and 2019 resulted in a range of new regulations on youth tobacco use. By January 1, 2021, a new law with multiple tobacco preventive initiatives became effective. The law comprises multiple initiatives; among them are increased tobacco prices; a ban of additive flavours such as fruit, menthol, and mint; promotion ban at point of sale (POS); standardised tobacco packaging; health warnings on all nicotine-containing products; increased age control at POS; smoke-free school time; and an increased ban against advertising and sponsorship of tobacco, e-cigarettes, and nicotine-containing products. The new laws concern conventional tobacco products as well as ATPs. These new regulations had, thus, not been implemented at the time of the current study (2017).

Research that concerns the characteristics of adolescents who engage in risk behaviours such as tobacco use has consistently found that boys, adolescents with a low academic performance, low satisfaction, and low commitment to school, and with parents, siblings, and friends who also smoke cigarettes are more prone to smoke cigarettes themselves (Geckova et al., 2002; Joffer et al., 2014; Wellman et al., 2016). In addition, adolescents smoking cigarettes tend to have higher anxiety, depressive, and stress symptoms as well as lower

well-being, self-esteem, and a higher risk of engaging in other risk-behaviours (e.g., binge drinking) than their non-smoking counterparts (e.g., Geckova et al., 2002; Wellman et al., 2016). Existing research on factors associated with ATP use among youths has to some extent indicated similar findings. Adolescents using ATPs often have low school satisfaction and performance, are binge drinkers, and are more often boys (Cooper et al., 2019; Geidne et al., 2016; Hanewinkel & Isensee, 2015; Jawad et al., 2014; Kinnunen et al., 2016; Larsen et al., 2013; Perikleous et al., 2018). Some studies also found higher odds for using ATPs among adolescents with parents, siblings, and close friends who smoked (Jawad et al., 2013; Kinnunen et al., 2015; Kinnunen et al., 2016; Kinnunen et al., 2021; Larsen et al., 2013; Lundberg et al., 2019; Perikleous et al., 2018), while other research did not find these relationships (Hanewinkel & Isensee, 2015; Larsen et al., 2013). Moreover, past research found that users of snus and e-cigarettes had higher academic performance and mean grades compared with adolescents exclusively smoking cigarettes (Cooper et al., 2016; Larsen et al., 2013). The literature is somewhat inconsistent in regard to how adolescents' well-being is associated with ATP use. One study found that loneliness was not related to using e-cigarettes (Lindström & Rosvall, 2018), while another study found experience with being bullied was associated with higher odds for using e-cigarettes (Azagba et al., 2020). These well-being measures are associated with engagement in other risk behaviours, i.e., binge drinking and smoking conventional cigarettes, although the directions of the associations are not unidimensional (Dyal & Valente, 2015; Niño et al., 2016; Varga & Piko, 2015; Vieno et al., 2011).

Studies with the aim of characterising adolescents as young as aged 13 with diverse tobacco use patterns are sparse, e.g., existing studies have often comprised a study population of older adolescents (> 15 years; Ali et al., 2016; Cho et al., 2018), focused on adolescents'

use of a single tobacco product and which factors are associated with using the product (e.g., Geidne et al., 2016; Kinnunen et al., 2015; Kinnunen et al., 2016), or compared a single ATP with smoking conventional cigarettes (Hanewinkel & Isensee, 2015; Jawad et al., 2013; Larsen et al., 2013). Moreover, there is a lack of studies exploring how multiple well-being characteristics of adolescents relate to diverse tobacco use patterns. Theoretical perspectives in the intersection of sociology and criminology assume risk behaviours such as tobacco use to have important implications in adolescence; they can be used as a means of creating and maintaining relationships with peers as well as to become a part of a social community (Akers et al., 1995; Hirschi, 1967). At the same time, the social environment is essential for which behaviour the individual engages in, e.g., if peers have risk-seeking behaviours, the individual may be more likely to engage in the same behaviours to feel accepted or included in the group. Moreover, they may view tobacco use as socially acceptable and normal if they are exposed to smoking in their social relations (Akers et al., 1995; Engels & ter Bogt, 2001). Therefore, investigating families' and friends' smoking behaviours as well as adolescents' well-being in terms of, e.g., loneliness and bullying is essential in the context of characterising youths' tobacco use patterns.

Adolescents attracted to using ATPs may constitute another group compared with adolescents to whom smoking conventional cigarettes exclusively appeals, and dual users of cigarettes and ATPs may comprise yet another group compared with exclusive users of cigarettes or ATPs. However, research among youths in this area is limited. It is well-established that earlier age of experimenting with cigarette smoking is a risk factor for heavier long-term use, greater nicotine dependence, and difficulties with quitting smoking (Chassin et al., 1990). Further, research has found experimenting with ATPs in youth increases the risk of switching to conventional cigarette smoking, dual use of tobacco products, and continued tobacco use

in adulthood (Chaffee et al., 2018; Chapman et al., 2019; Glantz & Bareham, 2018; Grøtvedt et al., 2019; Jensen et al., 2010). Although long-term health effects of ATPs are not yet established, existing research has evidenced that using e-cigarettes, snus, and waterpipes is linked to diverse health hazards with or without concurrent cigarette smoking as well as nicotine dependence (e.g., El-Zaatari et al., 2015; Glantz & Bareham, 2018; Norwegian Institute of Public Health, 2019). Another consideration is the risk of adolescents learning smoking habits through the use of, e.g., e-cigarettes, including the body language, habits of taking smoking breaks, and the handling of a tobacco product (Chapman et al., 2019).

Exploring what characterises adolescents with diverse tobacco use patterns and, hence, their common or distinct traits is essential for future prevention efforts, and more in-depth knowledge in this area may inform smoking preventive interventions aiming at reducing the incidence of tobacco use. Prior intervention strategies aiming at reducing tobacco uptake among youth have often focused on conventional cigarette smoking (Thomas et al., 2013). There is an increasing need to develop more specific interventions aiming at reducing the use of ATPs in youth (e.g., Lopez et al., 2017). Therefore, the present study sought to investigate the magnitude of diverse tobacco product use as well as what characterises adolescents with diverse tobacco use patterns.

More specifically, this study aimed to explore several characteristics (families' and friends' smoking, binge drinking, and well-being measures) of 13-year-olds in Denmark in relation to their tobacco use patterns. These patterns included (1) students having ever exclusively smoked cigarettes, (2) students having ever exclusively used alternative tobacco products (ATPs; i.e., either e-cigarettes, snus, or waterpipes), and finally, (3) students having ever both smoked cigarettes and used ATPs.

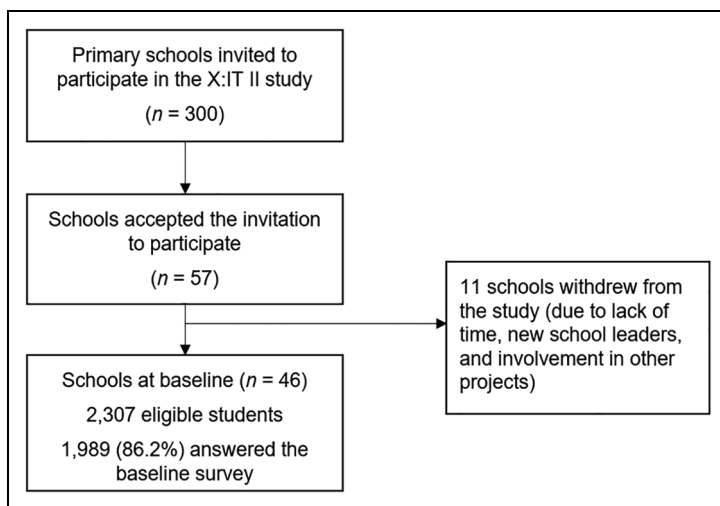


Figure 1. Flowchart of enrolled schools and students in the X: IT II baseline data collection.

Methods

Study design

Data were drawn from the X: IT II intervention, a multi-component school-based intervention with the purpose of preventing smoking uptake among adolescents from 7th to 9th grade (13- to 15-year-olds; Bast et al., 2019). For the recruitment process, 300 schools were randomly selected and invited to participate in the study from 31 municipalities all over Denmark. Of these, 57 schools were enrolled in the X: IT II study. However, prior to the baseline data collection, 11 schools withdrew their participation due to reasons centring around lack of time, other priorities, and changes in the organisational structure of the school. Thus, 46 schools were included at baseline in 2017. In this study, we used data from the baseline measurement where all students in the 7th grade at the included schools were invited to participate ($n = 2,307$; see also Figure 1). The data collection consisted of an internet-based self-reported questionnaire that students could answer in the classroom during school hours after a standardised instruction given by the teacher. The questionnaire comprised topics

related to their use of tobacco products, parents', siblings', and friends' smoking patterns, sociodemographic items, items concerning their well-being, and finally, items regarding the X: IT II intervention (i.e., the three intervention components – smoke-free school time, smoke-free curriculum, and parental involvement; Bast et al., 2019). Of all eligible students, 1,989 students answered the baseline measurement (response rate: 86.2%).

Measures

Tobacco use

Smoked cigarettes was determined by asking students if they had ever smoked cigarettes (more than a single puff) divided into no vs. yes. *Current smoking* was assessed by dichotomising the item “how often do you smoke?” into do not smoke vs. currently smoking (daily, weekly, monthly, or more seldom). *Used waterpipes, snus, or e-cigarettes*, respectively, was determined by asking students if they had ever smoked a waterpipe, used snus, or used e-cigarettes divided into no vs. yes (a single time up to more than 40 times). *Diverse tobacco use patterns* was categorised such that 0 = all

students who had never used a tobacco product and 1 = students who had ever used any tobacco products. Further, used in this study, the group of students who had ever used any tobacco products was divided into 1 = students who had ever smoked cigarettes exclusively, 2 = students who had ever used ATPs (i.e., snus, e-cigarettes, or waterpipes) exclusively, and 3 = students who had both smoked cigarettes and used ATPs.

For the subsequent logistic regression analyses, the dependent variable was *used any tobacco products* (vs. never-use of any tobacco products). Thereafter, the study sample was restricted such that the dependent variables were (1) smoked cigarettes exclusively, (2) used ATPs exclusively, and (3) smoked both cigarettes and used ATPs (vs. never-use of any tobacco products).

Student characteristics

Gender was assessed with the question “are you a boy or a girl?” divided into boy, girl, and students who felt they did not fit into either of the two first categories. Students in the last category were not reported in this study due to the small size of the group (1.3%).

Family occupational social class (OSC) was determined by two questions concerning the occupations of students’ fathers and mothers. Information about parental occupation was categorised from I = High to V = Low social class and VI = Parents receiving social benefits. The parent ranking highest determined the OSC. OSC was categorised into four groups: High (I to II), Medium (III to IV), Low (V to VI), and Non-classifiable (Hansen, 1978). Previous research has found students are capable of answering questions about their parents’ occupation with fair validity (Lien et al., 2001; West et al., 2001). In this study, the descriptive results of OSC are reported in Table 1 but OSC is not included in the logistic regression analyses (Table 2) due to the low number of observations in some groups.

Immigrant or descendant background was assessed by students’ ethnic background dichotomised into Danish vs. non-Danish origin (immigrants or descendants). In this study, the descriptive results of this variable are reported in Table 1 but the variable is not included in the logistic regression analyses (Table 2) due to the low number of observations in some groups.

Parental, siblings’, and friends’ smoking, respectively, were assessed by asking students whether their mother and father, one or more siblings, their friends (either their best friend or other friends), respectively, smoked cigarettes dichotomised into no vs. yes (every day or sometimes).

Binge drinking was assessed by the question “In the last month, how often have you consumed five or more units of alcohol on one occasion?” dichotomised into zero times vs. one or more times.

Well-being at home and school, respectively, were assessed by the question “How are you feeling . . . ? – at home, at school” dichotomised into well or really well vs. fairly or not so well.

Loneliness was assessed by asking participants whether they feel lonely, dichotomised into no vs. yes (very often, often, or sometimes).

Bullied was assessed by asking students how often they had been bullied within the past few months either at the school or in leisure time divided into no bullying vs. experience with bullying (once or twice and up to several times a week).

Analyses

SAS version 9.4 was used for all data analyses. First, descriptive analyses were conducted for characteristics of students stratified by tobacco use patterns. Second, we performed multi-level regression analyses taking school level into account. The associations between characteristics of students (smoking patterns of friends and family, binge drinking, and well-being measures) and the odds for having ever used any tobacco products were first analysed with

Table 1. Characteristics of students, stratified by diverse tobacco use patterns.

Characteristics	Total (N = 1,989) % (N)	Never used a tobacco product (86.8%, n = 1,702) % (n)	Used any tobacco products (13.2%, n = 259) % (n)	Smoked cigarettes exclusively (2.0%, n = 39) % (n)	Used ATPs exclusively (7.2%, n = 141) % (n)	Smoked cigarettes and used ATPs (4.0%, n = 79) % (n)
Girl,	51.6 (1,014)	53.7 (909)	38.3 (97)	47.2 (17)	34.3 (48)	41.6 (32)
2% of observations are missing						
Family occupational social class (OCS),						
6% of observations are missing						
High	36.0 (673)	37.5 (610)	26.0 (63)	21.9 (7)	26.7 (36)	26.7 (20)
Medium	32.8 (613)	32.4 (527)	35.5 (86)	25.0 (8)	44.4 (60)	24.0 (18)
Low	10.3 (193)	10.3 (167)	10.7 (26)	15.6 (5)	8.9 (12)	12.0 (9)
Non-classifiable	20.8 (389)	19.8 (322)	27.7 (67)	37.5 (12)	20.0 (27)	37.3 (28)
Immigrant or descendant background,						
1% of observations are missing						
Danish background	89.6 (1,772)	90.8 (1,546)	87.3 (226)	n/a ^a	n/a ^a	n/a ^a
Immigrant or descendant background	6.2 (123)	6.1 (103)	7.7 (20)	n/a ^a	n/a ^a	n/a ^a
Non-classifiable	4.2 (82)	3.1 (53)	5.0 (13)	n/a ^a	n/a ^a	n/a ^a
Parents' smoking,	33.9 (626)	31.5 (508)	50.4 (118)	53.1 (17)	40.8 (53)	66.7 (48)
7% of observations are missing						
Siblings' smoking,	13.2 (236)	10.8 (170)	30.1 (66)	20.7 (6)	25.0 (31)	43.9 (29)
10% of observations are missing						
Friends' smoking,	18.9 (326)	14.4 (216)	48.7 (110)	55.2 (16)	36.8 (46)	66.7 (48)
13% of observations are missing						
Binge drinking,	7.9 (152)	4.8 (81)	28.2 (71)	21.2 (7)	18.6 (26)	48.1 (38)
3% of observations are missing						
Loneliness,	27.1 (480)	25.7 (396)	36.1 (84)	45.2 (14)	32.0 (41)	39.2 (29)
11% of observations are missing						
Bullied,	11.9 (237)	11.0 (187)	19.3 (50)	23.1 (9)	21.3 (30)	13.9 (11)
1% of observations are missing						

(continued)

Table 1. (continued)

Characteristics	Total (N = 1,989) % (N)	Never used a tobacco product (86.8%, n = 1,702) % (n)	Used any tobacco products (13.2%, n = 259) % (n)	Smoked cigarettes exclusively (2.0%, n = 39) % (n)	Used ATPs exclusively (7.2%, n = 141) % (n)	Smoked cigarettes and used ATPs (4.0%, n = 79) % (n)
Low well-being at school, 8% of observations are missing	11.5 (212)	10.0 (160)	21.8 (52)	31.3 (10)	19.6 (27)	21.6 (16)
Low well-being at home, 8% of observations are missing	4.9 (90)	4.0 (64)	10.9 (26)	n/a ^a	5.3 (7)	20.3 (15)
Smoked cigarettes (ever), 2% of observations are missing	5.8 (114)	–	45.6 (118)	100 (39)	–	100 (79)
Currently smoking cigarettes, 2% of observations are missing	2.2 (42)	–	16.3 (42)	30.8 (12)	–	38.0 (30)
Smoked a waterpipe (ever), 4% of observations are missing	6.2 (119)	–	48.4 (119)	–	54.7 (76)	57.3 (43)
Used snus (ever), 4% of observations are missing	1.8 (35)	–	14.5 (35)	–	8.8 (12)	31.9 (23)
Used e-cigarettes (ever), 3% of observations are missing	7.5 (145)	–	57.8 (145)	–	56.0 (79)	84.6 (66)

Note. 1% of observations are missing on the variable of diverse tobacco use patterns (i.e., the variable used to stratify the complete sample). ATPs = alternative tobacco products; OCS = occupational social class.

^aThere were < 5 observations in the cells and consequently, n/a was reported in these cells.

Table 2. Multi-level logistic regression analyses studying characteristics (families' and friends' smoking patterns, binge drinking, and well-being measures) and the odds for having used any tobacco products, smoked cigarettes exclusively, used alternative tobacco products (ATPs) exclusively, and used both cigarettes and ATPs, respectively. Unadjusted estimates and estimates adjusted for gender are reported.

	Used any tobacco products ^a (n = 259)		Smoked cigarettes exclusively ^a (n = 39)		Used ATPs exclusively ^a (n = 141)		Used both cigarettes and ATPs ^a (n = 79)	
	OR [95% CI]	Adjusted OR* [95% CI]	OR [95% CI]	Adjusted OR* [95% CI]	OR [95% CI]	Adjusted OR* [95% CI]	OR [95% CI]	Adjusted OR* [95% CI]
Parents' smoking	2.14 [1.61--2.84]	2.24 [1.68--2.99]	2.4 [1.18--4.86]	2.46 [1.21--4.99]	1.49 [1.03--2.16]	1.55 [1.06--2.26]	4.08 [2.45--6.80]	4.27 [2.56--7.14]
Siblings' smoking	3.43 [2.45--4.80]	3.69 [2.62--5.20]	2.08 [0.83--5.19]	2.11 [0.84--5.27]	2.72 [1.75--4.23]	2.98 [1.90--4.67]	6.18 [3.66--10.42]	6.53 [3.84--11.08]
Friends' smoking	5.21 [3.83--7.10]	5.21 [3.81--7.13]	7.15 [3.36--15.22]	7.17 [3.37--15.26]	3.17 [2.12--4.74]	3.05 [2.02--4.59]	11.39 [6.76--19.18]	11.46 [6.78--19.38]
Binge drinking	7.55 [5.23--10.90]	7.53 [5.17--10.96]	5.38 [2.24--12.92]	5.42 [2.25--13.02]	4.37 [2.67--7.15]	4.28 [2.58--7.09]	15.03 [8.93--25.29]	20.78 [12.01--35.96]
Loneliness	1.54 [1.15--2.08]	1.83 [1.34--2.48]	2.29 [1.12--4.71]	2.45 [1.17--5.14]	1.31 [0.89--1.94]	1.6 [1.07--2.40]	1.81 [1.11--2.95]	2.06 [1.25--3.41]
Bullied	2 [1.41--2.84]	2.17 [1.52--3.10]	2.45 [1.14--5.25]	2.74 [1.26--5.95]	2.28 [1.47--3.52]	2.44 [1.56--3.81]	1.35 [0.69--2.63]	1.47 [0.75--2.88]
Low well-being at school	2.36 [1.64--3.38]	2.54 [1.76--3.66]	4.1 [1.89--8.90]	4.32 [1.98--9.43]	2.14 [1.34--3.41]	2.38 [1.48--3.84]	2.16 [1.19--3.93]	2.26 [1.24--4.13]
Low well-being at home	2.81 [1.72--4.60]	3.29 [1.99--5.44]	n/a	n/a	1.31 [0.58--2.95]	1.61 [0.71--3.66]	5.86 [3.07--11.17]	6.63 [3.42--12.85]

^aLogistic regression analyses with never-users of any tobacco products as reference category (n = 1,702)

*Adjusted for gender.

never-users of tobacco products as the reference group. Next, we restricted the study population such that never-users of tobacco products was kept as the reference group, and hence, we analysed the associations between characteristics and the odds for having ever smoked cigarettes exclusively, having used ATPs exclusively, and both smoked cigarettes and used ATPs. Unadjusted and adjusted *ORs* for gender were reported. A *p*-value of $< .05$ was considered statistically significant for all statistical analyses.

Results

Descriptive characteristics of students stratified by tobacco use patterns are shown in Table 1. Of the total 1,989 students included in the study, 52% were girls. Most students came from either a medium (32.8%) or a high (36.0%) family occupational social class (OCS) and almost 90% had a Danish background. Approximately a third (33.9%) of students' parents smoked cigarettes, while almost one in five (18.9%) had friends and 13.2% had siblings who smoked cigarettes. There were 7.9% who reported to binge drink at least once a month. Almost one-third (27.1%) reported being lonely, 11.9% had been bullied at school or in leisure time, 4.9% had low well-being at home, and 5.8% had low well-being at school.

Overall, most students had never used a tobacco product (86.8%), while 2.0% had ever exclusively smoked cigarettes, 7.2% had ever exclusively used ATPs, and 4.0% had both smoked cigarettes and used ATPs. Among students having used ATPs exclusively, 54.7% had smoked a waterpipe, 8.8% had used snus, and 56.0% had used e-cigarettes. Of students who had both smoked cigarettes and used ATPs, all (100%) had ever smoked cigarettes, 38.0% currently smoked cigarettes, 57.3% had smoked a waterpipe, 31.9% had used snus, and 84.6% had used e-cigarettes.

In Table 2, results are shown for the multi-level logistic regression analyses of the associations between student characteristics (i.e.,

parental, siblings', and friends' smoking patterns, binge drinking, and well-being characteristics) and the odds for having ever used any tobacco products, smoked cigarettes exclusively, used ATPs exclusively, and both smoked cigarettes and used ATPs, respectively, compared with never-use of any tobacco products. Overall, all studied characteristics were associated with having ever used any tobacco products (i.e., cigarettes, e-cigarettes, waterpipe, or snus). In particular, adolescents with friends who smoked and who binge drank had 5–7-fold higher odds for having used any tobacco products compared with adolescents without friends who smoked and who did not binge drink.

Concerning the exclusive use of cigarettes, results show that parents' and friends' smoking were associated with higher odds for having exclusively smoked cigarettes, while no relationship was detected for siblings' smoking. Binge drinking, loneliness, experience with being bullied, and low well-being at school were also related with having exclusively smoked cigarettes. The associations remained in unadjusted and adjusted analyses for gender. We were unable to report results for low well-being at home and the relationship with exclusive cigarette smoking due to too few observations in some cells ($n < 5$).

We found that most studied characteristics were also associated with having exclusively used ATPs; these included having siblings and friends who smoked, binge drinking, being bullied, and low well-being at school. In unadjusted analyses, loneliness was not related to having exclusively used ATPs (*OR*: 1.31, *CI*: 0.89–1.94); however, when adjusting for gender, feeling lonely became significantly associated with having used ATPs exclusively (*OR*: 1.60, *CI*: 1.07–2.40). This finding thus indicates gender-related differences in the relationship between loneliness and exclusive use of ATPs. A sensitivity analysis showed the driver of this relationship was that girls who felt lonely had significantly higher odds for having used ATPs exclusively compared with girls

who were not bothered by loneliness (data not shown).

Students with parents, siblings, and friends who smoked, who binge drank, felt lonely, and had low well-being at home and at school had significantly higher odds for having used both cigarettes and ATPs. Experience with being bullied was, however, not related to the use of both cigarettes and ATPs (*OR*: 1.47, *CI*: 0.75–2.88). The associations did not markedly differ when the analyses were adjusted for gender. Results showed somewhat stronger relationships between the studied characteristics and the odds for having used both cigarettes and ATPs relative to the exclusive use of cigarettes and ATPs – especially binge drinking (*OR*: 20.78, *CI*: 12.01–35.96). Low well-being at home was associated with almost 7-fold higher odds for having used both cigarettes and ATPs (*OR*: 6.63, *CI*: 3.42–12.85), while low well-being at home was not associated with having used ATPs exclusively (*OR*: 1.61, *CI*: 0.71–3.66). Moreover, friends' smoking was more strongly related to having exclusively smoked cigarettes (*OR*: 7.17, *CI*: 3.37–15.26) and used both cigarettes and ATPs (*OR*: 11.46, *CI*: 6.78–19.38) relative to having used ATPs exclusively (*OR*: 3.05, *CI*: 2.02–4.59).

Discussion

Among 13-year-olds in Denmark, approximately 13% had ever used one or more tobacco products. Of these, 2% had exclusively smoked cigarettes, 7% had exclusively used ATPs, and 4% had both smoked cigarettes and used ATPs. Common characteristics across the groups of youths with diverse tobacco use patterns were smoking in social relations (parents and friends), binge drinking, loneliness, and low well-being at school. Some distinct characteristics of these groups were also found: experience with being bullied was associated with exclusive use of cigarettes and ATPs but not with the use of both, while low well-being at home was only related to the use of both cigarettes and ATPs. Siblings' smoking was not related to

exclusive use of cigarettes but was, however, associated with the other tobacco use patterns. Overall, characteristics of adolescents with diverse tobacco use patterns were rather similar and findings were not markedly influenced by gender. Nonetheless, findings also indicated that adolescents having used both cigarettes and ATPs constituted a somewhat more risk-averse group compared with the groups having exclusively smoked cigarettes and exclusively used ATPs. For example, a strong relationship was detected with binge drinking, parents', siblings', and friends' smoking, and low well-being at home.

This study indicated that a markedly higher proportion of adolescents had ever used ATPs compared with conventional cigarettes. Most research has indicated recent upward trends in the use of e-cigarettes, waterpipes, and snus among adolescents (Goniewicz et al., 2014; Jawad et al., 2018; Kinnunen et al., 2016), and in line with our findings, some measures indicated modest differences in the proportion of youths having used ATPs compared with conventional cigarettes (Kinnunen et al., 2021; Lundberg et al., 2019; Rasmussen et al., 2018). Moreover, a recent Danish study found that the proportion of 15–17-year-olds reporting that they first started using e-cigarettes and smokeless tobacco products was considerably higher compared with older youths (18–24- and 25–29-year-olds), although the majority in all age groups first started smoking conventional cigarettes (Jarlstrup et al., 2020). Thus, current tendencies may indicate a shift towards a higher uptake of ATPs among the younger part of the population. This may be due to an increased focus on the health consequences of cigarettes and the perception of ATPs as less harmful than conventional cigarettes (Roditis et al., 2016) as well as prevention efforts aimed specifically at preventing or reducing youth cigarette smoking (e.g., Thomas et al., 2013). Also, some ATPs have been promoted with flavours such as candy or fruit, which seem to appeal to young users in particular (Jarlstrup et al., 2020). These characteristic aromas in, e.g., e-cigarettes, have

been banned in the new Danish regulations. Thus, in the years to come, recent trends in the use of ATPs may be discontinued due to national legislation.

Other Danish measures among 13-year-olds found likewise modest differences in the use of diverse tobacco products: 9% of boys and 6% of girls had smoked cigarettes, while 11% of boys and 5% of girls had used e-cigarettes (Rasmussen et al., 2018). These gender differences are consistent with findings from this study; more boys compared with girls had ever used tobacco products – especially ATPs. These findings have also been evidenced across other countries globally (Ali et al., 2016; Geckova et al., 2002; Jawad et al., 2014; Kinnunen et al., 2016; Kinnunen et al., 2021; Wellman et al., 2016). There may be several explanations as to why boys are more prone to use tobacco products compared with girls; in general, boys may be more risk-seeking compared with girls and have often higher prevalences of, e.g., binge drinking (WHO, 2020). Importantly, there may also exist differences in the adoption of prevention initiatives. Hence, research indicates that girls are more positive about several components of smoking prevention interventions (Lund et al., 2020). Further, more girls than boys reported that health dangers, the risk of getting addicted, not being allowed to smoke by parents, and the fact that smoking is illegal until the age of 18 were important reasons not to smoke cigarettes (Kjeld et al., 2021). Thus, there seem to be gender differences in both the perception of and engagement in risk behaviours.

The relationship between binge drinking and the use of tobacco products is well-known, and our findings are therefore consistent with previous literature (Cooper et al., 2019; Geidne et al., 2016; Jawad et al., 2014; Lundberg et al., 2019; Wellman et al., 2016). The association with binge drinking was, in particular, strong among adolescents who had used both cigarettes and ATPs. Hence, we found a strong gradient from approximately 5% binge drinkers among adolescents having never used tobacco products to almost 50% among adolescents who

had used both cigarettes and ATPs. The present findings are in line with existing research that demonstrates engagement in one risk behaviour increases the risk of engaging in others, i.e., clustering of risk behaviours (Noble et al., 2015). The Danish context may be important to bear in mind when interpreting these findings, e.g., Denmark has the highest proportion of 15-year-olds in Europe who binge drink, while the proportion of 11- to 13-year-olds is more on par with the European average (WHO, 2020). Consequently, alcohol consumption and binge drinking may be viewed as more socially acceptable in Denmark and as a part of youth life compared with other international contexts.

Experiencing smoking in close social relations was generally associated with diverse tobacco use patterns. These findings are consistent with past research indicating that friends' and families' smoking patterns affect adolescents' use of tobacco products (Jawad et al., 2013; Kinnunen et al., 2015; Kinnunen et al., 2016; Larsen et al., 2013; Lundberg et al., 2019; Perikleous et al., 2018). However, some studies did not find associations between families' smoking patterns and the subsequent use of tobacco among adolescents (Hanewinkel & Isensee, 2015; Larsen et al., 2013). Parents' and friends' smoking had also somewhat stronger relationships with exclusive use of cigarettes and use of both cigarettes and ATPs compared with exclusive use of ATPs. Our findings, as well as the inconsistency in previous studies, may be explained by the question framings utilised in the research where adolescents are asked about whether their friends and family smoke cigarettes. Future research may employ questions about the use of ATPs among adolescents' friends and families.

Similar to our findings, existing research has found school satisfaction, commitment, and engagement to be associated with smoking cigarettes and using ATPs (Geckova et al., 2002; Geidne et al., 2016; Joffer et al., 2014; Wellman et al., 2016). However, to our knowledge, no previous studies have focused on well-being in other aspects of adolescents' lives, e.g.,

at home, which was associated with the use of both cigarettes and ATPs in this study. Future studies may further examine how well-being at home relates to tobacco use, as the present study was unable to analyse the associations between well-being at home and the use of cigarettes exclusively. To our knowledge, research investigating factors such as loneliness and bullying in terms of using ATPs is sparse; thus, our findings contribute to the existing knowledge regarding what characterises young adolescents with diverse tobacco use patterns. Our findings concerning the relationships between well-being characteristics and diverse tobacco use patterns are, like those of most existing studies, not unidimensional (Azagba et al., 2020; Dyal & Valente, 2015; Lindström & Rosvall, 2018; Niño et al., 2016; Varga & Piko, 2015; Vieno et al., 2011), which may underpin the complex associations between well-being and tobacco use – especially considering the social implications of tobacco use behaviours (e.g., Engels & ter Bogt, 2001). Tobacco use may be used as a means to feel included in a group, e.g., because they are exposed to other peers' smoking. On the other hand, tobacco use may be a means to compensate for lack of inclusion in groups, feelings of loneliness, bullying, or low well-being (Akers et al., 1995; Engels & ter Bogt, 2001). However, more in-depth examinations of these associations are needed in future research.

The findings from the present study hold potential for guiding future preventive strategies aiming at reducing the uptake of tobacco products among young adolescents. Given that the market for ATPs has increased over the past decades, there is an urgent need for more knowledge about both the popularity of these products and what characterises the users – and whether they differ from adolescents exclusively smoking conventional cigarettes. We only found a small proportion of youths who had exclusively smoked cigarettes; thus, it is no longer enough to solely focus on conventional tobacco products in prevention strategies as a significant proportion of youths have tried

ATPs. We found that most of the same factors characterised adolescents who had smoked cigarettes exclusively, had used ATPs exclusively, or used both. Consequently, some of the intervention components in existing interventions aiming at reducing the uptake of cigarette smoking may be applicable in reducing the use of ATPs among adolescents. So far, several interventions have been implemented – especially in the school arena – aiming at reducing smoking uptake among adolescents (Thomas et al., 2013) with some demonstrating promising results (e.g., Andersen et al., 2015). Future studies may investigate whether all or some intervention components are also effective in reducing the use of ATPs. At least, prevention efforts may focus on raising awareness about the health risks of ATP use among youths; this use may result in a lifelong addiction to tobacco products and an increased risk of switching to conventional cigarette smoking or dual use of tobacco products (Chapman et al., 2019; Glantz & Bareham, 2018; Grøtvedt et al., 2019). Like conventional cigarettes, most ATPs contain different levels of nicotine which is addictive and especially harmful for the young brain and brain development (Leslie, 2020; US Department of Health and Human Services, 2016). Prevention efforts may also have special attention to the social implications of tobacco use. One strategy could be to educate adults (i.e., parents, teachers, or trainers) about the mechanisms in which adolescents learn risk behaviours, e.g., by seeing other peers or adults in their social environment use tobacco products (e.g., Akers et al., 1995).

Strengths and limitations

The current study holds several strengths, including a large study population of Danish 13-year-olds at 46 schools across Denmark, the ability to examine the prevalence of several tobacco products, and investigating various relevant factors in relation to tobacco use. However, there are also some limitations. First, the cross-sectional study design hinders any causal

interpretations of the findings and, therefore, the direction of associations is not possible to determine. Thus, future studies should investigate the longitudinal trajectories of factors associated with the use of cigarettes exclusively, ATPs exclusively, and both. Second, a possible self-selection bias may have occurred due to the design of this study. As we included all schools interested in participating in the X:IT II intervention study, schools may have been a non-representative sample of all schools in Denmark. However, in a recent study comparing schools participating in X: IT II to other schools nationwide in Denmark, findings showed that participating schools were representative in terms of organisational resources, student enrolment, ethnic composition, average grades, and academic well-being. Nonetheless, more private schools participated as well as schools with more students reporting high social well-being and low well-being related to support and inspiration (Kjeld et al., 2020). These findings indicate that the included schools in this study do not constitute a markedly different group compared with other schools in Denmark.

In this study, a larger proportion of students with a medium and high OSC participated compared with students with a low OSC, and about 21% of students were categorised with a non-classifiable OSC. The group of students with a non-classifiable OSC was rather heterogenous according to several characteristics examined in this study; however, on multiple characteristics, the non-classifiable OSC group was most similar to the low or middle OSC group. Nonetheless, there may be some risk of selection bias where some students with a low OSC decided not to participate in this study. For example, boys were underrepresented in the lowest OSC group and as tobacco product use is most prevalent among boys, this may have caused an underestimation of the prevalences. However, more boys compared with girls were included in the non-classifiable OSC group which may – at least to some extent – explain the underrepresentation of boys in the lowest OSC group.

Conclusion

The present study found that almost one in eight 13-year-olds in Denmark had ever used a tobacco product. Of those, most adolescents had used ATPs exclusively, fewer had used both cigarettes and ATPs, and only 2% had exclusively smoked cigarettes. We found that common characteristics across diverse tobacco use patterns were smoking in social relations (parents and friends), binge drinking, loneliness, and low well-being at school. Although tobacco use was most prevalent among boys compared with girls, the characteristics associated with diverse tobacco use patterns were not markedly influenced by gender. Thus, findings indicate adolescents' engaging in tobacco use generally share the same characteristics regardless of whether they have smoked conventional cigarettes, used ATPs, or both. Nonetheless, students who had used both cigarettes and ATPs constituted a somewhat more risk-averse group and may be in special need of prevention efforts. Future strategies should not only aim at conventional tobacco products but may, to a larger extent, focus on the nature of ATP use and on informing adolescents about the health risks associated with their use. Our findings point to the importance of dealing with risk behaviours in adolescents' social relations, adolescents' engagement in other risk behaviours such as binge drinking, and their well-being state in smoking prevention initiatives.

Data availability statement

Data that support the findings of this study are available from University of Southern Denmark (SDU). Restrictions apply to the availability of data which were used under license for the current study and are not publicly available. However, data are available from the corresponding author upon reasonable request and with permission from SDU.

Ethics approval

There is no formal institution for ethical assessment and approval of questionnaire-based population studies in Denmark. However, the study was approved by

the SDU Research and Innovation Organization. The X: IT II study is registered at the Danish Data Protection Agency, ref: 2015-57-0008, and conducted in accordance with the Helsinki and its late amendments ethical standards.

Informed consent

Principals at schools received written information about participation in the study, and school coordinators were informed that completion of questionnaires was optional and information was treated with confidence. Parents and students were informed that participation was voluntary, and any answers could be withdrawn upon request.

Declaration of conflicting interests

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