

Changes in cigarette smoking and smokeless tobacco use during the COVID-19 lockdown period among youth and young adults in Denmark

Lotus Sofie Bast, Simone Gad Kjeld^a, Marie Borring Andersen

^aCorresponding author

Marie Borring Andersen, MSc

National Institute of Public Health, University of Southern Denmark

Studivstraede 6, 1455 Copenhagen K, Denmark

E-mail: mboa@sdu.dk

ORCID: <https://orcid.org/0000-0002-8644-2971>

Simone G. Kjeld, MSc

National Institute of Public Health, University of Southern Denmark

Studivstraede 6, 1455 Copenhagen K, Denmark

E-mail: simk@sdu.dk

ORCID: <https://orcid.org/0000-0001-6883-8764>

Lotus S. Bast, PhD

National Institute of Public Health, University of Southern Denmark

Studivstraede 6, 1455 Copenhagen K, Denmark

E-mail: loni@sdu.dk

ORCID: <https://orcid.org/0000-0003-0310-5871>

Abstract

Introduction: Cigarettes and smokeless tobacco (snus and nicotine pouches) are prevalent among youth and young adults in Denmark. Here, we examined the extent of changes in the use of cigarettes and smokeless tobacco during the first COVID-19 lockdown in March and April 2020 in Denmark as well as reasons for changed behavior.

Methods: This study used data from a nationwide survey conducted among 15- to 29-year-olds from January to March 2021 including 13,530 respondents (response rate = 36.0%). Logistic regression analyses assessed the associations between sociodemographic characteristics and the odds of initiating or increasing as well as trying to stop or decreasing cigarette smoking and smokeless tobacco use.

Results: The prevalence of cigarette smoking was 17.8% and 10.5% reported using smokeless tobacco. Around 40% of those currently smoking cigarettes reported smoke on par during the COVID-19 lockdown as before, 24.5% started to smoke or increased their smoking, and 27.4% tried to stop or smoked less. Approximately 37% used smokeless tobacco on the same level as before the COVID-19 lockdown, 38.8% initiated or used more, and 14.1% tried to stop or used less. Females were more prone to initiate smokeless tobacco use and increase their level of smoking during the lockdown, and younger participants smoked less. More females compared with males changed their smoking behaviors due to their mood, and more younger participants did so due to fewer social gatherings.

Conclusion: Although most youths and young adults' tobacco behaviors remained the same during the COVID-19 lockdown, many also increased or decreased their behaviors – especially females and younger participants.

Implications: This study enables the possibility of detecting new tendencies in smoking and the use of smokeless tobacco among subgroups of the population during the COVID-19 lockdown. This knowledge is crucial for identifying which groups of youths are vulnerable to increasing their tobacco use in other pandemic situations and which groups call for special attention after the lockdown period. Future efforts may focus on vulnerable groups affected by the COVID-19 pandemic, such as females, and there is a need to monitor closely whether youth tobacco use changes as society becomes more normalized.

Keywords: Smoking, youth, COVID-19, SARS-CoV-2, cigarettes, smokeless tobacco, snus, nicotine pouches, behavior, smoking during lockdown

Introduction

As many other countries globally, Denmark has periodically been locked down during the past years due to the COVID-19 pandemic. The pandemic has had widespread societal and individual effects with more than 229 million reported cases and 4.7 million deaths associated with the pandemic globally as of September 2021.¹ The lockdown in March and April 2020 was the first of the lockdown periods in Denmark. It affected youth and young adult life in several ways; All primary, secondary, and higher education schools were closed, and many students received online teaching only. Food stores remained open, while many other stores, as well as restaurants and bars were closed. Leisure time activities were very limited, and meeting in larger groups were banned, also outdoor activities.

The COVID-19 pandemic has been suggested to impact tobacco consumption in diverse directions by disrupting normal everyday life and habits and thus, consequently disrupting habits of smoking.²⁻⁴ More specifically, being in lockdown may pose a lot of stress on some groups in the population due to, e.g., uncertainty about the future or economic struggles, which may generate stronger incentives to smoke. On the other hand, the COVID-19 pandemic may be linked to declining use of tobacco products through several mechanisms.^{4,5} For example, as research has found smoking to be linked with an increased risk of more severe disease prognosis of COVID-19,⁶ this may be viewed as an incentive to reduce or quit smoking. Moreover, being in lockdown with children may cause reductions in smoking among parents in order to not expose their children for the health hazards of second-hand smoking. For young people living with their parents, the lockdown may also decrease smoking due to not wanting to or not being allowed to smoke at home. Youth is generally characterized as a period with a high level of social activities, which have not been possible to maintain during the lockdown. As there are substantial social implications of tobacco use, e.g., smoking at parties and at social gatherings often in combination with alcohol use,⁷ this may be reflected in the tobacco use patterns among youths.

The current literature on tobacco use patterns during the COVID-19 pandemic reflects the diverse directions in which the pandemic and the subsequent lockdown may affect groups of individuals in the society. In England, the lockdown period was associated with an increased smoking prevalence among younger adults (18-34-year-olds) during the lockdown period (26.8%) compared with before the lockdown (21.5%).⁸ Nonetheless, a significant proportion of young people who currently smoked tried to quit smoking during the lockdown period (29.5% before the lockdown compared with 37.6% during lockdown), many of which succeeded (3.9% before the lockdown vs. 10.0 during lockdown). In the U.S., the lockdown also caused an increased smoking prevalence among adults. Of those who reported to smoke, 41.0% said they increased smoking, 20.1% decreased smoking, while 38.9% smoked on the same level as before the lockdown.⁹ In Ireland, most adults who were currently smoking (60.9%) reported no change in their consumption during lockdown, although 30.5% reported an increased level of smoking.¹⁰ In a study from Italy, 5.5% of participating adults quit or reduced smoking during the lockdown; however, 9.0% of the sample initiated, relapsed smoking, or increased their smoking intensity during the period.¹¹ The research on youth and young adult smoking patterns and reasons for behavior changes during the COVID-19 pandemic is sparse. Research concerning these matters is essential for keeping track on new tendencies among youth and for developing appropriately designed prevention efforts aiming at reducing tobacco use in subgroups of the population. From existing research, there are well-documented gender and socioeconomic differences in the

uptake and development of tobacco use.^{12,13} Therefore, these factors may be essential for investigating behavior changes in relation to tobacco use during the COVID-19 pandemic.

In recent years, there has been an increasing trend in the use of alternative tobacco and nicotine products among youth and young adults. In fact, cigarette smoking and use of smokeless tobacco are the most prevalent tobacco- and nicotine products used among young people in Denmark.¹⁴ Here, smokeless tobacco refers to snus and nicotine pouches. Recent studies among young Danes show that they do not differ between snus and nicotine pouches,¹⁵ and both types are therefore referred to as smokeless tobacco. An increasing public health concern is that efforts during the past decades to discontinue youth and young adults engagement in cigarette smoking may be replaced by recent increases in other tobacco products, e.g., smokeless tobacco. Current national estimates indicate some support to these concerns, i.e., from 2020 to 2021 in Denmark, cigarette smoking decreased, while use of smokeless tobacco increased among 15-29-year-olds.¹⁴ In other Scandinavian countries, an upward trend in the use of smokeless tobacco has also been found in recent years.¹⁶ Although long-term health effects of smokeless tobacco are not yet established, the current evidence links smokeless tobacco to several health adversities, nicotine dependence, and an elevated risk of switching to conventional cigarette smoking.^{17,18} Moreover, a significant proportion of youth and young adults experiments with multiple substance use.^{14,16,19} Especially among youth and young adults, tobacco and nicotine product use raises significant concerns as nicotine damages the brain development,²⁰ and youths initiating tobacco use at an early age are in high risk of establishing smoking habits that track into adulthood.²¹

It is unclear how the COVID-19 lockdown affected the use of cigarette smoking and smokeless tobacco use among youth and young adults in Denmark. This knowledge is important in order to detect new tendencies in smoking and use of smokeless tobacco among subgroups of the population as well as to examine which groups of youths are vulnerable to increase their tobacco use in other pandemic situations. Therefore, the aim of this study was to examine characteristics among those who changed their use of cigarettes and smokeless tobacco behavior during the COVID-19 lockdown in March and April 2020, as well as the reasons for changed behavior.

Methods

Study design

This study is a secondary analysis of data collected in the “§SMOKE – a study of tobacco, behavior and regulations” collected among 15- to 29-year-olds in Denmark. The purpose of the surveys is to assess trends in tobacco use in youth and young adulthood parallel with the implementation of new and stronger tobacco regulations in Denmark. The study runs from 2020 until 2025. The National Institute of Public Health is responsible for the data collections in collaboration with the Danish Cancer Society, the Heart Association, and the Lung Association with financial support from the TrygFoundation.

Data collection

Data was collected from January 15th until March 11th, 2021. In total, 37,611 persons received a secure electronic e-mail with a link to the survey. Two reminders were sent to all non-respondents. Topics in the questionnaire were related to the patterns of tobacco and nicotine product use (cigarettes, snus, and nicotine pouches). In total, 13,660 persons responded to the questionnaire. Respondents who did not answer the question about cigarette smoking was excluded from the sample, leaving 13,530 valid responses (response rate = 36.0%).

Participants and sample size

Study participants were a nationally representative sample of Danish 15-29-year-olds with permanent residence in Denmark at the time of study. All Danish citizens have a unique identification number registered in The Danish Civil Registration System that was used to draw the random sample.²² To ensure sufficient data, the requested sample size was set to 15,000 respondents. With an expected response rate in this age group at 40%, we invited approx. 37,500 individuals to participate in the study.

Data weighting

Data underwent a weighting procedure to account for the possible selection bias in which participants responded to the survey. Weights were constructed using auxiliary information from Statistics Denmark's registers. Weights were based on information on gender and age which were the primary factors that differed between respondents and non-respondents. We also examined the geographical distribution of responses and non-responses according to region in Denmark and found that the distributions did not markedly differ (data not shown). The weights ensured representability of the study sample and reduced the impact of non-responses.

Measures

Information on *gender*, *age*, and *citizenship* was obtained from registers. All other measures were collected in the survey.

Age was coded into three age groups: 15-17 years, 18-24 years, and 25-29 years. In Denmark, you are legally allowed to buy tobacco from the age of 18.

Citizenship was classified into three groups: Danish background, Western background (from the 28 European Union member states as well as Andorra, Iceland, Liechtenstein, Monaco, Norway, San Marino, Switzerland, Vatican City, Canada, the USA, Australia, and New Zealand) or non-Western background (all other countries).²³

Current educational and work status was coded from multiple response categories in the survey into eight categories: 'Primary education (most respondents in age 15-16 years)', 'Vocational education (e.g., education to become electrician)', 'High school', 'Attending higher education (max. 2 years)', 'Attending higher education (≥ 3 years)', 'Working', 'Unemployed', and 'Other (e.g., shorter courses, military recruits, and Danish folk high schools)'.

Household composition consists of five groups: 'Living alone', 'Living with a partner or friends', 'Living with children (with or without a partner)', 'Living with parents (one or both parents as well as any constellation with stepparents)', and 'Other (including foster care)'.

Cigarette smoking and smokeless tobacco use (snus and nicotine pouches) had the response categories: 'Daily', 'Occasionally', 'Ever tried', 'Previously', and 'Never'. Changes in cigarette use and in use of smokeless tobacco were binary coded.

Changes in smoking and smokeless tobacco use during lockdown were measured by asking "Think back to the period in the spring of 2020, when much of Denmark was in lockdown due to the COVID-19 pandemic. Did your smoking/smokeless tobacco use change during the lockdown?". Response options were 'I started smoking', 'I smoked/used less than before', 'I smoked/used the same as before', 'I smoked/used more than before', and 'Do not know'.

Reasons for changes in cigarette smoking and reasons for change in smokeless tobacco use during lockdown included several response options which were not mutually exclusive. Thus, each respondent had the option to choose from several response options, including: 'Economic reasons', 'Fewer opportunities to buy cigarettes', 'Fewer social gatherings', 'Worrying about health consequences', 'Mood/boredom', 'Lockdown with family', 'Other', and 'Don't know'. Participants had the opportunity to write a personal response in the 'Other' category. Responses in this category were individually assessed by two researchers independent of each other with the aim of recategorizing responses that fit into the existing six first listed categories (cigarettes, n=55; smokeless tobacco, n=22). Responses that could not be classified within these original categories remained in the 'Other' category.

Statistical analyses

All statistical analyses were performed using the software STATA/IC 16.1. All descriptive data are presented as actual numbers as well as weighted percentages. Logistic regression analyses were used to assess associations between changes in smoking/smokeless tobacco use and sociodemographic characteristics. Outcomes were 1) initiated/increased use vs. no change or decreased use and 2) decreased use/tried to stop vs. no change or increased use. The models assessing changes in cigarette smoking and changes in using smokeless tobacco were performed separately. Results of the logistic regression analyses are presented as odds ratio (OR) with 95% confidence intervals (CI). In all logistic regression models, a p-value of <0.05 indicated statistical significance. Further, numbers of five or less is reported as n/a.

Ethics

Ethical review and approval were not required for the study on human participants in accordance with the local legislation in Denmark and institutional requirements. The study was registered at the SDU Research and Innovation Organization. Participants received an invitation letter for the study along with written information about the purposes of the study and how data was handled. Participants were also informed that completion of the questionnaire was voluntary, and that their responses would be treated with confidence.

Results

Table 1 shows the unweighted and weighted characteristics for the study population. Based on weighted numbers, 50.9% of the respondents were males, 46.0% were between 18- to 24-years-old, 35.0% were 25 years or older, while 18.2% were between 15- to 17-years-old. Most respondents attended high school, higher education, or was currently working. Overall, 17.8% currently smoked cigarettes of which 9.0% smoked daily and 8.8% smoked

occasionally. Further, 10.5% currently used smokeless tobacco (6.3% daily and 4.2% occasionally). In total, 4 % currently used both cigarettes and smokeless tobacco daily or occasionally (results not shown).

----- Insert Table 1 around here -----

Table 2 shows cigarette smoking and use of smokeless tobacco during the lockdown period for participants reporting to either smoke (17.8% of respondents) or use smokeless tobacco (10.5%). Around 40% of those currently smoking reported to smoke on the same level during lockdown as before the lockdown, whereas 23.1% reported to reduce their smoking, and 21.5% increased smoking during lockdown. More females compared to males increased smoking (25.7% of females vs. 17.9% of males). Overall, 36.7% of participants using smokeless tobacco reported to use on the same level during lockdown as they did before, while 28.3% increased their use, and additional 10.5% started using smokeless tobacco during lockdown. More females compared to males initiated a smokeless tobacco use during the lockdown period (16.8% vs. 7.9%; Table 2).

----- Insert Table 2 around here -----

Among participants who previously smoked, 1.2% (n=168) reported that they stopped smoking cigarettes during the lockdown, and 0.8% (n=110) stopped and substituted their cigarette use with another tobacco product, e.g., smokeless tobacco or e-cigarettes. Among participants previously using smokeless tobacco, 0.5% (n=62) reported that they stopped using during lockdown, while 0.1% (n=18) stopped and substituted with another tobacco product, e.g., cigarettes or e-cigarettes(results not shown).

Table 3 shows the logistic regression analyses of characteristics associated with initiating or increasing cigarette smoking as well as smokeless tobacco during lockdown. More females compared to males initiated or increased cigarette smoking (OR = 1.60, CI: 1.31-1.97) as well as smokeless tobacco use (OR = 1.37, CI: 1.05-1.78) during the COVID-19 lockdown. Initiating or increasing use was more prevalent among younger respondents for both cigarette smoking (15- to 17-year-olds: OR: 1.88, CI: 1.32-2.68; 18- to 24-year-olds: OR: 1.27, CI: 1.01-1.58) and smokeless tobacco use (15- to 17-year-olds: OR: 2.31, CI: 1.52-3.50; 18- to 24-year-olds: OR: 1.76, CI: 1.28-2.43). For cigarette smoking, attending vocational school (OR = 1.56, CI: 1.04-2.35) and higher education (max. 2 years; OR = 2.31, CI: 1.16-5.59) were associated with initiating or increasing smoking compared with respondents in high school. Regarding smokeless tobacco, attending vocational school (OR = 0.60, CI: 0.37-0.99), higher education (three years or more; OR = 0.65, CI: 0.46-0.94), and working (OR = OR = 0.54, CI: 0.39-0.75) were associated with lower odds for initiating or increasing smokeless tobacco use compared with attending high school. For smokeless tobacco, living with parents (OR = 1.53, CI: 1.16-2.01) was associated with initiating or increasing use compared with living with a partner or a friend. Compared with daily cigarette smoking and smokeless tobacco use, smoking and using smokeless tobacco occasionally were associated with lower odds for initiating or increasing cigarette smoking (OR = 0.60, CI: 0.49-0.73) and smokeless tobacco use (OR = 0.51, CI: 0.40-0.66).

----- Insert Table 3 around here -----

Regarding the logistic regression analyses of characteristics associated with decreasing or trying to stop smoking cigarettes as well as smokeless tobacco during lockdown, there were

no marked gender differences in participants reporting to decrease or trying to stop smoking cigarettes and smokeless tobacco (see also Table 3). More participants in the 18- to 24-years age group (OR = 1.51, CI: 1.22-1.86) reported to decrease or trying to stop smoking cigarettes compared with 25- to 29-year-olds, while for smokeless tobacco, more 15- to 17-year-olds reported to (OR = 1.74, CI: 1.05-2.89) decrease or trying to stop using compared with 25- to 29-year-olds. Compared with high-school students, fewer participants in all other categories in the educational and working groups reported to decrease or trying to stop smoking cigarettes. There were no marked educational or work differences in relation to smokeless tobacco. Living alone (OR = 0.68, CI: 0.50-0.92), living with children (OR = 0.43, CI: 0.26-0.71), and living in other constellations (e.g., foster care; OR = 0.22, CI: 0.08-0.58) was associated with lower odds for decreasing or trying to stop smoking cigarettes, while living with parents (OR = 1.35, CI: 1.05-1.76) was associated with decreasing or trying to stop smoking cigarettes. Compared with daily cigarette smoking and smokeless tobacco use, smoking and using smokeless tobacco occasionally were associated with decreasing or trying to stop smoking cigarettes (OR = 5.44, CI: 4.37-6.78) and smokeless tobacco use (OR = 3.82, CI: 2.70-5.41).

Table 4 presents reasons for changes in smoking and smokeless tobacco use during lockdown. Most prevalent reasons for changes in cigarette smoking during lockdown was fewer social gatherings (32.0%), followed by mood or boredom (24.9%). Among respondents stopping or decreasing cigarette smoking, the most prevalent reason was fewer social gatherings (41.8 %), while respondents reporting to start or increase their smoking, said that it was due to mood or boredom (57.4 %). There seemed to be some differences according to gender, e.g., 27.6% of females changed their behavior due to mood, while the corresponding proportion was 22.3% for males. Moreover, there were some differences according to age; 15- to 17-year-olds reported to a larger extent changing their consumption due to being in lockdown with family (17.7%) compared with older respondents, i.e., the 25- to 29-year-olds (7.3%), while fewer 15- to 17-year-olds reported worrying about health consequences (5.0%) as reasons for changing tobacco use patterns compared with 25- to 29-year-olds (15.5%).

Regarding smokeless tobacco, the most prevalent reason for changing behavior was mood or boredom (35.8 %), followed by fewer social gatherings (24.2 %). Among respondents saying that they started or increased their use of smokeless tobacco, half of them (49.7 %) reported that it was due to mood or boredom. Lockdown with family was an equally present reason among persons starting/increasing use and stopping/decreasing use. However, divided into age groups, most of the 15- to 17-year-olds reported this.

----- Insert Table 4 around here -----

Discussion

The current study is among the few to explore which factors are associated with changing tobacco and smokeless tobacco use patterns, as well as reasons for changing use among youth and young adults during the COVID-19 lockdown. Knowledge derived from this study is crucial for gaining in-depth insights into tobacco and smokeless tobacco use behaviors among young people during pandemic situations and for identifying subgroups in special need of prevention efforts. Overall, this study showed a mixed picture of changes in cigarette

smoking and use of smokeless tobacco in Denmark during the first of the COVID-19 lockdowns, i.e., in March and April 2020.

For a substantial proportion of participants, their use of cigarettes and smokeless tobacco was on par with their level of use before the lockdown period. However, many also changed their behaviors; around one-fourth currently smoking cigarettes reported to decrease or trying to stop smoking, while another fourth initiated or increased their level of cigarette smoking. Compared with global studies on tobacco use during COVID-19 lockdowns, most report diverging findings in line with findings from the present study, e.g., among Irish and German adults, most reported no change in their level of cigarette consumption during the lockdown, although around one-fifth to one-third either increased or decreased their smoking in the lockdown period.^{10,24} However, among U.S. adults, there were markedly more reporting to increase their smoking level during the lockdown compared with the current study.⁹ In a Scandinavian context, the literature on youth and young adults' tobacco use patterns during the COVID-19 lockdown is sparse.

Overall, among participants using smokeless tobacco, one in ten stated that they initiated their use during lockdown, which was only a very small proportion for cigarette smoking. These findings may reflect the increasing popularity of smokeless tobacco among youth in Denmark,¹⁴ or that smokeless tobacco may be used as a substitute to cigarette smoking due to, e.g., the perception of harm reduction by replacing smoking with smokeless tobacco use.²⁵ Females in this study were more prone to increase their level of cigarette smoking, while men to a higher degree reported keeping the same level of use during lockdown as before. Studies comparing male and females in regard to their tobacco consumption patterns did mostly not find notable gender differences,^{24,26} while one study – in line with our findings – found females to be more susceptible to increase their smoking compared with males.¹¹ One study found females to be less prone to increase their use of substances compared with males.²⁷ However, this study utilized a combined measure of smoking, vaping, alcohol, and cannabis use, which could explain the diverse results from this study and other research in the area. The increased levels of smoking among females may – at least to some extent – be explained by females generally reporting to experience more stress in their daily lives because of the COVID-19 situation compared with males, i.e., women perceive the situation as more stressful than men do.^{26,28} Moreover, other research found a dose-response relationship with higher experienced stress being connected with higher smoking intensity during the COVID-19 lockdown.² In this study, there were also markedly more females reporting mood or boredom as a reason for changing tobacco use patterns, and mood or boredom was mostly related to increasing use of tobacco, which has also been reported elsewhere.²⁹ There were no marked gender differences in participants reporting to increase their level of smokeless tobacco; however, twice as many females started to use smokeless tobacco compared to males during the lockdown period. To our knowledge, this is the first study to explore subgroup differences in the use of smokeless tobacco during the COVID-19 lockdown, and more research within this area is needed to qualify the present findings.

More of the youngest respondents (15-17-year-olds) reported to initiate smoking during lockdown. However, this finding corresponds to the usual patterns of smoking development where most adolescents initiate their use before the age of 18.^{30,31} Hence, these patterns are not considered as a unique result in relation to the lockdown period. Moreover, in this study, more of the 15- to 17-year-olds reported to smoke less during lockdown compared with 25- to 29-year-olds. To our knowledge, no studies have reported comparable tobacco use

behaviors in youth and young adult subgroups as in the current study. Nonetheless, in an Italian study, participants in the 18 to 34 age groups were more prone to decrease or quit smoking during lockdown compared with older age groups.¹¹ The decreasing use among the youngest respondents may be explained by a lower level of social activities, i.e., leisure time activities and parties, due to the COVID-19 restrictions. Among young people, tobacco use is often initiated at social gatherings, e.g., parties, and in combination with alcohol.⁷

The most prevalent reasons for changes in consumption differed according to type of tobacco product; mood or boredom was the most frequent reason for changes in smokeless tobacco use, whereas fewer social gatherings were the most frequent reason for changes in cigarette consumption. These findings are in line with research from the Netherlands among 16- to 24-year-olds that found fewer social gatherings to be the top reason for decreasing cigarette smoking,³² while a study from Belgium among adults reported e.g., boredom and lack of social contacts as main reasons for consuming more tobacco.³³ This may also reflect that smoking cigarettes – for many young people – is a social thing, that could not be maintained during lockdown. Further, especially among the youngest respondents, being in lockdown with family may have made it difficult to smoke cigarettes, but not equally difficult to use smokeless tobacco, without parents knowing it. The proportions reporting to be worried about health consequences as reasons for changing their behaviors were almost equal across types of tobacco products. Due to the nature of the COVID-19 virus being a lung virus, it could be expected that more respondents that smoke cigarettes would decrease their use due to well-known health risks. Hence, other research found that smokers perceived smokeless tobacco to be overall less harmful to health, and especially respiratory health, than conventional cigarettes.^{25,33} Subsequently, future research may further investigate reasons for changing behaviors due to the COVID-19 lockdown across types of tobacco products. It is well-known that a social gradient in smoking behaviors exists,^{34,35} and several studies also show a socially skewed effect of the pandemic.^{36,37}

Examining the social and socioeconomic implications of the lockdown period in relation to smoking and smokeless tobacco use would provide useful insights for future research and practice. However, this was not investigated in the present study, as it can be difficult to measure a social gradient among this group of young people using the measures available in this study. Many young people have not yet finished their education, and thus, the educational measure may not reflect the actual socioeconomic status of the participants. Future research is encouraged to investigate these topics further.

Methodological considerations

The strengths of this study are the large sample size drawn randomly from a national register, the questionnaire with multiple tobacco and nicotine products, as well as other tobacco related items enabling the study of patterns and trends – also within subgroups.

The response rate in this study was 36.0% which is in accordance with response rates among youth in other Danish population-based studies. In Denmark, there has been an overall declining trend in participation in health surveys over the past decades, and the rather low participation rate may be a result of a general questionnaire fatigue among youth, which has also been the case in other studies.³⁸ To ensure the highest possible response rate and representability of the study sample, the questionnaire was sent by a secure

electronic mail which the vast majority of people living in Denmark are able to receive. Two reminders were sent to the whole sample size to optimize the number of respondents. To account for possible selection bias, we examined differences among participants and non-participants and used weighting for age and gender to account for possible bias in the responses due to these factors. This study is the first in a row of cross-sectional studies in the §SMOKE study, which altogether contributes to the evaluation of the tobacco regulations in Denmark.

The reliability of self-reported survey data is based on confidence in the accuracy of the respondents' recall as well as on their motivation to provide truthful information on the topic of interest. Youth behaviors were self-reported with the risk of social desirability bias. However, previous research shows good correspondence between adolescent self-reported smoking status and biological measures.^{39,40} There is also some risk of recall bias in which participants may have issues recalling their tobacco use during the lockdown period. Hence, around ten percent of participants smoking cigarettes and using smokeless tobacco reported that they could not remember how their tobacco use changed during lockdown. This group was not included in the analyses regarding changing smoking and smokeless tobacco use behaviors. Another general limitation of the survey data used is the cross-sectional study design which impedes conclusions to be drawn on the direction of causality as well as the short time frame of the lockdown period.

Conclusion

This study showed that most young Danes smoked and used smokeless tobacco on the same level during the first COVID-19 lockdown as they did before; however, around one-fourth increased and another fourth decreased smoking. Especially females were more vulnerable to increase their smoking or initiate smokeless tobacco use, while younger participants were more prone to decrease their level of use. Participants' state of mind during lockdown and lack of social gatherings influenced their tobacco use behaviors. Future efforts may pay specific attention to vulnerable groups affected by the COVID-19 pandemic and there is a need to monitor closely whether youth tobacco use changes as the society becomes more normalized.

Conflicts of interest: The authors declare no conflicts of interest.

Funding sources: Data collection and preparation of the publication is supported by the TrygFoundation. The study is anchored at the National Institute of Public Health, University of Southern Denmark, in collaboration with the Danish Cancer Society, the Heart Association, and the Lung Association.

Author contributions: LSB is the principal investigator on the §SMOKE-study. All authors participated in the development of the questionnaire items, the data collection, data work, and drafting of the manuscript. MBA ran the analyses, and SGK edited the final version of the manuscript.

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

Accepted Manuscript

References

1. Center for Systems Science and Engineering (CSSE). COVID-19 Dashboard. John Hopkins University. <https://coronavirus.jhu.edu/map.html>
2. Bommelé J, Hopman P, Walters BH, et al. The double-edged relationship between COVID-19 stress and smoking: implications for smoking cessation. *Tob Induc Dis.* 2020;18.
3. Chen DT-H. The psychosocial impact of the COVID-19 pandemic on changes in smoking behavior: Evidence from a nationwide survey in the UK. *Tob Prev Cessat.* 2020;6.
4. Stanton R, To QG, Khalesi S, et al. Depression, anxiety and stress during COVID-19: associations with changes in physical activity, sleep, tobacco and alcohol use in Australian adults. *Int J Environ Res Public Health.* 2020;17(11):4065.
5. Klemperer EM, West JC, Peasley-Miklus C, Villanti AC. Change in tobacco and electronic cigarette use and motivation to quit in response to COVID-19. *Nicotine Tob Res.* 2020;22(9):1662-1663.
6. Umnuaypornlert A, Kanchanasurakit S, Lucero-Prisno DEI, Saokaew S. Smoking and risk of negative outcomes among COVID-19 patients: A systematic review and meta-analysis. *Tob Induc Dis.* 2021;19
7. Wetzels J, Kremers SP, Vitoria PD, De Vries H. The alcohol–tobacco relationship: a prospective study among adolescents in six European countries. *Addiction.* 2003;98(12):1755-1763.
8. Jackson SE, Beard E, Angus C, Field M, Brown J. Moderators of changes in smoking, drinking, and quitting behaviour associated with the first Covid-19 lockdown in England. *Addiction.* 2021;ckab050.
9. Zhang X, Oluyomi A, Woodard L, et al. Individual-level determinants of lifestyle behavioral changes during COVID-19 lockdown in the United States: results of an online survey. *Int J Environ Res Public Health.* 2021;18(8):4364.
10. Reynolds CM, Purdy J, Rodriguez L, McAvoy H. Factors associated with changes in consumption among smokers and alcohol drinkers during the COVID-19 ‘lockdown’ period. *Eur J Public Health.* 2021;
11. Carreras G, Lugo A, Stival C, et al. Impact of COVID-19 lockdown on smoking consumption in a large representative sample of Italian adults. *Tob Control.* 2021.
12. White HR, Pandina RJ, Chen P-H. Developmental trajectories of cigarette use from early adolescence into young adulthood. *Drug Alcohol Depend.* 2002;65(2):167-178.
13. Loring B. *Tobacco and inequities: Guidance for addressing inequities in tobacco-related harm.* World Health Organization. Regional Office for Europe; 2014.
14. Andersen MB, Bast LS. §RØG – En undersøgelse af tobak, adfærd og regler: udvalgte tendenser 2021 [§SMOKE – A study of tobacco, behaviour and regulations: selected tendencies 2021]. 2021.
15. Pedersen MT, Lund L, Bast LS. Brug af røgfri nikotinprodukter blandt unge: §RØG – en undersøgelse af forbrug af snus, tyggetobak og nikotinposer [Use of smokeless nicotine products among youth: §SMOKE – a study on use of snus, chewing tobacco, and nicotine pouches]. Copenhagen, Denmark: Danish Health Authority; 2022.
16. Lundberg CS, Kvaavik E, Tokle R. Nye bruksmønstre i et tobakksmarked i endring–kombinert bruk av sigaretter, snus og e-sigaretter blant ungdom [New patterns of use in a changing tobacco market–combined use of cigarettes, snus, and e-cigarettes among youth]. *Nord Stud Alcohol Drugs.* 2019;36(1):6-20. 17. Norwegian Institute of Public Health. *Helserisiko ved snusbruk [Health risks from snus use].* Norwegian Institute of Public Health; 2019.
18. Grøtvedt L, Forsén L, Ariansen I, Graff-Iversen S, Holmen TL. Impact of snus use in teenage boys on tobacco use in young adulthood; a cohort from the HUNT Study Norway. *BMC Public Health.* 2019;19(1):1-10.
19. Kjeld SG, Andersen S, Andersen A, et al. 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. *Nord Stud Alcohol Drugs.* 2021.

20. Leslie FM. Unique, long-term effects of nicotine on adolescent brain. *Pharmacol Biochem Behav.* 2020;173010.
21. US Department of Health Human Services. *Preventing tobacco use among youth and young adults: a report of the surgeon general.* US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2012.
22. Pedersen CB. The Danish civil registration system. *Scand J Public Health.* 2011;39(7_suppl):22-25.
23. Statistics Denmark. *Statistikdokumentation for Indvandrere og efterkommere 2017 [Statistics documentation for immigrants and descendants 2017].* Statistics Denmark. 2017.
24. Koopmann A, Georgiadou E, Reinhard I, et al. The effects of the lockdown during the COVID-19 pandemic on alcohol and tobacco consumption behavior in Germany. *Eur Addict Res.* 2021;1-15.
25. Øverland S, Hetland J, Aarø LE. Relative harm of snus and cigarettes: what do Norwegian adolescents say? *Tob Control.* 2008;17(6):422-425.
26. Gendall P, Hoek J, Stanley J, Jenkins M, Every-Palmer S. Changes in tobacco use during the 2020 COVID-19 lockdown in New Zealand. *Nicotine Tob Res.* 2021;23(5):866-871.
27. Chaiton M, Dubray J, Kundu A, Schwartz R. Perceived impact of COVID on smoking, vaping, alcohol and cannabis use among youth and youth adults in Canada. *Can J Psychiatry.* 2021:07067437211042132.
28. Elling JM, Crutzen R, Talhout R, De Vries H. Tobacco smoking and smoking cessation in times of COVID-19. *Tob Prev Cessat.* 2020;6
29. O'donnell R, Eadie D, Stead M, Dobson R, Semple S. 'I was smoking a lot more during lockdown because I can': A qualitative study of how UK smokers responded to the Covid-19 lockdown. *Int J Environ Res Public Health.* 2021;18(11):5816.
30. Danish Health Authority. *Danskernes rygevaner 2020. Delrapport 1: Nikotinafhængighed [Smoking habits among Danish citizens 2020. Sub-report 1: Nicotine dependence].* 2021.
30. Centers for Disease Control and Prevention. *Youth and Tobacco Use.* 2020. https://www.cdc.gov/tobacco/data_statistics/fact_sheets/youth_data/tobacco_use/index.htm
31. Benschop A, Van Bakkum F, Noijen J. Changing patterns of substance use during the coronavirus pandemic: Self-reported use of tobacco, alcohol, cannabis, and other drugs. *Front Psychiatry.* 2021;12.
32. Vanderbruggen N, Matthys F, Van Laere S, Zeeuws D, Santermans L, Van den Aemele S, Crunelle CL. Self-reported alcohol, tobacco, and cannabis use during COVID-19 lockdown measures: results from a web-based survey. *Eur Addict Res.* 2020;26(6):309-15.
33. Wackowski OA, Ray AE, Stapleton JL. Smokers' perceptions of risks and harm from snus relative to cigarettes: a latent profile analysis study. *Addict Behav.* 2019;91:171-74.
34. Holstein BE, Andersen A, Damsgaard MT, Due P, Bast LS, Rasmussen M. Trends in socioeconomic differences in daily smoking among 15-year-old Danes 1991–2014. *Scand J Public Health.* 2019;48:667–73.
35. de Looze M, ter Bogt T, Hublet A, Kuntsche E, Richter M, Zsiros E, et al. Trends in educational differences in adolescent daily smoking across Europe, 2002–10. *Eur J Public Health.* 2013;23:846–52.
36. Nicola M, Alsafi Z, Sohrabi C, Kerwan A, Al-Jabir A, Iosifidis C, Agha M, Agha R. The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *Int J Surg.* 2020;78:185-193.
37. Gustafsson PE, San Sebastian M, Fonseca-Rodriguez O, et al. Inequitable impact of infection: social gradients in severe COVID-19 outcomes among all confirmed SARS-CoV-2 cases during the first pandemic wave in Sweden. *J Epidemiol Community Health.* 2022;76:261-267.
38. Pisinger V, Thorsted A, Jezek A, Jørgensen A, Christensen A, Thygesen L. *Sundhed og trivsel på gymnasiale uddannelser [Health and wellbeing in high schools].* National Institute of Public Health; 2019.

39. Kentala J, Utraiainen P, Pahkala K, Mattila K. Verification of adolescent self-reported smoking. *Addict Behav.* 2004;29(2):405-411.
40. Caraballo RS, Giovino GA, Pechacek TF. Self-reported cigarette smoking vs. serum cotinine among US adolescents. *Nicotine Tob Res.* 2004;6(1):19-25.

Accepted Manuscript

Table 1. Characteristics of the study population (n=13,530)

	Unweighted		Weighted	
	%	(n)	%	(n)
Gender (n=13,530)				
Male	42.2	(5,714)	50.9	(6,884.5)
Female	57.8	(7,816)	49.1	(6,638.0)
Age group (n=13,530)				
15 to 17 years	20.2	(2,726)	18.2	(2,459.4)
18 to 24 years	47.8	(6,472)	46.0	(6,216.2)
25 to 29 years	32.0	(4,332)	35.8	(4,846.9)
Currently working or going to school (n=13,515)				
Primary education	8.7	(1,179)	7.9	(1,061.2)
Vocational education	6.6	(896)	6.8	(912.8)
High school	19.9	(2,689)	18.6	(2,511.2)
Higher education (max. 2 years)	2.1	(282)	2.0	(273.5)
Higher education (≥ 3 years)	19.7	(2,666)	19.6	(2,648.3)
Working	33.4	(4,517)	35.5	(4,792.2)
Unemployed	6.5	(879)	6.7	(908.6)
Other	3.0	(407)	3.0	(399.5)
Citizenship (n=13,350)				
Danish	93.7	(12,680)	93.6	(12,654.8)
Western	3.7	(499)	3.8	(509.7)
Non-western	2.6	(351)	2.7	(358.0)
Household composition (n=11,546)				
Living alone	14.8	(1,710)	15.6	(1,795.9)
Living with partner or friend	34.4	(3,972)	35.5	(4,074.6)
Living with children	7.6	(877)	7.9	(903.8)
Living with parents	40.9	(4,725)	38.7	(4,448.2)
Other	2.3	(262)	2.3	(262.6)
Smoke cigarettes (n=13,530)				
Daily	8.7	(1,181)	9.0	(1,220.7)
Occasionally	8.7	(1,174)	8.8	(1,186.6)
Tried smoking	35.0	(4,736)	34.9	(4,723.0)
Former smoker	11.8	(1,599)	12.3	(1,665.9)
Never smoker	35.8	(4,840)	35.0	(4,726.3)
Use smokeless tobacco (n=11,575)				
Daily	5.9	(678)	6.3	(721.0)
Occasionally	4.1	(478)	4.2	(488.1)
Tried using	28.2	(3,269)	28.6	(3,298.0)
Former user	3.4	(391)	3.6	(412.1)
Never user	58.4	(6,759)	57.3	(6,596.2)

Table 2. Cigarette smoking and use of smokeless tobacco during the COVID-19 lockdown

	Male		Female		15-17 years		18-24 years		25-29 years		Total	
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
Cigarettes (n=2,035)												
I started smoking	2.6	(25)	3.4	(39)	10.3	(22)	2.5	(28)	1.8	(14)	3.0	(64)
I smoked less	22.9	(211)	23.3	(266)	24.6	(56)	26.6	(289)	18.4	(132)	23.1	(477)
I smoked the same amount	44.2	(393)	35.8	(400)	27.7	(60)	35.9	(389)	49.0	(344)	40.3	(793)
I smoked more	17.9	(161)	25.7	(292)	21.0	(49)	22.8	(259)	20.0	(145)	21.5	(453)
I tried stop smoking	4.4	(40)	4.3	(47)	3.0	(7)	4.0	(42)	5.1	(38)	4.3	(87)
I do not remember	8.0	(75)	7.6	(86)	13.5	(30)	8.2	(87)	5.8	(44)	7.8	(161)
Smokeless tobacco (n=1,138)												
I started using	7.9	(57)	16.8	(72)	16.5	(37)	9.8	(76)	7.7	(16)	10.5	(129)
I used less	10.1	(72)	14.3	(61)	17.0	(36)	9.6	(74)	12.0	(23)	11.3	(133)
I used the same amount	39.9	(279)	29.0	(123)	19.7	(43)	37.6	(270)	48.0	(89)	36.7	(402)
I used more	28.9	(208)	26.7	(114)	26.1	(55)	31.1	(227)	21.1	(40)	28.3	(322)
I tried stop using	3.0	(22)	2.4	(10)	3.2	(6)	2.9	(21)	2.3	(5)	2.8	(32)
I do not remember	10.1	(73)	10.9	(47)	17.5	(38)	8.9	(65)	8.9	(17)	10.4	(120)

Note. Data are presented as actual numbers and weighted percentages.

Accepted Manuscript

Table 3. Associations between smoked/used more and smoked/used less during the COVID-19 lockdown and selected sociodemographic characteristics.

	Smoked/used more (initiated or increased)				Smoked/used less (tried to stop or decreased)			
	Cigarettes (n = 517)		Smokeless tobacco (n = 451)		Cigarettes (n = 564)		Smokeless tobacco (n = 165)	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Gender								
Male	1.00 (ref.)		1.00 (ref.)		1.00 (ref.)		1.00 (ref.)	
Female	1.60 (1.31-1.97)	<0.001	1.37 (1.05-1.78)	0.020	1.01 (0.83-1.22)	0.956	1.35 (0.95-1.91)	0.093
Age groups								
25-29 years of age	1.00 (ref.)		1.00 (ref.)		1.00 (ref.)		1.00 (ref.)	
15-17 years of age	1.88 (1.32-2.68)	<0.001	2.31 (1.52-3.50)	<0.001	1.41 (0.99-2.02)	0.059	1.74 (1.05-2.89)	0.033
18-24 years of age	1.27 (1.01-1.58)	0.034	1.76 (1.28-2.43)	0.001	1.51 (1.22-1.86)	<0.001	0.85 (0.56-1.31)	0.468
Currently working or going to school								
High school	1.00 (ref.)		1.00 (ref.)		1.00 (ref.)		1.00 (ref.)	
Primary education	1.87 (0.99-3.56)	0.056	0.76 (0.40-1.44)	0.395	0.36 (0.18-0.74)	0.005	1.78 (0.86-3.66)	0.118
Vocational education	1.56 (1.04-2.35)	0.033	0.60 (0.37-0.99)	0.047	0.21 (0.14-0.35)	<0.001	0.67 (0.33-1.34)	0.254
Higher education (max. 2 years)	2.31 (1.16-4.59)	0.017	0.65 (0.28-1.55)	0.335	0.29 (0.13-0.65)	0.003	0.76 (0.23-2.48)	0.643
Higher education (≥ 3 years)	1.00 (0.70-1.42)	0.996	0.65 (0.46-0.94)	0.020	0.58 (0.42-0.80)	0.001	0.80 (0.50-1.28)	0.354
Working	0.78 (0.57-1.08)	0.140	0.54 (0.39-0.75)	<0.001	0.38 (0.29-0.52)	<0.001	0.65 (0.42-1.01)	0.055
Unemployed	0.84 (0.54-1.30)	0.426	0.68 (0.37-1.27)	0.229	0.54 (0.37-0.81)	0.003	0.36 (0.12-1.08)	0.067
Other	0.87 (0.45-1.69)	0.685	1.03 (0.50-2.15)	0.934	0.53 (0.29-0.98)	0.043	1.03 (0.41-2.59)	0.957
Citizenship								
Danish	1.00 (ref.)		1.00 (ref.)		1.00 (ref.)		1.00 (ref.)	
Western	0.94 (0.53-1.66)	0.836	1.05 (0.56-1.96)	0.888	0.58 (0.31-1.08)	0.084	0.89 (0.37-2.15)	0.802
Non-Western	0.73 (0.37-1.42)	0.347	1.30 (0.50-3.35)	0.593	0.93 (0.51-1.70)	0.810	0.37 (0.06-2.48)	0.306
Household composition								
Living with partner or friend	1.00 (ref.)		1.00 (ref.)		1.00 (ref.)		1.00 (ref.)	
Living alone	1.13 (0.84-1.52)	0.411	1.67 (0.78-1.74)	0.451	0.68 (0.50-0.92)	0.012	0.87 (0.45-1.52)	0.622
Living with children	0.77 (0.49-1.22)	0.273	1.16 (0.56-2.39)	0.694	0.43 (0.26-0.71)	0.001	0.72 (0.25-2.16)	0.567
Living with parents	0.86 (0.65-1.14)	0.299	1.53 (1.16-2.01)	0.002	1.35 (1.05-1.76)	0.022	1.12 (0.78-1.60)	0.555
Other (foster care)	1.27 (0.69-2.35)	0.439	1.70 (0.67-4.35)	0.266	0.22 (0.08-0.58)	0.002	0.53 (0.10-2.68)	0.441
Current smoking/ smokeless tobacco use								
Daily	1.00 (ref.)		1.00 (ref.)		1.00 (ref.)		1.00 (ref.)	
Occasional	0.60 (0.49-0.73)	<0.001	0.51 (0.40-0.66)	<0.001	5.44 (4.37-6.78)	<0.001	3.82 (2.70-5.41)	0.001

OR: odds ratio; CI: confidence intervals.

Table 4. Reasons for changes in cigarette smoking and use of smokeless tobacco during the COVID-19 lockdown

	Total		Male		Female		15-17 years		18-24 years		25-29 years		Started or increased ^a		Stopped, decreased, or replaced ^a	
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
Cigarettes (n=1,886)																
Economic reasons	5.8	(102)	7.4	(57)	4.1	(45)*	2.4	(5)	6.0	(62)	6.3	(35)	3.7	(23)	7.0	(79)
Fewer opportunities to buy cigarettes	2.4	(46)	2.8	(23)	2.0	(23)	5.8	(12)	2.5	(26)	1.3	(8)	n/a	n/a	3.6	(44)
Fewer social gatherings	32.0	(609)	31.4	(248)	32.6	(361)	30.5	(68)	34.6	(365)	28.7	(176)	15.0*	(102)	41.8	(502)
Worried about health consequences	10.6	(191)	11.6	(88)	9.6	(103)	5.0	(11)	8.4	(86)	15.5*	(94)	2.2*	(14)	15.4	(177)
Mood/boredom	24.9	(480)	22.3	(174)	27.6*	(306)	26.9	(61)	25.2	(273)	23.9*	(146)	57.4	(404)	6.4	(76)
Lockdown with family	10.1	(197)	8.9	(71)	11.2	(126)	17.7	(47)	10.5	(113)	7.3	(44)	9.3	(65)	10.5	(132)
Other	10.1	(183)	10.6	(80)	9.5	(103)	5.6	(3)	8.1	(85)	14.2	(85)	7.2	(48)	11.7	(134)
Don't know	4.2	(78)	4.9	(39)	3.4	(39)	6.1	(13)	4.7	(49)	2.9	(16)	4.9	(36)	3.5	(38)
Smokeless tobacco (n=942)																
Economic reasons	2.0	(18)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.2	(7)	3.5	(11)
Fewer opportunities to buy smokeless tobacco	2.9	(28)	3.4	(21)	1.9	(7)*	n/a	n/a	n/a	n/a	n/a	n/a	1.4	(8)	6.0	(20)
Fewer social gatherings	24.2	(234)	22.7	(137)	28.0*	(99)	21.3	(43)	25.1	(151)	24.6	(31)	17.5*	(110)	37.8	(126)
Worried about health consequences	8.0	(70)	9.3	(54)	4.7	(16)	3.0	(6)	7.6	(44)	15.7	(20)	2.8	(17)	18.2	(54)
Mood/boredom	35.8	(334)	35.0	(210)	37.8*	(134)	32.5	(75)	38.3	(233)	30.6	(38)	49.3*	(316)	9.0	(27)
Lockdown with family	12.7	(123)	12.6	(77)	12.4	(46)	17.3	(34)	12.5	(75)	7.6	(10)	13.6*	(87)	11.2	(37)
Other	8.9	(82)	9.5	(56)	7.6	(26)	7.0	(15)	7.8	(46)	15.7	(21)	7.8	(48)	11.1	(34)
Don't know	5.4	(53)	5.2	(32)	5.9	(21)	10.5	(25)	4.1	(25)	4.4	(6)*	6.1	(41)	3.3	(10)

Note. For these items, the respondents had the opportunity to select several response categories. Thus, the categories are not mutually exclusive

^bn does not sum up to the total study population (N) due to missing answers on some of the items

*marks statistical significance at the $p < 0.05$ level.