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Original investigation

Patterns of Nicotine and Tobacco Product Use in Youth and Young Adults in the United States, 2011–2015

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Abstract

Introduction: As cigarette smoking has decreased among youth and young adults (YAs) in the United States, the prevalence of other tobacco and nicotine product use has increased.

Methods: This study identified common past 30-day patterns of tobacco and nicotine product use in youth (grades 6–12) and YAs (aged 18–24). Using data from the 2011–2015 National Youth Tobacco Survey (NYTS) and corresponding years of the Truth Initiative Young Adult Cohort Study (TIYAC), past 30-day use of the following products was assessed: cigarettes, e-cigarettes, any type of cigar, smokeless tobacco, hookah, and other tobacco products (pipe, bidis, kreteks, dissolvable tobacco, and snus). A user-generated program in R was used to assess all possible combinations of product-specific and polytobacco use.

Results: The top five patterns of past 30-day use in youth were exclusive cigarette use (12.0%), exclusive cigar use (10.3%), exclusive e-cigarette use (10.0%), dual use of cigarettes and cigars (6.1%), and exclusive hookah use (5.2%). In YAs, the top five patterns were exclusive cigarette use (46.5%), exclusive cigar use (10.0%), dual use of cigarettes and cigars (6.4%), exclusive hookah use (5.9%), and dual use of cigarettes and e-cigarettes (3.9%).

Conclusions: As noncigarette tobacco and nicotine products become increasingly popular among tobacco users, further research is needed to identify predictors and correlates of specific tobacco use patterns in youth and YAs. This analysis can inform tobacco prevention efforts focusing on emerging tobacco products such as e-cigarettes and hookah. Educational and other intervention efforts should focus on the diversity of products and use patterns in these age groups.

Implications: This study uses population-based data to provide new information on the most prevalent patterns of past 30-day nicotine and tobacco use over a 5-year period among youth and young adults. Study findings demonstrate that youth and young adults report using tobacco and nicotine products in different combinations, with varying popularity over time. Additionally, by examining young adults as a separate group, this study highlights the unique patterns of use not previously discussed in the adult literature.

Introduction

Although cigarette use among youth and young adults (YAs) has declined in the past decade, use of other combustible products, including little cigars/cigarillos and hookah, remains prevalent among youth and YAs.[1] Past 30-day use of two (dual use) or more (poly use) tobacco and nicotine products is popular in youth[2–4] and YAs.[3,5,6] In 2012, nearly two-thirds (62.4%) of current YA tobacco users reported dual or poly use of cigarettes and other tobacco products.[7] The most common product combination for YAs was cigarettes with little cigars/cigarillos[8] and hookah.[9–12] Among youth who used tobacco in the past 30 days, 43% reported use of multiple tobacco and nicotine products in 2013, with use of cigarettes and e-cigarettes reported as the most common product combination.[3]

Cross-sectional studies of adolescents have demonstrated an association between past 30-day tobacco use and risk behaviors such as illicit substance use.[13–15] Evidence suggests that this association is even stronger among adolescents who report use of multiple tobacco and nicotine products.[13,15,16] Past 30-day use of multiple tobacco and nicotine products may also lead to greater nicotine dependence among youth and YA users,[17,18] particularly among cigarette smokers who use other tobacco and nicotine products.

A previous examination of patterns of tobacco and nicotine products identified dual use of cigarettes and e-cigarettes as the most prevalent pattern among adults polytobacco users.[3] However, this prior work did not separate YAs from older adults, who were likely to have established their tobacco and nicotine product use when different products were on the market. National data highlight that YAs (aged 18–24) reported a higher prevalence of any past 30-day tobacco use than adults aged ≥25, and YAs have been shown to be more likely to use multiple products than older adults.[3,6,7,19]

To address these gaps in the literature, this study used data from the 2011–2015 National Youth Tobacco Survey (NYTS) and corresponding years of data from the Truth Initiative Young Adult Cohort (YA Cohort) Study to assess patterns of past 30-day tobacco and nicotine product use in youth (aged 12–17) and YAs (aged 18–24) and changes in use pattern prevalence over time. Tobacco and nicotine products of interest include cigarettes, e-cigarettes, cigars, little cigars/cigarillos, hookah tobacco, and smokeless tobacco.

Methods

This study leverages data from two large contemporary cohorts. One is a national, self-administered survey of US middle and high school students (NYTS); the other is a national longitudinal online survey of YAs (YA Cohort Study). Both surveys are described in detail elsewhere.[5,20] Detail on both samples and the measures employed in parallel analyses are described below.

National Youth Tobacco Survey

The NYTS provides estimates of past 30-day tobacco use among adolescents.[20] Sample sizes and overall response rates were 18 866 (72.7%) for 2011, 24 658 (73.6%) for 2012, 18 406 (67.8%) for 2013, 22 007 (73.3%) for 2014, and 17 711 (63.4%) for 2015. The current analyses focus on a subset of 17 527 (unweighted) observations from youth who had used at least one tobacco or nicotine product in the past 30 days. Additional information on the NYTS and its methodology can be found at http://www.cdc.gov/tobacco/data_statistics/surveys/nyts/index.htm. Protocols were approved by the Centers for Disease Control and Prevention Institutional Review Board-G (IRB00000188, CDC Protocol #4118). The approved IRB protocols included written parental permission and oral consent for all respondents to ensure student anonymity. Student participation was voluntary and anonymous, and subsequent data were analyzed anonymously. This study was exempt from institutional review board approval because it is a secondary data analysis of a publicly available dataset.

Product-Specific Past 30-Day Use

Past 30-day use of various tobacco and nicotine products was assessed with items for particular products (eg, cigarettes, cigars/little cigars/cigarillos, chewing tobacco/snuff/dip, and e-cigarettes) and multiple response items that included a range of products (eg, hookah, snus, and dissolvable tobacco products), depending on the year of administration. Participants who reported use of any tobacco or nicotine product in the past month were defined as past 30-day tobacco users.

Participants who reported using cigarettes, roll-your-own cigarettes, or flavored cigarettes in the past 30 days were identified as past 30-day cigarette smokers. Past 30-day e-cigarette use was defined as any use of an e-cigarette in the past 30 days. Participants who reported using cigars, cigarillos, little cigars, or flavored little cigars in the past 30 days were identified as past 30-day cigar smokers. Participants who reported using chewing tobacco, snuff, or dip in the past 30 days were identified as past 30-day smokeless users. Past 30-day hookah use was assessed using the question: "During the past 30 days, which of the following tobacco products did you use on at least one day?" with participants selecting the response choice "Hookah or waterpipe used with tobacco" identified as past 30-day hookah users. Other tobacco products included pipe tobacco, bidis, kreteks, snus, dissolvable tobacco, and "some other new product not listed here." Participants who reported using any of these products in the past 30 days were identified as past 30-day other tobacco product users. We combined these products into a single category because of previously reported low past 30-day use prevalence and to limit the number of possible use patterns in the analysis.[21]

In previously published work, we limited product-specific denominators to those who reported past 30-day use and past 30-day frequency of use (if applicable). Due to the surveys not including items for past 30-day frequency for all products, we did not place this restriction on the product-specific denominators in this study. This study uses a subset of participants who reported using at least one tobacco or nicotine product in the past 30 days of survey completion, yielding a total of 16 925 observations (unweighted).

Correlates

Sociodemographic correlates included age (categorized into four groups: 9–11 years old, 12–14 years old, 15–17 years old, and ≥18 years old), sex, race (categorized as White, Black/African American, Asian, and other/multiple races), and education (categorized as 6th–8th grade, 9th–11th grade, 12th grade, and ungraded/other grade). Those who identified as American Indian/Alaskan Native or Native Hawaiian/Other Pacific Islander or selected more than one race were categorized as "other/multiple races."

Truth Initiative Young Adult Cohort Study

To align with NYTS annual fielding dates, this study uses data from waves 1, 3, 4, 6, and 8 of the Truth Initiative Young Adult Cohort Study (YA Cohort; July 2011–July 2015). The cohort comprised a

nationally representative sample of YAs aged 18–34 drawn from GfK's KnowledgePanel that is recruited via address-based sampling to provide statistically valid representation of the US population, including cell phone-only households. African American and Hispanic YAs were oversampled at wave 1 to ensure sufficient sample sizes for subgroup analyses, and the survey was administered online in English and Spanish. The validity of this methodology has been reported previously, and it has been used broadly in the peer-reviewed medical literature.[22–27] The cohort is refreshed at each wave to retain the initial sample size.

The panel recruitment rate (RECR) ranged from 13.5% to 14.8% across the seven waves.[28] In 64.2% to 65.7% of the households identified for the panel, one member completed a core profile survey in which key demographic information was collected (profile rate—PROR). At each wave, only one panel member per household was selected at random to be part of the study sample, and no members outside of the panel were recruited. The completion rate (COMR) ranged from 46.2% to 65.7%. The cumulative response rate (CUMRR1) (the product of these three rates) ranged from 4.4% to 6.3%, consistent with other published studies.[29,30] This study was approved by the Independent Investigational Review Board, Inc, for waves 1 and 3 (Protocol #20036-007) and Chesapeake Institutional Review Board, Inc, for waves 4, 6, and 8 (Protocol #20036020). Online consent was collected from participants before survey self-administration. The present analysis focused on a subset of 1170 participants 18–24 years of age who reported using at least one tobacco or nicotine product in the past 30 days of wave completion, yielding a total of 1618 observations (unweighted) and a mean number of 1.4 waves (SD = 0.7) of participation.

Product-Specific Past 30-Day Use

At each wave, participants were asked "Which of the following products have you used in the past 30 days? (select all that apply)" and provided a list of 11 tobacco and nicotine products including cigarettes, cigars, pipe, little cigars/cigarillos, electronic cigarettes (e-cigarettes), chewing tobacco, dip/snuff, snus, dissolvable tobacco products, and hookah/shisha. Participants who selected cigars or little cigars/cigarillos were classified as past 30-day cigar users. Participants who reported using chewing tobacco or dip/snuff in the past 30 days were identified as past 30-day smokeless tobacco users. Past 30-day use of pipe tobacco, snus, and dissolvable tobacco was collapsed into past 30-day use of other tobacco products to align with the NYTS use group. Participants who reported use of any tobacco or nicotine product in the past month were defined as past 30-day tobacco users in that particular wave.

Correlates

Sociodemographic correlates included sex, race/ethnicity (White, non-Hispanic; Black, non-Hispanic; other, non-Hispanic; Hispanic), and highest level of education completed with response options ranging from "Elementary or middle school, but no high school" to "Doctoral or professional degree (PHD, JD, MD)" (categorized as less than high school, high school, and some college or greater).

Past 30-day alcohol use was determined by two items. The first asked about frequency of alcohol use in the past year ("never," "monthly or less," "2–4 times per month," "2–3 times per week," and "4 or more times per week"). Those who reported any use of alcohol were then queried about the frequency of use in the past 30 days, with respondents using ≥1 days defined as past 30-day users. Respondents were asked how often they currently use marijuana

and other drugs (cocaine, heroin, ecstasy, meth, etc.), with response options of "Not at all," "Some days," and "Every day." Respondents who indicated use "some days" or "every day" were asked how frequently in the past 30 days they used each substance. Current or past 30-day use of each of these substances was categorized as past 30-day use (yes/no). Those who refused to respond reported "not at all" or reported 0 days used in the past 30 days were categorized as non-past 30-day users.

Data Analysis

A user-generated program developed in R was used to identify an exhaustive list of every reported combination of past 30-day use of cigarettes, e-cigarettes, cigars, smokeless tobacco, hookah, and other tobacco separately for youth and YAs. Once the top five patterns were identified in each sample, variables to identify each pattern were generated in Stata/SE 14.2, and pattern prevalence was estimated using survey commands accounting for data weighting by primary sampling unit and sampling stratum in each age group. Weighted prevalence estimates were also estimated for descriptive purposes. In post hoc analyses, bivariate and adjusted log-binomial models were used to identify statistically significant correlates of pattern use prevalence in the top five patterns among past 30-day users in each age group. When adjusted log-binomial models failed to reach convergence, modified Poisson models were used as an approximation and noted in tables.[31]

Results

Prevalence Estimates

Before evaluating patterns of tobacco and nicotine product use, we present product-specific prevalence estimates in youth and YA past 30-day users from 2011 to 2015 (Table 1). Combustible products (cigarettes, cigars, and hookah) had the greatest prevalence of use, with cigarettes maintaining the highest prevalence in use among YA past 30-day users from 2011 to 2015. Although e-cigarettes were the least prevalent product in both age groups in 2011, e-cigarettes emerged as the most prevalent product in youth past 30-day users and the second most prevalent product (behind cigarettes) in YA past 30-day users in 2015. Prevalence of past 30-day cigar use declined over time in both age groups, with a more rapid decline in 2014 and 2015. Although there appeared to be a consistent prevalence of past 30-day smokeless tobacco use in youth, YAs reported a decline in smokeless tobacco use from 2011 to 2014 with a reemergence in popularity in 2015. Conversely, other tobacco products had a consistent prevalence in YAs and a steady decline in youth. Both youth and YAs reported greater past 30-day hookah use prevalence from 2011 to 2014 with lower prevalence of use in 2015.

Patterns of Use

Among past 30-day tobacco users, youth provided a greater variety of patterns of use compared with YAs throughout all 5 years (youth: 61–64 patterns; YAs: 26–30 patterns). Across 2011–2015, the top five patterns of past 30-day tobacco use among youth were (1) exclusive cigarette use (12.0%), (2) exclusive cigar use (10.3%), (3) exclusive e-cigarette use (10.0%), (4) dual use of cigarettes and cigars (6.1%), and (5) exclusive hookah use (5.2%; Table 2). The top five patterns of past 30-day tobacco use across 2011–2015 among YAs were (1) exclusive cigarette use (46.5%), (2) exclusive cigar use (10.0%), (3) dual use of cigarettes and cigars (6.4%), (4) exclusive

Table 1. Weighted Product-Specific Prevalence Estimates Among Past 30-Day Tobacco Users

	2011	2012	2013	2014	2015
	P30D (%)	P30D (%)	P30D (%)	P30D (%)	P30D (%)
NYTS					
Cigarettes	57.5	55.9	49.8	35.9	35.0
E-cigarettes[a]	5.7	12.3	17.7	53.2	64.0
Cigars	43.5	49.8	48.1	30.7	31.2
Smokeless[b]	27.8	26.1	23.0	22.0	21.6
Other tobacco[c]	30.5	31.6	26.6	15.4	11.0
Hookah	14.4	21.1	20.0	35.9	27.0
TIYAC					
Cigarettes	84.0	62.7	65.0	70.6	65.0
E-cigarettes	5.2	8.2	7.7	18.3	21.8
Cigars	28.8	27.7	24.8	12.6	16.9
Smokeless[d]	12.3	8.4	5.8	5.9	12.7
Other tobacco[e]	9.2	7.7	9.6	8.8	10.1
Hookah	8.4	13.1	14.1	15.2	9.1

[a]From 2011 to 2013, past 30-day use of e-cigarettes was assessed using the question: "During the past 30 days, which of the following tobacco products did you use on at least one day?" with participants selecting the response choice "Electronic cigarettes or e-cigarettes, such as Ruyan or NJOY" identified as past 30-day users; there were 10 products presented in this list in 2011, 9 in 2012, and 11 in 2013. In 2014, past 30-day use of e-cigarettes was assessed using the stand-alone question, "During the past 30 days, on how many days did you use electronic cigarettes or e-cigarettes such as Blu, 21st Century Smoke, or NJOY?" In 2015, the question was changed to "During the past 30 days, on how many days did you use electronic cigarettes or e-cigarettes?" Response categories included "0 days," "1 or 2 days," "3–5 days," "6–9 days," "10–19 days," "20–29 days," and "all 30 days." Participants who reported using e-cigarettes on at least 1 or 2 days were classified as past 30-day e-cigarette users.

[b]Smokeless tobacco includes chew, dip, and snuff.

[c]Other tobacco includes pipe tobacco, dissolvable tobacco, snus, bidis, kreteks, and "some other product not listed here." Kreteks were either identified as "clove cigars (kreteks)" in 2011 and 2013 or "clove cigarettes (kreteks)" in 2012. Kretek use was not assessed in 2014 or 2015.

[d]Smokeless tobacco includes chew, dip, and snuff. In 2013–2015, a preface was included in the smokeless tobacco section: "Please do not think about using snus when you answer these questions." Snus users were included in the "other tobacco product user" category below.

[e]Other tobacco includes pipe tobacco, dissolvable tobacco, and snus.

hookah use (5.9%), and (5) dual use of cigarettes and e-cigarettes (3.9%) (Table 3). The top five patterns represented 43.7% of all patterns of past 30-day use in youth and 72.6% of all patterns of past 30-day use in YAs.

The most popular patterns of past 30-day tobacco use in youth and YAs favored exclusive use of a single product, commonly of a combustible product (ie, cigarettes, cigars, and hookah; Tables 2 and 3). In both age groups, the only dual use patterns that emerged in the top five included cigarettes and use of cigars, smokeless tobacco, hookah, or e-cigarettes. Exclusive cigarette use was consistently the most popular pattern in YAs across all 5 years, while the most popular pattern in youth experienced more volatility. In youth tobacco users, the most popular pattern of past 30-day tobacco use in 2011 and 2012 was exclusive cigarette use (17.6%; 15.7%), followed by exclusive cigar use in 2013 (14.4%) and exclusive e-cigarette use in 2014 (19.0%) and 2015 (25.4%). In youth, exclusive cigarette use fell to the second most prevalent pattern in 2013 (12.5%), third in 2014 (6.8%), and maintained the third-place ranking in 2015 (7.2%).

While exclusive cigarette use and exclusive cigar use remained in the top five patterns of use across all 5 years in each age group, other patterns of use emerged over time while others declined in popularity. In youth, dual use of cigarettes and cigars maintained a fourth-place ranking from 2011 (8.9%) to 2013 (8.2%), but fell from the top five in later years. In YAs, this pattern was the second most prevalent pattern in 2011 (11.6%), fell to fifth in 2012 (4.4%), fourth in 2013 (7.5%), and dropped from the top five in later years. In both age groups, a similar trend in the prevalence of exclusive hookah use appears over time, emerging in the top five patterns in

2012, maintaining in 2013, and rising to the second most prevalent pattern in 2014. In 2015, exclusive hookah use dropped from the top five most prevalent patterns of use altogether in youth and fell to the fifth most popular pattern in YAs.

A few of the most prevalent patterns of tobacco use were unique to specific age groups. Exclusive use of smokeless tobacco appeared as the fourth most prevalent pattern of use in youth from 2011 (6.8%) to 2013 (5.0%) and the fifth most prevalent pattern in 2015 (5.6%). This pattern was not among the top five most prevalent patterns of past 30-day tobacco use in YAs. Similarly, dual use of e-cigarettes and hookah did not appear in the top five patterns in YAs, but was the fifth most prevalent pattern in youth in 2014 (6.4%) and the second most prevalent pattern in 2015 (8.0%).

Conversely, three dual use patterns appear in the top five patterns of YA tobacco use, but not youth tobacco use. Dual use of cigarettes and smokeless tobacco was the fourth most prevalent pattern in 2011 (4.6%), but fell from the top five in later years. Similarly, dual use of cigarettes and hookah was the fifth most prevalent pattern in 2011 (3.6%), but also did not emerge in the top five patterns in later years. Dual use of cigarettes and e-cigarettes appeared as the fourth most prevalent pattern in 2014 (5.9%) and rose to the second most prevalent pattern in 2015 (8.9%).

Significant pattern-specific correlates existed among the top five patterns in youth and YAs (Supplementary Tables 1A–2B). Bivariate and multivariable log-binomial regressions identified significant relationships between age, sex, race, education, and pattern-specific use in youth. Black/African American respondents (vs. White) had significantly lower prevalence of exclusive e-cigarette use after controlling for age, sex, and education. Female youth respondents had

Table 2. Top Five Patterns of Tobacco Use in NYTS, 2011–2015

	2011–2015	2011	2012	2013	2014	2015
1	Cigarette exclusive use 12.0%	Cigarette exclusive use 17.6%	Cigarette exclusive use 15.7%	Cigar exclusive use 14.4%	E-cigarette exclusive use 19.0%	E-cigarette exclusive use 25.4%
2	Cigar exclusive use 10.3%	Cigar exclusive use 11.1%	Cigar exclusive use 13.3%	Cigarette exclusive use 12.5%	Hookah exclusive use 11.2%	E-cigarette and hookah dual use 8.0%
3	E-cigarette exclusive use 10.0%	Cigarette and cigar dual use 8.9%	Cigarette and cigar dual use 8.6%	Cigarette and cigar dual use 8.2%	Cigarette exclusive use 6.8%	Cigarette exclusive use 7.2%
4	Cigarette and cigar dual use 6.1%	Smokeless exclusive use 6.8%	Smokeless exclusive use 6.3%	Smokeless exclusive use 5.0%	Cigar exclusive use 6.4%	Cigar exclusive use 6.6%
5	Hookah exclusive use 5.2%	Other tobacco exclusive use 5.2%	Hookah exclusive use 4.2%	Hookah exclusive use 3.7%	E-cigarette and hookah dual use 4.9%	Smokeless exclusive use 5.6%

significantly higher prevalence of dual use of e-cigarettes and hookah and exclusive cigarette use, while male youth had significantly higher prevalence of exclusive smokeless use. Sex was not a significant correlate of exclusive cigar use in youth; however, Black/African American respondents and those in high school (vs. middle school) reported significantly higher prevalence of exclusive cigar use. Race was also significant correlate of exclusive smokeless use, with a significantly lower prevalence among those considering themselves to be American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, or more than one race.

Non-Hispanic Black (vs. White) race was significantly associated with higher prevalence of exclusive cigar use in YAs in both the bivariate and adjusted models controlling for sex, race, education, past 30-day use of alcohol, marijuana, and other drug use. Although the relationship between education and exclusive e-cigarette use was nonsignificant in the bivariate model, education emerged as a statistically significant correlate in the adjusted model. Finally, past 30-day marijuana use was significantly associated with lower prevalence of exclusive cigarette use in YAs in both the bivariate model and adjusted models.

Discussion

This study identifies top patterns of past 30-day tobacco use among youth and YAs. When considering the top patterns of tobacco use, exclusive use of a single product was the dominant pattern in both age groups, with exclusive cigarette use having the greatest prevalence from 2011 to 2015. Among YAs, exclusive cigarette use was the dominant pattern of use each year. Previous research on patterns of use among adults found dual use of cigarettes and e-cigarettes to be the most prevalent pattern of use.[3] This discrepancy highlights the need to examine YAs separate from adults. In youth, exclusive cigarette use was the most prevalent pattern of use in 2011 and 2012, but was replaced by exclusive cigar use in 2013 and exclusive e-cigarette use in 2014 and 2015. Although we did not examine the reasons for these changes in patterns among youth, it may be attributed to youth's reduced risk perceptions of these products[32,33] and their appealing flavors.[34–36] Our findings also reveal several patterns of use unique to each age group such as exclusive use of smokeless tobacco among youth and dual use of cigarettes and e-cigarettes among YAs. Additional research is needed to identify and better understand predictors and correlates of tobacco use patterns in youth and YAs. This analysis can inform tobacco prevention efforts focusing on emerging tobacco products such as e-cigarettes and hookah. Education and other intervention efforts should focus on the diversity of products and use patterns in these age groups.

Despite cigarette use among youth and YAs being at a historic low, study findings underscore the continued and high rate of use of combustible tobacco products across both age groups. Cigarettes were the most prevalent product across all years for YAs. Among youth, cigarettes were the most prevalent product from 2011 to 2013, but surpassed by e-cigarettes from 2014 to 2015. This shift may be due in part to the rising costs of cigarettes[37] and the increased marketing of e-cigarettes.[38–40] For both age groups, past 30-day hookah use increased from 2011–2014, but declined in 2015. This is consistent with data from the Monitoring the Future study (MTF), which reported a decline of 3.1% points in past 12-month hookah use among 12th graders.[41]

There are several limitations to consider when reviewing these findings. First, the cross-sectional nature of the data does not allow

Table 3. Top Five Patterns of Tobacco Use in TIYAC, 2011–2015

	2011–2015	2011	2012	2013	2014	2015
1	46.5% Cigarette exclusive use	52.3% Cigarette exclusive use	44.2% Cigarette exclusive use	42.8% Cigarette exclusive use	50.6% Cigarette exclusive use	41.5% Cigarette exclusive use
2	10.0% Cigar exclusive use	11.6% Cigar exclusive use	15.9% Cigar exclusive use	12.5% Hookah exclusive use	8.0% Hookah exclusive use	8.9% Cigarette and e-cigarette dual use
3	6.4% Cigarette and cigar dual use	8.1% Hookah exclusive use	6.1% Hookah exclusive use	8.7% E-cigarette exclusive use	6.4% E-cigarette exclusive use	7.3% E-cigarette exclusive use
4	5.9% Cigarette and smokeless dual use	4.6% Other tobacco exclusive use	4.5% Cigarette and cigar dual use	7.5% Cigarette and cigar dual use	5.9% Cigarette and e-cigarette dual use	6.8% Cigar exclusive use
5	3.9% Cigarette and hookah dual use	3.6% Cigarette and cigar dual use	4.4% Other tobacco exclusive use	5.0% Other tobacco exclusive use	3.9% Cigar exclusive use	5.7% Hookah exclusive use

for causal interpretations. Second, the low popularity of a pattern does not signify low prevalence of a specific substance. A product may be prevalent, but may be used in a variety of different patterns and therefore does not emerge in the top five patterns listed. This speaks to the complexity of how youth and YAs use tobacco and nicotine products. Additionally, this study is not able to assess whether the dual or poly use occurred at the same event or more distally, such as within the past 30 days.

This study uses population-based data to provide new information on the most prevalent patterns of past 30-day nicotine and tobacco use over a 5-year period among youth and YAs. Study findings demonstrate that youth and YAs report using tobacco and nicotine products in different combinations, with varying popularity over time. Additionally, by examining YAs as a separate group, this study highlights the unique patterns of use not previously discussed in the adult literature. As non-cigarette tobacco and nicotine products become increasingly popular among youth and YAs, knowledge of the relative popularity of dual and poly use of these products is vital to effective prevention efforts.

Supplementary Material

Supplementary data are available at *Nicotine & Tobacco Research* online.

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Declaration of Interests

None declared.

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References

1. US Department of Health and Human Services. *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General.* Atlanta, GA: 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; 2014.
2. Collins LK, Villanti AC, Pearson JL, et al. Frequency of youth e-cigarette, tobacco, and poly-use in the United States, 2015: update to Villanti *et al.*, "Frequency of youth e-cigarette and tobacco use patterns in the United States: measurement precision is critical to inform public health". *Nicotine Tob Res.* 2017;19(10):1253–1254.
3. Kasza KA, Ambrose BK, Conway KP, et al. Tobacco-product use by adults and youths in the United States in 2013 and 2014. *N Engl J Med.* 2017;376(4):342–353.

4. Villanti AC, Pearson JL, Glasser AM, et al. Frequency of youth e-cigarette and tobacco use patterns in the U.S.: measurement precision is critical to inform public health. *Nicotine Tob Res*. 2016;19(11):1345–1350.

5. Rath JM, Villanti AC, Abrams DB, Vallone DM. Patterns of tobacco use and dual use in US young adults: the missing link between youth prevention and adult cessation. *J Environ Public Health*. 2012;2012:679134.

6. Fix BV, O'Connor RJ, Vogl L, et al. Patterns and correlates of polytobacco use in the United States over a decade: NSDUH 2002-2011. *Addict Behav*. 2014;39(4):768–781.

7. Lee YO, Hebert CJ, Nonnemaker JM, Kim AE. Multiple tobacco product use among adults in the United States: cigarettes, cigars, electronic cigarettes, hookah, smokeless tobacco, and snus. *Prev Med*. 2014;62:14–19.

8. Richardson A, Rath J, Ganz O, Xiao H, Vallone D. Primary and dual users of little cigars/cigarillos and large cigars: demographic and tobacco use profiles. *Nicotine Tob Res*. 2013;15(10):1729–1736.

9. Barnett TE, Smith T, He Y, et al. Evidence of emerging hookah use among university students: a cross-sectional comparison between hookah and cigarette use. *BMC Public Health*. 2013;13:302.

10. Cobb C, Ward KD, Maziak W, Shihadeh AL, Eissenberg T. Waterpipe tobacco smoking: an emerging health crisis in the United States. *Am J Health Behav*. 2010;34(3):275–285.

11. Grekin ER, Ayna D. Waterpipe smoking among college students in the United States: a review of the literature. *J Am Coll Health*. 2012;60(3):244–249.

12. Jarrett T, Blosnich J, Tworek C, Horn K. Hookah use among U.S. college students: results from the National College Health Assessment II. *Nicotine Tob Res*. 2012;14(10):1145–1153.

13. Everett SA, Malarcher AM, Sharp DJ, Husten CG, Giovino GA. Relationship between cigarette, smokeless tobacco, and cigar use, and other health risk behaviors among U.S. high school students. *J Sch Health*. 2000;70(6):234–240.

14. Gilpin EA, Pierce JP. Concurrent use of tobacco products by California adolescents. *Prev Med*. 2003;36(5):575–584.

15. Everett SA, Giovino GA, Warren CW, Crossett L, Kann L. Other substance use among high school students who use tobacco. *J Adolesc Health*. 1998;23(5):289–296.

16. McCabe SE, West BT, Veliz P, Boyd CJ. E-cigarette Use, Cigarette Smoking, Dual Use, and Problem Behaviors Among U.S. Adolescents: Results From a National Survey. *J Adolesc Health*. 2017;61(2):155–162.

17. Timberlake DS. A latent class analysis of nicotine-dependence criteria and use of alternate tobacco. *J Stud Alcohol Drugs*. 2008;69(5):709–717.

18. US Department of Health and Human Services. *Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General*. Atlanta, GA: Centers for Disease Control and Prevention; 2012.

19. Sung HY, Wang Y, Yao T, Lightwood J, Max W. Polytobacco use of cigarettes, cigars, chewing tobacco, and snuff among US adults. *Nicotine Tob Res*. 2016;18(5):817–826.

20. Arrazola RA, Singh T, Corey CG, et al.; Centers for Disease Control and Prevention (CDC). Tobacco use among middle and high school students—United States, 2011–2014. *MMWR Morb Mortal Wkly Rep*. 2015;64(14):381–385.

21. Singh T, Arrazola RA, Corey CG, et al. Tobacco use among middle and high school students–United States, 2011–2015. *MMWR Morb Mortal Wkly Rep*. 2016;65(14):361–367.

22. Chang L, Krosnick JA. National surveys via RDD telephone interviewing versus the internet comparing sample representativeness and response quality. *Public Opin Q*. 2009;73(4):641–678.

23. Rhodes DJ, Radecki Breitkopf C, Ziegenfuss JY, Jenkins SM, Vachon CM. Awareness of breast density and its impact on breast cancer detection and risk. *J Clin Oncol*. 2015;33(10):1143–1150.

24. Yeager DS, Krosnick JA, Chang L, et al. Comparing the accuracy of RDD telephone surveys and internet surveys conducted with probability and non-probability samples. *Public Opin Q*. 2011;75(4):709–747.

25. Fowler FJ Jr, Gerstein BS, Barry MJ. How patient centered are medical decisions?: results of a national survey. *JAMA Intern Med*. 2013;173(13):1215–1221.

26. Grande D, Mitra N, Shah A, Wan F, Asch DA. Public preferences about secondary uses of electronic health information. *JAMA Intern Med*. 2013;173(19):1798–1806.

27. Kumar S, Quinn SC, Kim KH, Daniel LH, Freimuth VS. The impact of workplace policies and other social factors on self-reported influenza-like illness incidence during the 2009 H1N1 pandemic. *Am J Public Health*. 2012;102(1):134–140.

28. American Association for Public Opinion Research. *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*. Deerfield, IL: AAPOR; 2015.

29. Cohn A, Villanti A, Richardson A, et al. The association between alcohol, marijuana use, and new and emerging tobacco products in a young adult population. *Addict Behav*. 2015;48:79–88.

30. Villanti AC, Pearson JL, Cantrell J, Vallone DM, Rath JM. Patterns of combustible tobacco use in U.S. young adults and potential response to graphic cigarette health warning labels. *Addict Behav*. 2015;42:119–125.

31. Chen W, Shi J, Qian L, Azen SP. Comparison of robustness to outliers between robust poisson models and log-binomial models when estimating relative risks for common binary outcomes: a simulation study. *BMC Med Res Methodol*. 2014;14:82.

32. Centers for Disease C, Prevention. Current tobacco use among middle and high school students--United States, 2011. *MMWR Morb Mortal Wkly Rep*. 2012;61(31):581–585.

33. Soldz S, Dorsey E. Youth attitudes and beliefs toward alternative tobacco products: cigars, bidis, and kreteks. *Health Educ Behav*. 2005;32(4):549–566.

34. Saunders C, Geletko K. Adolescent cigarette smokers' and non-cigarette smokers' use of alternative tobacco products. *Nicotine Tob Res*. 2012;14(8):977–985.

35. Ambrose BK, Day HR, Rostron B, et al. Flavored tobacco product use among US youth aged 12-17 years, 2013–2014. *JAMA*. 2015;314(17):1871–1873.

36. Villanti AC, Johnson AL, Ambrose BK, et al. Flavored tobacco product use in youth and adults: findings from the first wave of the PATH Study (2013–2014). *Am J Prev Med*. 2017;53(2):139–151.

37. van Hasselt M, Kruger J, Han B, et al. The relation between tobacco taxes and youth and young adult smoking: what happened following the 2009 U.S. federal tax increase on cigarettes? *Addict Behav*. 2015;45:104–109.

38. Cantrell J, Emelle B, Ganz O, Hair EC, Vallone D. Rapid increase in e-cigarette advertising spending as Altria's MarkTen enters the marketplace. *Tob Control*. 2016;25(e1):e16–e18.

39. Kim AE, Arnold KY, Makarenko O. E-cigarette advertising expenditures in the U.S., 2011–2012. *Am J Prev Med*. 2014;46(4):409–412.

40. Kornfield R, Huang J, Vera L, Emery SL. Rapidly increasing promotional expenditures for e-cigarettes. *Tob Control*. 2015;24(2):110–111.

41. Johnston LD, O'Malley PM, Miech RA, Bachman JG, Schulenberg JE. *Monitoring the Future National Survey Results on Drug Use 1975–2015: 2015 Overview Key Findings on Adolescent Drug Use*. Ann Arbor, MI: University of Michigan; 2016.