

UCSF

UC San Francisco Previously Published Works

Title

Latent Class Analysis to Examine Patterns of Smoking and Other Tobacco Products in Young Adult Bar Patrons

Permalink

<https://escholarship.org/uc/item/09m9m1df>

Journal

Journal of Adolescent Health, 64(1)

ISSN

1054-139X

Authors

Lisha, Nadra E
Thrul, Johannes
Ling, Pamela M

Publication Date

2019

DOI

10.1016/j.jadohealth.2018.06.022

Peer reviewed



Published in final edited form as:

J Adolesc Health. 2019 January ; 64(1): 93–98. doi:10.1016/j.jadohealth.2018.06.022.

Latent Class Analysis to Examine Patterns of Smoking and Other Tobacco Products in Young Adult Bar Patrons

Nadra E. Lisha, Ph.D.^a, Johannes Thrul, Ph.D.^b, and Pamela M. Ling, M.D., M.P.H.^{a,*}

^aCenter for Tobacco Control Research and Education and Division of General Internal Medicine, University of California, San Francisco, California ^bDepartment of Mental Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland

Abstract

Purpose: Use of multiple tobacco products is increasing, particularly among young adults. Latent class analysis of substance-use patterns provides a framework for understanding the heterogeneity of use. We sought to identify different patterns of cigarette, e-cigarette, hookah, cigarillo, and smokeless tobacco use among young adult bar patrons.

Methods: We conducted repeated cross-sectional surveys of randomized time location samples of young adult California bar patrons in 2013 and 2014. Latent class analysis was used to examine patterns of use among current (past 30-day) tobacco users. Classes were compared on demographic characteristics and tobacco use correlates.

Results: Overall 84.4% of the current tobacco users were cigarette smokers, 38.7% used electronic cigarettes, 35.9% used hookah, 30.1% smoked cigars/cigarillos, and 15.4% used smokeless tobacco in the past 30 days. We extracted six latent classes: “Cigarette only” (n = 1690), “Hookah mostly” (n = 479), “High overall use” (n = 528), “Smokeless mostly” (n = 95), “E-cigarette mostly” (n = 439), “Cigars mostly” (n = 435). These classes differed in their risk profiles on both current use compared to no use, and number of days they used each tobacco product. Differences between classes emerged on demographics (age, sex, race/ethnicity) and tobacco correlates including perceived peer smoking, antitobacco industry attitudes, prioritizing social activities, and advertising receptivity.

Conclusions: Understanding different patterns of multiple tobacco product use may inform both prevention and cessation programming for young adults. It may be efficient to tailor messages to different latent classes and address the distinct demographic and attitudinal profiles of groups of multiple tobacco product users.

Keywords

Young adult; Tobacco; Cigarettes; Other tobacco products; Risk behavior

*Address correspondence to: Pamela M. Ling, M.D., M.P.H., Center for Tobacco Control Research and Education, University of California San Francisco, 530 Parnassus, Ste 366, San Francisco, CA 94143-1390. pamelal.ling@ucsf.edu (P.M. Ling).

Conflicts of Interest: The authors have no conflicts of interest to disclose.

Cigarette smokers exhibit mortality rates that are 2–3 times as high as persons who never smoked [1], and in 2014 in the United States, 16.7% of young adults were cigarette smokers [2]. Despite the current downtrend in smoking rates among young adults [2], other tobacco product (OTP) use is on the rise [3]. The 2013–2014 Population Assessment of Tobacco and Health Study, a large, nationally representative study of tobacco use, found that 8.9% of youths had used a tobacco product in the last 30 days; 1.6% of youths were daily users. They also found that 40% of tobacco users, adults and youths alike, used multiple tobacco products (cigarettes plus e-cigarettes being the most common) [4]. As such, in the United States there is increasing concern about the use of OTP among adolescents and young adults [5,6]. Growing rates of use may be a result of increased marketing; for example, a spokesperson at Phillip Morris called noncombustible tobacco products their “most exciting growth opportunity” at a recent Stockholder’s conference [7] and OTP promotion has included a focus on youth and young adults [8].

Young adults exhibit high rates of multiple tobacco product use [3,5,9], and in 2012 over 66% of young adult cigarette smokers were using more than one tobacco product [5]. However, not all young adults use cigarettes or OTP in the same ways [10]. Only a few studies have investigated patterns of tobacco product use in young adults [3,5,11], and there is a dearth of knowledge on how individual users may cluster into different groups based on patterns of use. Tobacco companies have long used bars and night-clubs to reach young adults and promote smoking [12,13]. Attending bars and having been exposed to tobacco bar marketing are related to increased smoking [14]. Because tobacco use and alcohol use are strongly linked [15], it makes sense to examine young adult tobacco use in a bar context.

There is some research on correlates of poly-tobacco use, including demographics, attitudes, and perceptions [3,16] in the overall population, but less is known about patterns and correlates of specific types of OTP use, particularly among young adults. For example, race/ethnicity is related to tobacco use; according to one study, Blacks are less likely than Whites to be users of noncombustible products, while Hispanics are more likely than Whites to use all tobacco products [5]. In addition to demographics, attitudes and perceptions are also relevant correlates of use. For example, the Social Prioritization Index (SPI), a measure of tendency to prioritize and take part in social activities, is positively associated with smoking [17]. Supporting action against the tobacco industry is negatively related with both daily and nondaily smoking [9], whereas advertising receptivity has been found to be related to both cigarette [18] and OTP use [19] in young adults.

While there are some research works on how products group together [11] and correlates of poly-use [3], less is known about how young adult individuals cluster into groups based on their patterns of use and what predicts group membership. One study [20] used latent class analysis to examine user groups based on six types of nicotine products: snus, hookah, electronic cigarettes, cigarillos, snuff, and cigarettes. They found five subgroups and compared them based on demographics, as well as marijuana and binge drinking. Some differences were found: notably, the poly-use group had the highest levels of marijuana and alcohol use. However, this study was conducted in a low-risk population based sample from Minnesota, predominantly White, and the resulting groups were not compared on other nondemographic correlates. In addition, products other than cigarettes were measured using

the question of “ever use” rather than past 30-day (current) use, which may include even brief experimentation with these products.

Two studies using latent class analysis have been conducted on younger populations; one in Southern California high school seniors [21] and another in middle and high school youth [22] using data from the 2013 National Youth Tobacco Survey. Gilreath found four distinct classes including one class of nonusers, poly-tobacco experimenters, e-cigarette/hookah users, and poly-tobacco users. Yu used a three-level variables in the latent class analysis (LCA) (any lifetime use, past-month use, never used) because of the low prevalence of use in this age group; they found four-classes they labeled “very low risk,” “lifetime smoking,” “life-time multiple tobacco,” and “past month multiple tobacco.” Young adulthood is an important developmental period to study where lifelong health related behaviors are established as individuals are oftentimes on their own for the first time without some kind of adult supervision (comparing childhood and college age) [23]. Young adults have also been a longstanding focus of tobacco industry marketing, which exploits these life transitions to promote tobacco use [24]. Young adult tobacco use behaviors and how they are clustered around certain products is a public health concern.

Person-centered analyses examining how individuals can be grouped together based on their use of different tobacco products can inform our understanding of patterns of tobacco product use. Determining the co-use of different tobacco products is key to inform strategies aimed at curbing tobacco use among young adults. By gaining an understanding of the most common patterns of use we can inform tobacco control policy, interventions, and educational efforts aimed at reducing poly-tobacco use. Patterns of different tobacco product use and associations with attitudes and perceptions can then guide tailored prevention and intervention approaches instead of focusing on broader, less targeted single product strategies. This will allow policy makers, researchers and interventionists to know which specific tobacco product combinations are the most popular, and the segments of the population who may benefit the most from a poly-tobacco intervention approach.

We sought to examine patterns of use within individuals to improve our knowledge of which groups are using which kinds of tobacco products, and if there are unique demographic or attitudinal correlates of the different patterns of tobacco use. Following were the aims of the current paper: (1) to extract latent classes of users based on five tobacco products, and (2) to determine how those classes differ on a variety of demographic, attitudinal, and perceptual correlates.

Method

Participants and procedure

From January 2012 through March 2014, surveys were collected from young adult bar patrons between the ages of 18 and 26 years in San Diego, Los Angeles, and San Francisco using time-location sampling strategies. This methodology was developed to reach underserved populations in the venues they frequent [25,26], and methods used in this study have been described previously [27,28]. Venues, dates, and times were selected randomly from a list of young adult-oriented bars and clubs and thus similar probabilities of selection

were assigned to individuals within the sample. Participants who used at least one of five tobacco products (cigarettes, e-cigarettes, hookah, cigars/cigarillos, or smokeless tobacco) in the past 30 days were retained for the purposes of this study (n = 3,666) from the total sample (N = 7,240). All study procedures and protocols were approved by the Committee for Human Research (the IRB) at the University of California San Francisco.

Measures

Cigarettes and other tobacco products.—Participants were asked “During the past 30 days, on how many days did you do each of the following” (number of days) for cigarettes, electronic cigarettes, hookah, “Black and Milds” or cigarillos (referred to as “cigarillos” throughout), and smokeless tobacco. Variables were dichotomized into use (1-30 days) and no-use (0 days).

Demographics.—Demographic variables included age in years (calculated based on self-reported birth date and data collection date), sex (male/female), race/ethnicity, and educational status. The items regarding race/ethnicity varied slightly between survey years but were recoded into the same five-level variable. In both 2012 2013 and 2014 waves participants were asked, “Are you of Hispanic, Latino, or Spanish origin?” (yes/no). In 2013, they were asked, “What is your race?” (African American, Asian, White, Hawaiian or Pacific Islander, American Indian or Alaskan Native, and more than one race) and were instructed to select one. In 2014, a similar question was posed but with the instructions to “check ALL that apply” (African American, Asian, White, Hawaiian or Pacific Islander, American Indian or Alaskan Native, or Other [fill in the blank]). Race/ethnicity was recoded into 5 categories: Non-Hispanic (NH) White, NH Black, NH Asian or Pacific Islander, NH Other (including multirace), and Hispanic. Participants were also asked about their educational status (1= I go to college in the local area, 2 = I go to college NOT in the local area, 3 = I have graduated from college, 4 = I dropped out of college, and 5 = I have graduated from high school/GED), which was recoded into a three-level variable (currently in college/graduated/dropped out or no college), and self-reported sexual orientation (1 = straight, 2 = gay, 3 = bisexual, and 4 = other) which was recoded into a dichotomous variable (straight/not straight).

Attitudes and perceptions

The SPI is a measure of a respondent’s sociability and tendency to select social activities [17]. The SPI is a 13-item scale that includes personality items and information on how frequently participants attend bars and how late they stay out. Perceived peer smoking was assessed using a single item “Based on what you have seen, how many people your age smoke tobacco?” and asking participants to circle a percent-age from a scale ranging from 0% to 100% with 10% increments. Based on previous studies [18,29] support for action against the tobacco industry was assessed using agreement with three statements [18] (“I want to be involved with efforts to get rid of cigarette smoking”, “I would like cigarette companies to go out of business”, and “Taking a stand against smoking is important to me”), measured on a five-point Likert scale from “not at all” to “a great deal.” The mean score of the three items was used as a continuous variable in analyses. Tobacco marketing receptivity [30,31] was assessed using a single item, “Some tobacco companies offer promotional items

(such as clothing and bags) which have the company brand name or logo on them that the public can buy or get for free. Do you think you would use a tobacco industry promotional item?" (yes/no).

Analysis

Multilevel latent class analysis (MLCA) was used to identify latent classes among young adult tobacco users, taking into account the clustered data structure with participants nested in venues (locations where data were collected). Conditional class probabilities were used to assign participants to classes. One of the underlying assumptions of LCA is that measurement error creates a certain amount of homogeneous, mutually exclusive error, assuming measurement invariance of latent classes. To determine the adequate number of classes, we used MLCA iteratively, beginning with a parsimonious one-class model, accounting for clustering by venue [32,33], and sequentially increased the number of latent classes while examining the fit statistics.

Goodness of fit indices was evaluated by considering the overall model fit (Bayesian information criterion [BIC], entropy, Lo Mendell Rubin likelihood ratio test [LMRT]). BIC indicates a more parsimonious model when the value is low (high log likelihood estimate and low number of parameters) [34–36] and differences of 10 or more considered as evidence favoring one model over another [37]. Each individual is classified into their most likely class, and thus a table is created where rows correspond to individuals and columns correspond to conditional probabilities of class belongingness [38]. In addition, an entropy summary statistic indicates the quality of the classification. Values of this statistic range from 0 to 1; values closer to 1 represent better classification quality [39]. The LMRT of model fit is used to quantify the likelihood that the data can be described by a model with one-less class and a p-value smaller than .05 indicating that the additional class significantly improves fit over a model with $k - 1$ classes [40]. The “Average Latent Class Probabilities for Most Likely Latent Class Membership (Row) by Latent Class (Column) for LCA” information was also used in addition to entropy to look at classification quality. The diagonal values are optimal when closest to 1 (Table 1).

The surveys used a three-form design that includes a set of core questions that were asked of all participants, and another group of items that are included on only two of the three versions of the questionnaire, yielding answers from only two-thirds of randomly selected participants. [41] This design allowed us to reduce participant fatigue while completing questionnaires in a bar/club environment, while still allowing a larger variety of questions on the survey. This design also allows the assumption that missing data are missing completely at random. Analyses were performed using Mplus 8 software [42]. The LCA analyses used in this paper employ the full information maximum likelihood method in Mplus to account for missing data [43,44]. The full information maximum likelihood method has been shown to produce greater accuracy in model estimations by adjusting for the uncertainty caused by missing data [45,46]. The three-step method was used to examine class differences while adjusting for classification errors in Mplus [47].

Results

Demographics

Our sample of young adult current tobacco users was predominantly male (59.3%) and racially/ethnically diverse with 39.9% NH White and 36.4% Hispanic. The mean age was 23.9 years ($SD = 1.9$), 37.9% were in college, 38.9% had graduated from college, and 23.1% had dropped out of college and/or completed high school or GED. In our sample 84.4% were cigarette smokers, 38.7% used electronic cigarettes, 35.9% used hookah, 30.1% smoked a cigar or cigarillo, and 15.4% used smokeless tobacco (all past 30-day use).

Latent class analysis (Tables 1 and 2)

Model fit was evaluated for between 1 and 7 class models. The optimal fit was achieved with six classes based on the BLRT, LMRT, the lowering of the AIC (less than 10 from 6 to 7 classes) and the BIC. Entropy was found to be adequate (.689). Examination of the average latent class membership by latent class (Table 1) indicated adequate separation among the profiles.

LCA: comparison of classes on cigarette and OTP use (Table 3)

Six distinct classes were extracted in the LCA. For descriptive purposes we labeled the latent classes, cigarette smokers “cigarette only” ($n = 1690$), “hookah mostly” ($n = 479$), “high overall use” ($n = 528$), “smokeless mostly” ($n = 95$), “e-cigarette mostly” ($n = 439$), and “cigars mostly” ($n = 435$). The largest class was the “cigarette only” at 46% of the sample.

LCA: comparison of classes on use (Table 3)

We found that for cigarettes, classes differed significantly from one another despite each class containing cigarette smokers, such that the cigarette smoker class was comprised of 100% cigarette smokers with an average number of 13.31 ($SD = 11.9$) days per month smoking. The “hookah mostly” class included 59.1% cigarette smokers who smoked on average 6.8 ($SD = 10.2$) days per month. The “high use overall class” contained many cigarette smokers (91.7%) who smoked 12.2 ($SD = 11.5$) days per month on average. The “smokeless mostly” class had only 40.2% cigarette smokers, though the number of mean days smoked was lower ($M = 5.5$, $SD = 10.2$). The “e-cigarette mostly” class had about half cigarette smokers (56.1%) who smoked 7.2 ($SD = 10.9$) days on average. The “cigars mostly” class included 78.7% cigarette smokers, who smoked on average 10.4 ($SD = 12.0$) days per month.

LCA: comparison of classes on demographics and other correlates (Table 3)

Only important differences are described below. The “cigarette only” and “hookah only” classes had a lower percentage of males compared to the “high overall use,” “smokeless mostly,” “e-cigarette mostly,” and “cigars mostly” classes. The “cigarette only” classes had a higher percentage of Whites than the “hookah mostly,” “high overall use,” and “cigars mostly” classes. The “high overall use” had a lower percentage of Whites compared to the “e-cigarette mostly” and “cigars mostly” classes. A higher percentage of Blacks was observed in the “cigars mostly” class compared to “cigarettes only,” “smokeless mostly” and

“e-cigarettes mostly”. The “cigarette only” class had a lower percentage of Blacks compared to “hookah mostly” and “high overall use”. Differences were also found on Hispanic race/ethnicity such that the percentage was lower between the “cigarette only” class and the “hookah only” and “high overall use” groups. Overall, the “hookah only” class had the lowest educational attainment.

The SPI differed only between the “hookah mostly” and “high overall use” and “cigars mostly” groups, who scored higher. Perceived peer smoking was higher for the “cigarette only” class compared to all but the “high overall use” class. Anti-industry attitudes were notably lower for the “cigarette only” class. Advertising receptivity was lowest in the “hookah mostly” group compared to the “high overall use”, “smokeless mostly”, and “e-cigarette only” groups. It was also lower in the “cigarette only” class compared to the “hookah mostly”, “high overall use”, and “cigars mostly” classes. The “high overall use” group scored notably higher than the “smokeless mostly”, “e-cigarette mostly”, and “cigars mostly” groups.

Discussion

The six classes showed substantial differences on a variety of cigarette and OTP use patterns, demographics, and attitudes and perceptions. In this sample of tobacco users, the cigarette smokers were the largest class; these data suggest that among young adult bar patrons using tobacco, cigarette smoking is still a substantial problem, and that cigarette smoking is also frequently accompanied by OTP use.

The other classes, while smaller, also highlight distinct patterns of OTP use that may require different strategies for intervention. For example, the “hookah mostly” and “smokeless mostly” groups have strong anti-industry attitudes. Antitobacco industry attitudes have been strongly negatively associated with smoking [29,48]. While the “Truth” campaign successfully decreased smoking among young people with its focus on anti-industry attitudes [49], our analysis suggests that campaigns promoting strong antitobacco industry attitudes may not necessarily result in a reduction in OTP use to the extent they did for cigarettes. These findings are consistent with a prior study showing that young adult hookah users had strong antitobacco industry attitudes [50], and it may be because hookah is not necessarily perceived as a tobacco product, or that hookah or OTP are not perceived as products of the tobacco industry. It is possible that education about cigarette companies being major producers of smokeless tobacco and electronic cigarettes could decrease use of these OTP.

In addition, we identified a “high use overall” class of tobacco users with high rates of both cigarette and all OTP use, as well as the highest frequency of use of each product. Advertising receptivity was the highest in the “high overall use” class, and this group also reported a high perceived prevalence of smoking. This suggests that nicotine use may be normalized in this class, and there is evidence that among adolescents tobacco advertising influences smoking behavior by normalizing perceptions of peer tobacco use [51]. As receptivity to e-cigarette advertising is associated with progression to tobacco use in youth and young adults, OTP advertising may particularly affect this class [52]. Given the high

rates of use of multiple tobacco products, one might expect that this class would also have higher rates of use of other substances such as alcohol or marijuana [53,54]. This group warrants further research to better elucidate potential reasons for use, how use of multiple substances interact, and what messages might be relevant to discourage tobacco use.

Half of the overall sample used at least one of the five tobacco products, and the majority of these individuals were using more than one product. This study highlights the importance of tailoring prevention and interventions differently for different groups of OTP users. For the high overall use class, it may be important to emphasize not only cigarettes, but also OTPs in prevention messaging: Richardson et al. [5] found that many of the multitobacco product users in their study started using products relatively close in time. For predominately cigarette smokers, one might consider continued strong antismoking messaging that also addresses e-cigarette, cigar, and smokeless tobacco use. Finally, for the “hookah only” and “smokeless mostly,” increasing recognition of the similarities between alternative and conventional tobacco products, and the involvement of cigarette companies in producing and promoting alternative tobacco products might be worth further exploration to leverage the stronger anti-industry attitudes in these classes. We found that in every class characterized by use of an alternative tobacco product, the rates of cigarette smoking remained high (40%-78%). This suggests that cessation of cigarette smoking should be a priority, even among users of alternative tobacco products, as dual use with cigarettes appears to be the dominant pattern of co-use in every class. Policy changes can also be informed by these latent classes. For example, the largest class remains the cigarette only class, which suggests that tobacco control policy needs to remain focused on this group and product. However, emerging products and the rise of e-cigarette use also need to be addressed with new regulations.

Limitations

While this study provides important insight into behavior among high-risk young adults, results are subject to certain limitations. The results of this study are not generalizable to the general population as they are from a young adult bar-going sample of current tobacco users. In addition, we used relatively limited measures of use (days per month). Future research should ask even more specific questions on use (e.g., time of day used, how long used per use session) to create more accurate risk profiles. The period the data was collected is around the time when e-cigarettes were gaining popularity, so patterns of use of this product may have changed over time [55]. Finally, while the current study included tobacco-related attitudes, it did not directly address motivations for use of each product; studies of product-specific motivations might better inform potential antitobacco messages that resonate with different classes of users.

Six classes of users emerged from the data indicating distinct patterns of poly-tobacco use that may have different risk profiles and receptivity to tobacco control programs or messages. It is important for both researchers and practitioners to understand that multitobacco product use is common, and that not all users exhibit the same patterns of use both for types of products and frequency of use. As interventions become increasingly tailored, grouping people together by patterns of use is a way to move towards more distinct

profiles of use and create effective interventions. Future initiatives should educate young adults about the involvement of the tobacco industry in OTP manufacturing and promotion.

Acknowledgments

Funding Sources

This research was supported by NCI Grant (1U01CA154240-01) Countering Young Adult Tobacco Marketing in Bars.

References

- [1]. Carter BD, Abnet CC, Feskanich D, et al. Smoking and mortality—Beyond established causes. *N Engl J Med* 2015;372:631–40. [PubMed: 25671255]
- [2]. Jamal A, Homa DM, O'Connor E, et al. Current cigarette smoking among adults—United States, 2005–2014. *Morb Mortal Wkly Rep* 2015;64:1233–40.
- [3]. 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;39:768–81. [PubMed: 24457900]
- [4]. 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;376:342–53. [PubMed: 28121512]
- [5]. Richardson A, Williams V, Rath J, Villanti AC, Vallone D. The next generation of users: Prevalence and longitudinal patterns of tobacco use among US young adults. *Am J Public Health* 2014;104:1429–36. [PubMed: 24922152]
- [6]. Lee YO, Hebert CJ, Nonnemaker JM, Kim AE. Youth tobacco product use in the United States. *Pediatrics* 2015;135:409–15. [PubMed: 25647680]
- [7]. Camilleri LC, Whitson J, Calantzopoulos A. Morris International's CEO presents at Annual Meeting of Stockholders Conference (transcript) May 8, 2013 Available at: <https://seekingalpha.com/article/1416951-philip-morris-inter-nationals-ceo-presents-at-annual-meeting-of-stockholders-conference-transcript>. Accessed September 17, 2018.
- [8]. Mejia AB, Ling PM. Tobacco industry consumer research on smokeless tobacco users and product development. *Am J Public Health* 2010;100:78–87. [PubMed: 19910355]
- [9]. Ling PM, Lee YO, Hong J, et al. Social branding to decrease smoking among young adults in bars. *Am J Public Health* 2014;104:751–60. [PubMed: 24524502]
- [10]. Popova L, Ling PM. Alternative tobacco product use and smoking cessation: A national study. *Am J Public Health* 2013;103:923–30. [PubMed: 23488521]
- [11]. 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. [PubMed: 22666279]
- [12]. Hendlin Y, Anderson SJ, Glantz SA. 'Acceptable rebellion': Marketing hipster aesthetics to sell Camel cigarettes in the US. *Tob Control* 2010;19:213–22. [PubMed: 20501494]
- [13]. Sepe E, Ling PM, Glantz SA. Smooth moves: Bar and nightclub tobacco promotions that target young adults. *Am J Public Health* 2002;92:414–9. [PubMed: 11867322]
- [14]. Gilpin E, White V, Pierce J. How effective are tobacco industry bar and club marketing efforts in reaching young adults? *Tob control* 2005;14:186–92. [PubMed: 15923469]
- [15]. McKee SA, Falba T, O'Malley SS, Sindelar J, O'Connor PG. Smoking status as a clinical indicator for alcohol misuse in US adults. *Arch Intern Med* 2007;167:716. [PubMed: 17420431]
- [16]. King BA, Dube SR, Tynan MA. Current tobacco use among adults in the United States: Findings from the National Adult Tobacco Survey. *Am J Public Health* 2012;102:e93–e100. [PubMed: 22994278]
- [17]. Lisha NE, Neilands TB, Jordan JW, Holmes LM, Ling PM. The social prioritization index and tobacco use among young adult bar patrons. *Health Educ Behav* 2016;43:641–7. 10.1177/1090198115621867. [PubMed: 26706863]

- [18]. Ling PM, Neilands TB, Glantz SA. The effect of support for action against the tobacco industry on smoking among young adults. *Am J Public Health* 2007;97:1449–56. [PubMed: 17600255]
- [19]. Thrul J, Lisha NE, Ling PM. Tobacco marketing receptivity and other tobacco product use among young adult bar patrons. *J Adolesc Health* 2016;59:642–7. [PubMed: 27707516]
- [20]. Erickson DJ, Lenk KM, Forster JL. Latent classes of young adults based on use of multiple types of tobacco and nicotine products. *Nicot Tob Res* 2014;16:1056–62.
- [21]. Gilreath TD, Leventhal A, Barrington-Trimis JL, et al. Patterns of alternative tobacco product use: emergence of hookah and e-cigarettes as preferred products amongst youth. *J Adolesc Health* 2016;58:181–5. [PubMed: 26598059]
- [22]. Yu M, Sacco P, Choi HJ, Wintemberg J. Identifying patterns of tobacco use among US middle and high school students: A latent class analysis. *Addic Behav* 2018;79:1–7.
- [23]. Arnett JJ. Emerging adulthood A theory of development from the late teens through the twenties. *Am Psychol* 2000;55:469–80. [PubMed: 10842426]
- [24]. Ling PM, Glantz SA. Why and how the tobacco industry sells cigarettes to young adults: Evidence from industry documents. *Am J Public Health* 2002;92:908–16. [PubMed: 12036776]
- [25]. Magnani R, Sabin K, Saidel T, Heckathorn D. Review of sampling hard-to-reach and hidden populations for HIV surveillance. *Aids* 2005;19:S67–72.
- [26]. Muhib FB, Lin LS, Stueve A, et al. A venue-based method for sampling hard-to-reach populations. *Public Health Rep* 2001;116(Suppl 1):216. [PubMed: 11889287]
- [27]. Jiang N, Lee YO, Ling PM. Association between tobacco and alcohol use among young adult bar patrons: A cross-sectional study in three cities. *BMC Public Health* 2014;14:500. [PubMed: 24886521]
- [28]. Jiang N, Ling PM. Impact of alcohol use and bar attendance on smoking and quit attempts among young adult bar patrons. *Am J Public Health* 2013;103:e53–61. [PubMed: 23488485]
- [29]. Ling PM, Neilands TB, Glantz SA. Young adult smoking behavior: A national survey. *Am J Prev Med* 2009;36:389–94. e2. [PubMed: 19269128]
- [30]. Pierce JP, Choi WS, Gilpin EA, Farkas AJ, Berry CC. Tobacco industry promotion of cigarettes and adolescent smoking. *JAMA* 1998;279:511–5. [PubMed: 9480360]
- [31]. Gilpin EA, White MM, Messer K, Pierce JP. Receptivity to tobacco advertising and promotions among young adolescents as a predictor of established smoking in young adulthood. *Am J Public Health* 2007;97:1489–95. [PubMed: 17600271]
- [32]. Connell CM, Gilreath TD, Hansen NB. A multiprocess latent class analysis of the co-occurrence of substance use and sexual risk behavior among adolescents. *J Stud Alcohol Drugs* 2009;70:943. [PubMed: 19895772]
- [33]. Kelly AB, Evans Whipp TJ, Smith R, et al. A longitudinal study of the association of adolescent polydrug use, alcohol use and high school non completion. *Addiction* 2015;110:627–35. [PubMed: 25510264]
- [34]. Schwarz G Estimating the dimension of a model. *Ann Stat* 1978;6:461–4.
- [35]. Muthen B Beyond SEM: General latent variable modeling. *Behaviormetrika* 2002;29:81–118.
- [36]. Nylund KL, Asparouhov T, Muthen B. Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Struct Equ Model: Multidiscip J* 2007;14:535–69.
- [37]. Raftery AE. Bayesian model selection in social research. *Sociol Methodol* 1995;25:111–64.
- [38]. Nagin DS. Analyzing developmental trajectories: A semiparametric, group-based approach. *Psychol Methods* 1999;4:139–57.
- [39]. Muthen B, Brown CH, Masyn K, et al. General growth mixture modeling for randomized preventive interventions. *Biostatistics* 2002;3:459. [PubMed: 12933592]
- [40]. Lo Y, Mendell NR, Rubin DB. Testing the number of components in a normal mixture. *Biometrika* 2001;88:767–78
- [41]. Graham JW, Taylor BJ, Olchowski AE, Cumsille PE. Planned missing data designs in psychological research. *Psychol Methods* 2006;11:323. [PubMed: 17154750]
- [42]. Muthen LK, Muthen BO. MPlus user's guide 7th ed. Los Angeles, CA: Muthen & Muthen.
- [43]. Little RJA, Rubin DB. Statistical analysis with missing data Muthen & Muthen . 1987.

- [44]. Rubin DB. Inference and missing data. *Biometrika* 1976;63:581–92.
- [45]. Collins LM, Schafer JL, Kam CM. A comparison of inclusive and restrictive strategies in modern missing data procedures. *Psychol Methods* 2001;6:330–51. [PubMed: 11778676]
- [46]. McArdle JJ, Hamagami F. Modeling incomplete longitudinal and cross-sectional data using latent growth structural models. *Exp Aging Res* 1992;18:145–66. [PubMed: 1459161]
- [47]. Asparouhov T, Muthen B. Auxiliary variables in mixture modeling: three-step approaches using M plus. *Struct Equ Model: Multidiscip J* 2014;21:329–41.
- [48]. Ling PM, Neilands TB, Glantz SA. The effect of support for action against the tobacco industry on smoking among young adults. *Am J Public Health* 2007;97:1449–56. [PubMed: 17600255]
- [49]. Farrelly MC, Heaton CG, Davis KC, et al. Getting to the truth: evaluating national tobacco countermarketing campaigns. *Am J Public Health* 2002;92:901–7. [PubMed: 12036775]
- [50]. Lee YO, Bahreinifar S, Ling PM. Understanding tobacco-related attitudes among college and noncollege young adult hookah and cigarette users. *J Am Coll Health* 2014;62:10–8. [PubMed: 24313692]
- [51]. National Cancer Institute. The role of the media in promoting and reducing tobacco use. Tobacco control monograph no. 19 Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, National Cancer Institute NIH Pub No. 07–6242.
- [52]. Pierce JP, Sargent JD, Portnoy DB, et al. Association between receptivity to tobacco advertising and progression to tobacco use in youth and young adults in the PATH study. *JAMA Pediatr* 2018;172:444–51. [PubMed: 29582078]
- [53]. Ramo DE, Liu H, Prochaska JJ. Tobacco and marijuana use among adolescents and young adults: A systematic review of their co-use. *Clin Psychol Rev* 2012;32:105–21. [PubMed: 22245559]
- [54]. Lisha NE, Carmody TP, Humfleet GL, Delucchi KL. Reciprocal effects of alcohol and nicotine in smoking cessation treatment studies. *Addic Behav* 2014;39:637–43.
- [55]. Herzog B, Gerber J, Scott A. Equity research: Nielsen-tobacco ‘all channel’ data Wells Fargo Securities 2015.

IMPLICATIONS AND CONTRIBUTION

Multiple tobacco product use is increasing in prevalence among young people, but there is limited knowledge on patterns of tobacco use. The current study used latent class analysis to investigate patterns of tobacco use among young adult bar patrons. The distinct groups identified may inform the development of tailored interventions addressing multiple tobacco products, which may be more efficient than addressing each tobacco product separately.

Table 1

Average latent class probabilities for most likely latent class membership (row) by latent class (column) for LCA

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Group 1	.726	.075	.048	.016	.049	.087
Group 2	.000	.943	.046	.007	.001	.003
Group 3	.000	.045	.704	.012	.109	.130
Group 4	.000	.000	.064	.908	.019	.008
Group 5	.000	.045	.045	.000	.889	.022
Group 6	.091	.000	.073	.007	.000	.829

Note: Diagonal values are important; better if closer to 1.

LCA = Latent class analysis.

Table 2

Fit indices for multilevel latent classes of young adult cigarette and OTP use (N=3,666) using dichotomous indicators (past month use)

Class	N1	N2	N3	N4	N5	N6	N7	BLRT	LMRT	AIC	BIC	Entropy
1	3,666							–	–	103833.49	104025.909	–
2	2,061	1,605						.0000	.0000	14705.549	14773.825	.429
3	2,345	323	998					.0000	.0000	14455.469	14560.985	.514
4	2,210	359	581	516				.0000	.0000	14385.388	14528.145	.600
5	391	168	852	119	2,136			.0000	.0000	14307.145	14487.14	.723
6	1,690	479	528	95	439	435		.0000	.0000	14245.049	14462.289	.689
7	1,693	195	366	76	55	215	1,066	1.0000	.3757	14251.954	14506.435	.591

Note: N = number of people in each class. BLRT = Bootstrapped likelihood ratio test, LMRT = Lo Mendell Rubin likelihood ratio test, AIC = Akaike information criterion, BIC = Bayesian information criterion.

Table 3
Demographic and other correlates by most likely latent class using the three-step auxiliary variable approach in Mplus

	Group 1 (Cigarette Only) (n = 1,690)	Group 2 (Hookah mostly) (n = 479)	Group 3 (High overall use) (n = 528)	Group 4 (Smokeless mostly) (n = 95)	Group 5 (E-cigarette mostly) (n = 439)	Group 6 (Cigars mostly) (n = 435)
Cigarettes (N, % using)	1,690 (100%)	274 (59.05%) _a	462 (91.67%)	37 (40.22%)	234 (56.12%) _b	328 (78.66%) _{ab}
E-cigarettes (N, % using)	0 (0%) _a	158 (33.91%)	441 (95.66%)	0 (0%) _a	439 (100%)	91 (22.03%)
Hookah (N, % using)	0 (0%) _a	477 (100%)	316 (66.34%)	22 (25.29%) _b	0 (0%)	69 (16.31%) _{ab}
Cigars (N, % using)	0 (0%) _a	0 (0%) _a	304 (93.25%) _b	0 (0%) _a	0 (0%) _a	435 (100%) _b
Smokeless (N, % using)	0 (0%) _a	0 (0%) _a	224 (68.09%)	86 (100%)	25 (7.84%) _b	34 (8.72%) _b
Cigarettes (M, SD for days using)	13.31 (11.86) _a	6.78 (10.23) _b	12.19 (11.49) _a	5.46 (10.20)	7.50 (10.89) _a	10.41 (11.99) _a
E-cigarettes (M, SD for days using)	0 (0) _a	2.21 (5.54) _b	8.91 (9.32) _c	0 (0) _a	8.51 (9.87) _c	1.46 (4.76) _b
Hookah (M, SD for days using)	0 (0) _a	5.20 (7.73) _b	5.98 (7.97) _b	1.57 (5.21) _c	0 (0) _a	1.42 (4.76) _c
Cigars (M, SD for days using)	0 (0) _a	0 (0) _a	8.24 (9.68) _b	0 (0) _a	0 (0) _a	7.81 (10.03)
Smokeless (M, SD for days using)	0 (0) _a	0 (0) _a	6.13 (8.83) _c	9.01 (10.37) _d	0.76 (4.11) _e	0.75 (3.75) _a
Age (M, SD)	23.97 (1.81) _{ac}	23.69 (2.03) _{bd}	23.87 (1.92) _{abd}	24.08 (1.80) _{ce}	23.99 (1.91) _c	23.97 (1.84) _a
Sex (N, % male)	940 (56.39%) _{ae}	248 (52.32%) _a	326 (64.43%) _b	73 (78.49%) _{de}	256 (59.95%) _b	284 (67.30%) _{cd}
Race/ethnicity (N, %)						
NH White	738 (44.19%) _a	181 (38.19%) _b	157 (30.49%) _{ce}	40 (42.55%) _{hd}	186 (43.66%) _a	142 (32.87%) _b
NH Black	58 (3.47%) _a	24 (5.06%) _b	43 (8.35%) _{bd}	3 (3.19%) _{ab}	20 (4.69%) _{ab}	31 (7.18%) _{cd}
NH API	157 (9.40%) _{ab}	50 (10.55%) _{ab}	46 (8.93%) _{ab}	9 (9.57%) _{ab}	34 (7.98%) _a	54 (12.50%) _b
NH Other	154 (9.33%) _a	36 (7.59%) _a	45 (8.74%) _a	6 (6.38%) _a	41 (9.62%) _a	43 (9.95%) _a
Hispanic	563 (33.71%) _a	183 (38.61%) _b	224 (43.50%) _{bd}	36 (38.30%) _{bc}	145 (34.04%) _{ac}	162 (37.50%) _{abcd}
Education (N, %)						
In college	588 (35.21%) _a	212 (44.44%) _b	203 (40.28%) _b	28 (29.47%) _a	174 (40.28%) _b	165 (38.55%) _b
Graduated from college	710 (42.51%) _a	170 (35.64%) _b	158 (31.35%) _b	44 (46.32%) _{bd}	164 (37.96%) _{cd}	156 (36.45%) _{bd}
Dropped out of college/completed high school or GED	372 (22.28%) _a	95 (19.92%) _a	143 (28.37%) _a	23 (24.21%) _a	94 (21.76%) _a	107 (25.00%) _a
SPI (M, SD)	9.44 (2.83) _{ab}	8.98 (2.86) _a	9.80 (3.19) _{bc}	8.74 (3.01) _{ac}	9.36 (3.20) _{ac}	9.85 (1.84) _{bc}
Perceived peer smoking (M, SD)	48.27 (21.25) _a	45.33 (21.34) _b	49.65 (23.46) _{ce}	42.53 (27.09) _{df}	44.21 (21.41) _{df}	48.48 (22.62) _{ac}

	Group 1 (Cigarette Only) (n = 1,690)	Group 2 (Hookah mostly) (n = 479)	Group 3 (High overall use) (n = 528)	Group 4 (Smokeless mostly) (n = 95)	Group 5 (E-cigarette mostly) (n = 439)	Group 6 (Cigars mostly) (n = 435)
Anti-industry attitudes (M, SD)	2.20 (1.10) _a	2.53 (1.15) _b	2.37 (1.07) _c	2.51 (1.25) _{bcd}	2.39 (1.10) _d	2.35 (1.17) _{cd}
Advertising receptivity (N, %)	356(25.23%) _a	63 (18.81%)	171(39.04%) _c	18(28.13%) _a	82 (24.62%) _a	95(27.07%) _b

Note: Matching subscripts indicated no differences between classes, $p < .05$.

Comparisons were carried out using the 3-step approach in Mplus.

The range of the SPI is 0-13, range for perceived peer smoking is 0% 100%, range for anti-industry attitudes is 1-5.