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Patterns of Alternative Tobacco Product Use: Emergence of Hookah and E-cigarettes as Preferred Products Amongst Youth

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Abstract

Purpose—There is a growing public health concern related to the rapid increase in the use of multiple tobacco products among adolescents. This study examined patterns of adolescent use of cigarettes, e-cigarettes, cigars/cigarillo, hookah/waterpipe, and smokeless/dip/chewing tobacco in a population of southern California adolescents.

Methods—Data from 2,097 11th- and 12th-grade participants in the Southern California Children's Health Study were collected via self-report in 2014. Study participants were asked about lifetime and current (past 30 days) use of cigarettes, cigars/cigarillos/little cigars, e-cigarettes, hookah/waterpipe, and smokeless/dip/chewing tobacco. Latent class analysis (LCA) was used to identify patterns of tobacco use.

Results—Hookah/waterpipe tobacco use had the highest current prevalence (10.7%) followed by e-cigarettes (9.6%). The prevalence of use of smokeless/dip/chewing tobacco was lowest, with 2.2% of adolescents reporting current use. The LCA suggested four distinct classes, comprising nonusers (72.3% of the sample), polytobacco experimenters (13.9%), e-cigarette/hookah users (8.2%), and polytobacco users (5.6%). Multinomial logistic regression based on these four classes found that males had double the odds to be polytobacco users relative to nonusers compared to females (odds ratio, 2.3; 95% confidence interval, 1.26–4.25).

Conclusions—By identifying naturally occurring configurations of tobacco product use in teens, these findings may be useful to practitioners and policymakers to identify the need for tobacco control interventions that address specific tobacco products and particular combinations of polytobacco use. LCA can be used to identify segments of the population overrepresented among certain tobacco use classes (e.g., boys) that may benefit most from targeted polyproduct intervention approaches.

There is a growing public health concern related to the rapid increase in the use of multiple tobacco products among adolescents, including traditional tobacco products such as combustible cigarettes and smokeless tobacco and emerging products such as e-cigarettes

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and hookah/waterpipes (hereafter referred to as polytobacco use). Over the past two decades, there have been documented increases in cigar/cigarillo, e-cigarette, and hookah/ waterpipe use among youth and young adults [1-4]. The popularity of e-cigarettes, small cigars, and hookah among adolescents can be traced to the marketing of such products with flavorings appealing to youth [5-7], perceptions of public acceptability of e-cigarette and hookah use [5], and beliefs that these products cause less harm than conventional tobacco products (e.g., combustible cigarettes) [8,9]. Because the marketplace provides a variety of traditional tobacco products (cigarettes, cigars, smokeless tobacco) and alternative tobacco products (e-cigs and hookah) that are popular among adolescents, it is not surprising that relatively high rates of current (past 30 days) polytobacco product use have been reported. Data from the 2014 National Youth Tobacco Survey showed that 12.5% of the U.S. high school students had used two or more tobacco products in the past 30 days [3].

Beyond epidemiology, a detailed examination of the patterns of use of multiple tobacco products is important to begin identifying social determinants of particular patterns and assessing health effects of tobacco products used in different combinations. There is variation in the amount of nicotine and other potentially harmful ingredients contained in tobacco products and differences in how products are used (this includes how often and quantity consumed) that lead to the expectation of differences in nicotine dependence potential and toxicity across products [10]. In addition to differences in addiction potential, little is known about the true harm potential of alternate products (hookah and e-cigarettes) relative to combustible cigarettes [5]. For example, there is research that suggests one hookah session could be the equivalent of toxicant exposure of smoking 1 to 50 cigarettes [6]. Furthermore, Eissenberg et al. [11] found that hookah produced a significantly higher carbon monoxide exposure while delivering the same amount of nicotine in a laboratory-controlled experiment compared to cigarettes. Assessments of the harm potential of e-cigarettes are also limited. The e-liquids available for e-cigarettes have a wide variation in nicotine content, and the amount of nicotine in many vials could be fatal if ingested orally or transdermally [12]. Recent studies indicate that e-cigarettes may be less harmful than combustible cigarettes [13,14].

Furthermore, among traditional tobacco products, there may be a perception that flavored and/or small cigar use may be safer than cigarette use based on anticipated usage patterns (nondaily use or fewer cigars smoked than cigarettes) [1]. In addition, hookah and e-cigarette use is not as widely banned as combustible product use, and there are specialized lounges/bars/shops for the use of e-cigarettes, hookah, and cigars which might encourage their use in social situations among youth [5,15]. Thus, the present tobacco use landscape gives cause for concerns about the actual health risk exposure of newer products, perceptions of risk of older products with resurgence in use due to the addition of flavoring, and the health effects of multiple product use.

Methodologically, understanding the patterns of polytobacco use across the five most popular products (cigarettes, e-cigarettes, hookah, cigars, and smokeless tobacco) is challenging using an ad hoc or variable-centered approach to grouping patterns of use. Latent class analysis (LCA) is a person-centered method for identifying homogeneous subgroups of people based on response characteristics, such as likelihood of using individual

tobacco products, within a heterogeneous population [16-18]. Instead of subgrouping all possible unitobacco and polytobacco use, LCA can identify a parsimonious set of groupings while accounting for measurement error. In the present study, LCA was used to identify patterns of adolescent use of cigarettes, e-cigarettes, cigars/cigarillo, hookah/waterpipe, and smokeless/ dip/chewing tobacco in a population of southern California adolescents enrolled in the Southern California Children's Health Study (CHS). Impacts of different risk factors associated with subgroups (race and gender) suggested by LCA were also investigated using multinomial logistic regression analysis.

Methods

In 2014, data were collected from a cohort of 2,097 11th- and 12th-grade participants in the CHS, who were originally enrolled in 2002–2003 (in kindergarten and first grade) [19,20]. The response rate for this wave and cohort was 87%. The design of the CHS for this cohort was based upon the selection of 12 communities in southern California and recruitment of a representative sample (representative of the community) of youth from schools. Self-administered questionnaires were completed at school under study staff supervision. Of 2,097 respondents, 2,091 were included in the final analysis (6 were missing data on all five tobacco products). The study was approved by the University of Southern California Institutional Review Board. Written parental informed consent and student assent were obtained before data collection; students who were aged 18 years provided their own written consent.

Tobacco product use assessment

Study participants were asked about age of initiation and current (past 30 days) use of cigarettes, cigars/cigarillos/little cigars, e-cigarettes, hookah/waterpipe, and smokeless/dip/chewing tobacco. To initially determine level of use of each product, participants were asked their age at the first use for each product, and those who indicated they had never used the product in question were coded as never users. Adolescents who provided an age of first use but no use in the past 30 days were classified as ever/lifetime users. Participants who reported current product use were classified as current users of that product. Thus, a variable with three levels (never, ever/lifetime, and current) was created individually for each of the five products (cigarettes, cigars/cigarillos/little cigars, electronic or e-cigarettes, smoking tobacco from a hookah/waterpipe, and smokeless/dip/chewing tobacco).

Analysis

LCA was conducted using Mplus 7.3 [21,22]. Models were run to determine the appropriate number of classes starting with a one-class model followed by a series of models specifying increased number of classes (e.g., two-class, three-class, etc.) representing different patterns of tobacco product use. Optimal model selection was based upon recommended indices including selecting the model with the lowest Akaike Information Criterion and adjusted Bayesian Information Criterion relative to other models and highest entropy/quality of classification (likelihood that respondents are classified in the correct class) [23].

Multinomial logistic regression analyses were conducted using the three-step method available in Mplus [24]. First, the appropriate number of latent classes are identified using the five tobacco use variables. Subsequently, the most likely class membership is identified and finally used in a multinomial logistic model controlling for the error/misclassification in class assignment. Odds ratios from the multinomial logistic regression analysis indicate how covariates are related to likelihood of belonging to a particular latent class. Covariates examined in this model included gender and race/ethnicity. The clustering of youth by community was adjusted for in the model. Missing data on tobacco use variables were analyzed via full-information maximum likelihood estimation.

Results

Descriptive statistics

Approximately, 50% of participants were men and 51.7% reported being Hispanic/Latino (Table 1). The mean age was 17.3 years with a standard deviation of .6. Hookah was the tobacco product with the highest current prevalence (10.7%) followed by cigarettes (9.6%). The prevalence of use of smokeless/dip/chewing tobacco was lowest, with only 2.2% of adolescents reporting current use.

Latent class analysis results

The four-class solution was identified as the best fit to the data using adjusted Bayesian Information Criterion (found to perform well for categorical data) and the Akaike Information Criterion [23]. The four-class solution had the lowest values for both and subsequent classes showed an increase in the values of each. Members of class 1 (nonusers) accounted for 72.3% of the sample and had very low probability of trying any of the five products (Table 2). Class 2 members (polytobacco experimenters, youth who generally had tried multiple products at some point in their lives but were not likely to be currently using products) accounted for 13.9% of the sample. These youth had at least a 48% (cigars) to 70% (e-cigarettes) chance of ever/lifetime use of cigarettes, cigars, e-cigarettes, or hookah. They had a 16% chance of ever using smokeless/dip/chewing tobacco. The third class (current e-cigarette/hookah users) comprised 8.2% of the sample. Youth in this class had a 5.5% chance of currently using cigarettes and a 6.6% chance of currently using cigar products. However, they had a 43% chance of being current e-cigarette users and 49% chance of currently using hookah. The final class (current polytobacco users) included 5.6% of the sample. These youth had a 46% (cigars) to 83% (e-cigarettes) chance of being current users of the four most common products (cigarettes, e-cigarettes, hookah, and cigars). They also had the highest probability of using smokeless/dip/chewing tobacco (18% chance of current use).

Multinomial regression results

Males had more than twice the odds of being poly tobacco users relative to non-users compared to females (odds ratio, 2.3; 95% confidence interval, 1.26–4.25; Table 3). There were no significant associations between race/ethnicity and tobacco use classes.

Discussion

This novel application of LCA provided an empirical grouping of patterns of tobacco use by youth in a market at a time of increasing diversity of products. Two of the four classes included high probability of polytobacco (experimental and current) use. Boys were more than twice as likely as girls to be current polytobacco users. Hookah and e-cigarette users constituted a relatively large and unique combination of polytobacco use. Across all tobacco use classes, e-cigarette and hookah had the highest probability of use.

The emergence of e-cigarettes and hookah as more commonly used tobacco products than combustible cigarettes is consistent with other studies. There is evidence that there have been significant increases in both e-cigarette and hookah use relative to cigarette use among teens nationally [3]. Finding a latent class differentiated by the co-use of e-cigarette and hookah reveals that some youth are engaging in a particularly distinct type of tobacco use dissimilar to general polytobacco use/experimentation or nonuse. This finding may suggest that teen use of e-cigarettes and hookah could derive from a shared etiology. Perhaps, e-cigarettes and hookah may be co-used because of a common characteristic that may be attractive to adolescents, such as the availability of e-cigarettes and hookah in appealing sweet flavors and/or their use in social settings.

After many years of social denormalization of smoking, a relatively new phenomenon of socially acceptable alternative tobacco product use venues is gaining in popularity. Hookah bars and vape shops are appearing in cities across the country [15] and becoming popular places to socialize. These business establishments offer hookah and e-cigarettes in a variety of flavors and allow users to consume the products in public areas within their venues so that the tobacco control tactic of marginalization is undermined and may make the use of these products socially acceptable. It has been hypothesized that these shifts have the potential to renormalize tobacco use, and with it smoking [5].

This study has some limitations. First, data were not collected on the nicotine content of e-cigarette or hookah products used. It is possible to use nicotine-free versions of these products which would eliminate addiction potential but not toxicity exposure. We did not include perceptions of harm or other covariates in the present analysis. However, the goal of this study was to provide a much needed approach for classifying patterns of polytobacco use in an increasingly complex panorama of potential tobacco use beyond knowing the prevalence of youth who use more than one product or how products are used in combination with cigarettes. As the data are cross-sectional, full exploration of causal risk factors is limited by temporality. It is also possible that those who are reported as current users may have only experimented 1 day with a given product. Number of days used in the past 30 days was not included in the analysis because of sparseness in responses. A final issue is the narrow age range of the youth and the racial/ethnic composition of the sample, largely Hispanic and non-Hispanic whites (although this is representative of the population in southern California).

There is mixed evidence that youth believe e-cigarettes and hookah are less harmful than cigarette use and have little or no risk to health [8,20]. E-cigarettes and hookah may contain

and deliver widely variable amounts of nicotine [12,25]. Such variability in nicotine content and exposure may make identifying addiction potential of individual products difficult. However, using multiple products of unknown nicotine content may increase the likelihood for nicotine dependence. Future research should prospectively examine dependence potential in the context of social use of multiple alternative tobacco products over time.

Based on these findings, research is needed to identify the consequences of different patterns of polytobacco use, including the implications of these patterns for subsequent cigarette use, changes in social norms for tobacco use, and the potential for nicotine dependence. The latter is likely to evolve as improved measures of smoking topography are developed, including puff, volume, use frequency, and nicotine content of alternative tobacco products. Finally, additional behavioral pharmacology and toxicology research on the long-term physical health risks of combined use above and beyond the known physiological risks of individual product use is also warranted [10].

Beyond etiologic research, the tobacco product prevalence and types of individuals represented in each pattern of use may be useful to practitioners and policymakers to identify (1) the need for tobacco control policy and education interventions that address specific tobacco products and combinations of polytobacco use, (2) the particular products that should be targeted together in such interventions, and (3) the segments of the population that may benefit most from targeted polyproduct intervention approaches. Our findings raise the possibility that a sizeable subgroup of teens may benefit from intervention targeting the use of e-cigarette and hookah products specifically. Furthermore, our results also indicate that another group of teens, overrepresented by boys, may benefit from interventions targeting all types of tobacco products. Current regulations related to tobacco products do not meaningfully impact three of the five products examined in this study (cigars, e-cigarettes, and hookah) [26]. The regulation of flavoring, youth access, and secondhand exposure are topics that should continue to receive careful consideration. Future studies should seek to replicate the current findings in larger, more diverse samples.

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IMPLICATIONS AND CONTRIBUTION

Recent research shows a substantial increase in alternative tobacco product use. Use of these products may have significant health implications for youth, although little is known about youth polytobacco use behaviors. To fill this gap, this study examines patterns of polytobacco use among high school–aged adolescents across five products.

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Table 1Descriptive statistics of tobacco product use^a

Variable	% (n)	Male %	Female %
Gender			
Male	50.5 (1,059)		
Female	49.5 (1,038)		
Race/ethnicity			
Hispanic/Latino	51.7 (1,085)		
Non-Hispanic white	35.0 (734)		
Other	13.2 (276)		
Cigarettes			
Never	81.3 (1,697)	80.2	82.4
Ever	13.0 (272)	13.8	12.3
Current	5.7 (119)	6.0	5.4
Cigars ^a			
Never	86.9 (1,814)	82.2	91.8
Ever	9.4 (197)	12.1	6.8
Current	3.6 (76)	5.8	1.4
E-cigarettes ^a			
Never	76.0 (1,585)	72.2	79.8
Ever	14.4 (301)	16.2	12.6
Current	9.6 (201)	11.6	7.6
Hookah			
Never	72.8 (1,519)	73.6	71.9
Ever	16.5 (345)	16.4	16.6
Current	10.7 (224)	9.9	11.5
Smokeless/dip/chewing [*]			
Never	96.6 (1,950)	90.1	97.2
Ever	4.2 (87)	6.3	2.0
Current	2.2 (46)	3.6	0.8

^aBecause of variation in missing responses total sample is different across variables.

^{*} $p < .05$ for the chi-square test of independence between gender and product use.

Table 2

Conditional probabilities of tobacco use among Southern California Children’s Health Study youth (n = 2,091)

Item	Nonsmokers	Polytobacco experimenters	E-cigarette /hookah users	Polytobacco users
Class				
prevalence	72.3%	13.9%	8.2%	5.6%
Cigarette				
Never	.974	.292	.723	.155
Ever	.021	.594	.222	.247
Recent	.005	.114	.055	.598
Cigar				
Never	.994	.478	.934	.109
Ever	.006	.486	.000	.429
Recent	.000	.036	.066	.462
E-cigarette				
Never	.960	.234	.418	.028
Ever	.036	.707	.145	.143
Recent	.003	.059	.437	.829
Hookah				
Never	.929	.241	.273	.067
Ever	.054	.643	.229	.310
Recent	.017	.116	.497	.623
Smokeless/dip/chewing				
Never	.995	.780	.950	.534
Ever	.002	.160	.027	.284
Recent	.003	.059	.023	.182

Akaike Information Criterion = 9,387.2; sample-size adjusted Bayesian Information Criterion = 9,493.3; entropy = .83.

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Table 3

Multinomial logistic regression of tobacco product use (n = 2,091)

Covariate	Polytobacco experimenters versus nonusers; OR (95% CI)	E-cigarette/hookah users versus nonusers; OR (95% CI)	Polytobacco users versus nonusers; OR (95% CI)
Gender			
Female	1.00	1.00	1.00
Male	1.44 (.99–2.09)	.61 (.33–1.11)	2.31 (1.26–4.25)
Race/ethnicity			
Hispanic/Latino	1.00	1.00	1.00
White	1.11 (.79–1.55)	1.37 (.80–2.37)	1.45 (.96–2.20)
Other	.78 (.49–1.24)	.79 (.41–1.55)	.43 (.16–1.16)

Bold indicates statistical significance;

$p < .01$.

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