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Progression of Poly-tobacco Product Use Patterns in Adolescents

Jimi Huh, PhD¹ and Adam M. Leventhal, PhD^{1,2}

¹Department of Preventive Medicine, University of Southern California, Los Angeles, California

²Department of Psychology, University of Southern California, Los Angeles, California

Abstract

Introduction—Diverse patterns of adolescent use and poly-use of tobacco products other than conventional cigarettes are emerging. Data characterizing common patterns of youth tobacco product use and typical transitions among patterns may inform tobacco control policy and prevention. This study identified common patterns of use and poly-use of five popular tobacco products (i.e., conventional cigarettes, electronic [e-]cigarettes, hookah, blunts, and cigars) and progression among patterns across time among ninth-graders using latent transition analysis (analyses conducted in 2015).

Methods—Data were from a longitudinal cohort study of ninth-grade students enrolled in ten public high schools in California (N=3,304; 46.6% male; 48.3% Hispanic; mean age, 14.58 [SD=0.40] years), involving a baseline (2013) and 6-month follow-up (2014). Past 6-month any use of the five tobacco products was assessed.

Results—Poly-use (two or more products) constituted 42% and 50% of tobacco-using teens at baseline and follow-up, respectively. Three common patterns were identified, which reflected successfully greater degrees of low, intermediate, and high diversity of tobacco product use: non-users (baseline prevalence, 0.75; follow-up prevalence, 0.64); e-cigarette/hookah users only (prevalence, 0.21, 0.27); and poly-tobacco product users of all five products (prevalence, 0.04, 0.09). Most typical transitions involved progressing to the next more diverse pattern (non-user → e-cigarette/hookah user [probability=0.13] and e-cigarette/hookah user → poly-tobacco product user [probability=0.19]). Transition from one of the user patterns to non-user status was rare (probability 0.08).

Conclusions—Adolescent poly-tobacco use is common. E-cigarette and hookah use may reflect an intermediate pattern of tobacco product use progression along a continuum of poly-product use diversity.

Introduction

Recent epidemiologic surveys estimate that electronic (e-)cigarettes (13.4%) are the most commonly used tobacco product in U.S. adolescents in the past 30 days, followed by hookah

Address correspondence to: Jimi Huh, PhD, Department of Preventive Medicine, Division of Health Behavior Research, University of Southern California Keck School of Medicine, Soto Street Building I, 2001 N. Soto Street, 302Y, MC 9239, Los Angeles CA 90032-3628. jimihuh@usc.edu.

(9.4%); cigarettes (9.2%); and cigars (8.2%),^{1,2} and poly-tobacco users of two or more products are common (12.7%).¹ Blunts (i.e., marijuana rolled in tobacco)³ are also rising in popularity among adolescents,⁴ particularly among users of other tobacco products.⁵

Prior prevalence estimates of use/co-use have primarily examined pairings of two products at a time and suggest numerous configurations of associations among multiple tobacco products.^{6–8} The countless configurations of poly-product use and transitions from one use pattern to another pose challenges for setting priorities for tobacco control policy.

Identifying a more parsimonious model that characterizes the most typical patterns of use and progression is needed to highlight whether:

1. single or poly-product tobacco prevention campaigns are warranted and for which products; and
2. certain patterns of use are associated with increased risk of progression to more diverse and harmful patterns of poly-tobacco use and therefore warrant increased surveillance and intervention.

In this longitudinal study, tobacco product use was surveyed among teens at the beginning and end of ninth grade. An innovative statistical modeling strategy (latent transition analysis [LTA]⁹) was applied to:

1. identify common patterns of use and poly-use of five popular tobacco products; and
2. investigate progression from one pattern to another in 6 months.

Methods

Data were drawn from a longitudinal survey of 3,396 ninth-graders enrolled in ten public high schools in Southern California (46.6% male; 48.3% Hispanic; mean age, 14.58 [SD=0.40] years). Participants with missing data at both waves ($n=7$) were excluded from the final analytic sample ($N=3,389$). On-site paper-and-pencil surveys during fall 2013 (baseline) and spring 2014 (follow-up) were conducted. The University of Southern California IRB approved the study.

Measure of Tobacco Product Use

At each wave, items based on the national Monitoring the Future¹ assessed past 6-month any use (yes/no) of:

1. conventional cigarettes (at least one puff);
2. e-cigarettes;
3. hookah (tobacco water pipe);
4. blunts (marijuana rolled in tobacco leaf); and
5. cigars (big/little cigars or cigarillos).

Analytic Strategy

This study used LTA to identify the most parsimonious set of groupings (i.e., latent statuses) of use and co-use among the five tobacco products and transitions from one status at baseline to another status at follow-up without sacrificing meaningful explanatory power.^{9–11} Three sets of parameters are estimated in LTA: item–response probabilities (probability of endorsing an item conditional on latent status membership), latent status membership prevalence (proportion of the population belonging to a latent status), and transitional probabilities (probabilities that members belonging to a particular latent status at baseline transition to another latent status at follow-up).⁹ The final model was conducted using Mplus, version 7.31 in which maximum likelihood estimation method was used to yield model-based estimates, adjusting for the potential cluster effects of schools. Model fit was determined by evaluating log likelihood, Akaike Information Criterion, and Bayesian Information Criterion. Analyses were conducted in 2015.

Results

E-cigarette use was most common (baseline, 13%; follow-up, 21%) followed by hookah (10%, 14%) and the other products (Table 1). Correlations between use of each of the tobacco products within and across time points varied widely ($r=0.16$ – 0.46 , Table 1). Poly-tobacco product use constituted 42% (baseline) and 52% (follow-up) of all tobacco product users (Table 2).

Both the three-status and four-status LTA solutions were comparable (Table 3). The four-status solution showed problematic identification. The three-status solution was therefore selected with fixed measurement parameters across the two time points (freeing measurement parameters did not improve model fit) as the most parsimonious model.

Qualitative labels were applied based on the use probabilities for each status (Table 4, top panel). Non-users were unlikely to use any products at both times (product use probabilities 0.02). E-cigarette/hookah users showed low probabilities of cigarette, cigar, and blunt use (probability range, 0.02–0.15) and moderate e-cigarette (0.49) and hookah (0.30) probabilities. Poly-tobacco product users had a high probability of using blunts, e-cigarettes, conventional cigarettes, or hookah (0.60) and moderate probability of using cigars (0.48).

Prevalence of e-cigarette/hookah use increased from 0.21 to 0.27 at follow-up (Table 4, middle panel). Poly-tobacco product use prevalence more than doubled from baseline to follow-up (0.04, 0.09). Prevalence of non-use decreased from baseline (0.75) to follow-up (0.64).

As illustrated in the bottom panel of Table 4, of baseline e-cigarette/hookah users, about one fifth (0.19) progressed to poly-tobacco product use by follow-up, and few transitioned to non-use (0.003). Baseline non-users progressed more often to e-cigarette/hookah use (0.13) than poly-tobacco product use (0.02). Poly-tobacco product users had small likelihood of transitioning to e-cigarette/hookah users (0.06) and non-users (0.08) at follow-up.

Discussion

Poly-tobacco product use was common and increased from the beginning to end of ninth grade. The heterogeneity in groupings of tobacco product use/co-use was reduced to three meaningful patterns that could represent a continuum of diversity of tobacco products:

1. a grouping that constituted the majority population (non-users), with the least diverse pattern of use and a very low likelihood of any product use;
2. a moderately sized grouping with an intermediate pattern of diverse product use (e-cigarette/hookah users), with a moderate probability of using e-cigarettes and hookah and a low likelihood of using other products; and
3. a least-common grouping with high diversity in product use characterized by a moderate to high probability of using all five assessed tobacco products (poly-tobacco product users).

The most typical transition in use patterns from the beginning to end of ninth grade involved progressing to the next most diverse use pattern along the continuum (i.e., non-user→e-cigarette/hookah user [probability= 0.13]; e-cigarette/hookah user→poly-tobacco product user [probability=0.19]). Transition from either pattern of tobacco use to non-use was rare.

Limitations

Limitations of this study include focus on a succinct, but important, period of development, narrow domain of tobacco use assessment, and absence of analysis of the possible role of explanatory/confounding factors in the transitions identified herein (e.g., age of initiation, familial/peer tobacco use, tobacco control policy and marketing). Longer periods of follow-up, more comprehensive assessment, and analysis of explanatory factors should be addressed in future work.

Conclusions

Bivariate prospective associations from e-cigarettes to cigarettes,^{6,8,12} e-cigarettes to cigars,⁸ and hookah to cigarettes¹² previously demonstrated may be accounted for by a more parsimonious model of progression across a continuum of diversity of tobacco products used. Of youths who are using a tobacco product as they enter high school, they are more likely to have done so with use of e-cigarettes or hookah and are at a sizeable risk of progressing to a more diverse pattern of poly-tobacco product use in as short as 6 months. Based on these results, continued surveillance of the growing population of e-cigarette- and hookah-using adolescents in the U.S. may be important to determine whether this group ultimately progresses to more diverse patterns of poly-tobacco product use in future years. Furthermore, strategies to limit access to and demand of e-cigarettes and hookah—the most common entry points for tobacco use—may reduce risk of progression to poly-tobacco product use.

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Prevalence and Bivariate Correlation Among Covariates and Past 6-Month Tobacco Product Use at Baseline and 6-Month Follow-Up^a

Table 1

Variable	Prevalence (%)	Correlations (<i>r</i>)							
		1.	2. ^b	3. ^b	4. ^b	5. ^b	6. ^b	7. ^b	8. ^b 9. ^b
Use at baseline									
1. Conventional cigarette	3.6								
2. E-cigarette	12.9	0.29							
3. Hookah	9.5	0.23	0.37						
4. Blunt	6.6	0.38	0.41	0.41					
5. Cigar	2.3	0.47	0.26	0.40	0.40				
Use at 6-month follow-up									
6. Conventional cigarette	8.3	0.29	0.21	0.22	0.16	0.16			
7. E-cigarette	20.6	0.19	0.27	0.23	0.16	0.33	0.33		
8. Hookah	13.5	0.18	0.36	0.24	0.16	0.30	0.42	0.42	
9. Blunt	10.4	0.27	0.31	0.42	0.22	0.39	0.38	0.40	0.40
10. Cigar	4.5	0.22	0.21	0.27	0.29	0.46	0.32	0.30	0.40 0.40

Note: Boldface indicates statistical significance ($p<0.001$).

^aNs range from 3.111 to 3.323, depending on bivariate pairings.

^bThese numbers correspond to the tobacco product use at each time point denoted on each row.

Table 2

Prevalence (%) by Number of Tobacco Products Used at Baseline and 6-Month Follow-Up

	Baseline	6-Month Follow-Up
0 Products	80.5%	70.7%
1 Product	11.4%	14.2%
2 Products	4.1%	8.1%
3 Products	2.7%	4.4%
4 Products	0.8%	2.0%
5 Products	0.5%	0.7%

Table 3

Model Fit Indices for LTA Models With 2 to 5 Statuses

Number of latent statuses	LL	df	Entropy	AIC	BIC
2	7,778.300	956	0.830	15,582.600	15,662.267
3 ^a	7,372.995	964	0.799	14,791.990	14,932.941
4	7,330.123	951	0.782	14,730.245	14,944.735
5	7,302.200	941	0.819	14,702.400	15,002.686

^aValues in this row indicate the selected LTA model.

AIC, Akaike's information criterion; BIC, Bayesian information criterion; LL, log likelihood; LTA, latent transition analysis.

Table 4

Item-Response Probabilities and Transition Probabilities for Selected LTA Model

	Latent status		
	Non-users	E-cigarette/hookah user	Poly-tobacco product users
Item-response probabilities			
Cigarette use in past 6 months	0.02	0.07	0.60 ^a
E-cigarette use in past 6 months	0.022	0.49 ^a	0.77 ^a
Hookah use in past 6 months	0.006	0.30 ^a	0.65 ^a
Blunt use in past 6 months	0.005	0.15	0.78 ^a
Cigar use in past 6 months	0.00	0.02	0.48 ^a
Proportion of sample constituted by each status			
Baseline	0.75	0.21	0.04
6-month follow-up	0.64	0.27	0.09
Transitions from baseline (rows) to 6-month follow-up (column) in LTA without covariates; values on the diagonal reflect cases without transition.			
Non-users	0.85 ^b	0.13	0.02
E-cigarette/hookah user	0.003	0.81 ^b	0.19
Poly tobacco users	0.08	0.06	0.87 ^b

^aThese values represent the probabilities that define status characteristics. Item-response probabilities were constrained to be equal across Time 1 and Time 2.

^bThese values indicate transitional probabilities that represent stability (i.e., staying the same status across both time points).

LTA, latent transition analysis.