Published in final edited form as:

Addict Behav. 2018 December ; 87: 131–137. doi:10.1016/j.addbeh.2018.06.028.

Hookah use as a predictor of other tobacco product use: A longitudinal analysis of Texas college students

Kathleen R. Case^{a,*}, MeLisa R. Creamer^a, Maria R. Cooper^a, Alexandra Loukas^b, and Cheryl L. Perry^a

^aUTHealth, School of Public Health in Austin, United States

^bDepartment of Kinesiology and Health Education, The University of Texas at Austin, United States

Abstract

Introduction: Hookah use is particularly prevalent among U.S. college students; however, few studies have investigated whether hookah use is a risk factor for the initiation of other tobacco products. This study examined whether hookah use predicted subsequent initiation of other combustible tobacco products (conventional cigarettes and cigar products) and Electronic Nicotine Delivery Systems (ENDS) among Texas college students during a 2.5-year study period.

Methods: This study involved a longitudinal analysis of data from Waves 1–6, with 6 months between each wave of the Marketing and Promotions Across Colleges in Texas Project (Project M-PACT). Two separate multilevel discrete-time survival analyses were used to model the associations between past 30-day hookah use and subsequent initiation of 1) other combustible tobacco products, and 2) ENDS during the 2.5 year study period, after controlling for demographic, other tobacco use, and risk-taking personality characteristics (i.e. sensation seeking and impulsivity).

Results: After controlling for covariates, past 30-day hookah use was associated with significantly higher odds of subsequent initiation of other combustible tobacco products. Past 30-day hookah use also predicted subsequent initiation of ENDS after controlling for covariates.

Conclusions: This study is one of the first to demonstrate that hookah use is a predictor of subsequent initiation of other combustible tobacco products and ENDS among college students. These findings suggest that hookah may prime individuals to use other tobacco products, which has important implications for prevention programs and future research.

*Corresponding author. Kathleen.R.Case@uth.tmc.edu (K.R. Case),
Contributors

Dr. Case conducted all statistical analyses and wrote the majority of the manuscript. Dr. Creamer contributed to the background and discussion sections, as well as helped with conceptualization of the manuscript. Dr. Cooper provided consultation on the statistical methods used and edited multiple versions of the manuscript. Dr. Loukas serves as Principal Investigator for the Project M-PACT and contributed to the conceptualization of the manuscript and provided feedback throughout the writing process. Dr. Perry serves as Principal Investigator for the entire Texas Tobacco Center of Regulatory Science and was involved in editing all versions of the manuscript. All authors contributed to and have approved the final manuscript.

MeLisa.R.Creamer@uth.tmc.edu (M.R. Creamer), Maria.R.Cooper@uth.tmc.edu (M.R. Cooper),
Alexandra.loukas@austin.utexas.edu (A. Loukas), Cheryl.L.Perry@uth.tmc.edu (C.L. Perry).

Conflict of interest

All authors declare that they have no conflicts of interest.

Keywords

Hookah; Tobacco products; Electronic cigarettes; College students

1. Introduction

Hookah is an increasingly popular tobacco product in the United States, particularly among college students. The 2016 National College Health Assessment estimated that 19% of college students had ever used hookah and 3.9% reported current use (American College Health Association, 2016). Other studies have estimated higher prevalence of hookah use among college students, ranging from 11% to 22% of college students reporting past 30-day use (Heinz et al, 2013; Latimer, Batanova, & Loukas, 2014). The high prevalence of hookah use is concerning because of potential health consequences associated with use. For example, one study found that a one hour hookah session exposes a user to nearly 50 times the amount of smoke as a conventional cigarette, and each puff from the hookah exposes the user to 12.0 times the amount of smoke as a single cigarette puff (Eissenberg & Shihadeh, 2009). Additional studies have linked hookah use to pulmonary disease and cardiovascular outcomes (Maziak, 2011; Waziry, Jawad, Bailout, Al Akel, & Akel, 2017).

However, many young adults report misperceptions regarding the harmfulness of hookah. In a recent study of college students, Creamer et al. (2016) found that over a quarter of respondents incorrectly believed there was no tobacco in hookah and 38% believed that hookah did not contain nicotine. In addition, hookah users had significantly lower harm perceptions and perceived addictiveness scores as compared to non-hookah users (Creamer et al., 2016). Research has indicated that decreased hookah harm perceptions and lack of knowledge are associated with hookah use (Berg et al., 2015); and that decreased harm perceptions are associated with using hookah more frequently (Creamer et al., 2016). Other correlates of hookah use include younger age, being male, and current cigarette use (Jarrett, Blosnich, Tworek, & Horn, 2012; Sutfin et al., 2011).

The role of hookah use in priming individuals for future tobacco product use has not been adequately addressed. In one of the few studies to investigate the longitudinal association between hookah use and cigarette smoking, Fielder, Carey, and Carey (2013) found that hookah use prior to college predicted future cigarette use (initiation of use or resuming use) in a sample of female college students over nine months. Furthermore, researchers found that hookah users at baseline smoked significantly more cigarettes and smoked cigarettes on more days at six months follow-up as compared to non-hookah users (Doran, Godfrey, & Myers, 2015). In addition, research involving adolescents echo findings from young adult studies that hookah use predicts future tobacco use. These studies indicate that hookah use at baseline predicted the following cigarette behaviors at follow up: initiation of use, past 30-day use, and intensity of use (Jaber et al., 2015; Soneji, Sargent, Tanski, & Primack, 2015; Watkins, Glantz, & Chaffee, 2018). Importantly, the previous studies examined the potential link between hookah and cigarette smoking but did not examine the role of hookah use in other types of tobacco product use, including ENDS and cigar products. Examining hookah use as a predictor of ENDS use is particularly important as the prevalence of ENDS use has

increased rapidly in recent years; over a quarter (26%) of college students reported ever use in 2015 (Miech, Johnston, O'Malley, Bachman, & Schulenberg, 2016). In addition, a recent nationwide study found that young adults aged 18 to 24 comprised the highest proportion of current established cigarillo users (35.9%), and more than one in five (22.1%) reported current established use of non-premium cigars (Corey et al., 2017).

Understanding tobacco use patterns, including how hookah use predicts the use of other tobacco products, in college students is important because emerging adulthood is a distinct period during which behaviors, such as tobacco use, are established and solidified (Arnett, 2000; U.S. Department Health and Human Services, 2012; White, Bray, Fleming, & Catalano, 2009). The purpose of this longitudinal study is two-fold: 1) To determine if past 30-day hookah use predicts subsequent initiation of other combustible tobacco products (conventional cigarettes and cigar products), and 2) To determine if past 30-day hookah use predicts subsequent initiation of ENDS use among Texas college students during a 2.5 year study period. We hypothesized that past 30-day use of hookah would predict subsequent initiation of other combustible tobacco products and ENDS, after controlling for demographic characteristics, other tobacco use behaviors, and risk-taking behaviors (i.e. sensation seeking and impulsivity).

2. Material and methods

2.1. Study design

This study was a longitudinal analysis of Waves 1–6 of the Marketing and Promotions Across Colleges in Texas Project (Project M-PACT). At Wave 1, participants included college students aged 18 to 29 who were enrolled in four-year colleges and two-year vocational programs in the five counties surrounding Austin, Dallas/Fort Worth, Houston, and San Antonio. Data were collected over a 2.5 year study period, which consisted of six waves spaced six months apart. To be eligible to participate individuals had to be enrolled as full-time or part-time degree or certificate-seeking undergraduate students attending a four-year college or a vocational/technical program at a two-year college. Students who met the eligibility criteria were recruited to participate via e-mail and student consent was obtained online prior to study enrollment. A more detailed description of study methods is described elsewhere (Loukas et al., 2016). Project M-PACT was reviewed and approved by the University of Texas at Austin Institutional Review Board (2013-06-0034).

2.2. Study participants

A total of 5,482 young adults participated in Wave 1 of Project M-PACT, and 4,384 participated in Wave 6 (retention = 80%); the overall participation rate for all eligible college students at Wave 1 was 40.0%. Data collection for Wave 1 began in November 2014, and subsequent waves were administered six months apart. As the purpose of the current study was to examine if past 30-day hookah use predicted subsequent initiation of 1) other combustible tobacco product use, and 2) ENDS use, two separate models were conducted. For the first model, analyses were restricted to never users of other combustible tobacco products (cigarettes and cigar products) at Wave 1. For the second model, analyses were restricted to never users of ENDS products at Wave 1. In addition, participants were

excluded from both models if they did not participate in at least two study waves ($n = 418$). The final sample sizes included 2,355 participants for the combustible tobacco product initiation analyses (model 1); and 2,590 participants for the ENDS initiation analyses (model 2).

2.3. Measures

2.3.1. Dependent variables: other combustible tobacco products and ENDS use initiation—Initiation of other combustible products (cigarettes and cigar products) was assessed at each of the six waves and served as the dependent variables of interest for the first model. For cigarettes, participants were asked: “How many cigarettes have you smoked in your entire life?” Response options ranged from “I have never smoked a cigarette, even 1 or 2 puffs” to “At least 100 or more cigarettes (5 packs or more).” If participants selected a response other than “I have never smoked a cigarette, even 1 or 2 puffs” they were considered a cigarette smoker. For cigars, two items were analyzed that began with the stem, “Have you ever tried either of these cigar product types as intended (i.e. with tobacco), even one or two puffs?”; 1) “Large cigars like Macanudo, Romeo y Julieta, Arturo Fuente, Garcia y Vega, Backwoods, etc” and 2) “Cigarillos or little filtered cigars like Black and Mild, Swisher Sweets, Dutch Masters, Phillie Blunts, Santa Fe, etc.” If participants responded “yes” to either item they were considered cigar users. Ultimately, if participants indicated ever use of cigarettes or cigar products (large cigars, little filtered cigars, or cigarillos) they were classified as combustible product initiators for the first wave in which they indicated use; individuals who did not initiate combustible product use during the study period were right-censored at the last wave in which they participated.

Initiation of ENDS was also assessed at each of the six waves and served as the dependent variable for the second model. Participants were asked “Have you ever used an ENDS product, (i.e. e-cigarette, vape pen, or e-hookah) as intended (i.e. with nicotine cartridges and/or e-liquid/e-juice), even one or two puffs?” Response options were “yes” and “no.” Similar to combustible product initiation, if participants indicated ever use of ENDS products they were classified as initiators for the first wave in which they indicated use; individuals who did not initiate ENDS use during the study period were right-censored at the last wave in which they participated.

2.3.2. Independent variable—The primary independent variable of interest for both models was past 30-day hookah use at each wave. Hookah use was measured with the question, “On how many of the past 30 days have you smoked a hookah as intended (i.e. with tobacco)?” If participants indicated 1 or more days of use they were classified as past-30 day hookah users for that wave; if participants indicated 0 days of use they were classified as non-users.

2.3.3. Covariates—Both time-varying and time-constant covariates were included in the analyses. For both models, sex, race/ethnicity, Wave 1 age, and Wave 1 type of college attended were included as time-constant covariates. To account for use of other tobacco products, all products that were not represented as independent or dependent variables served as control variables in the models. For the other combustible products model, past 30-

day use of other tobacco products (ENDS and/or smokeless tobacco) was included as a time-varying covariate (user of any other product versus non-user). For the ENDS model, past 30-day use of other tobacco products (cigarettes, cigar products, and/or smokeless tobacco) was included as a time-varying covariate (user of any other product versus non-user). To determine if past 30-day hookah use served as a predictor over and above other tobacco product use behaviors, all tobacco product variables were lagged to the previous wave at which individuals participated.

In addition, risk-taking behaviors as assessed by sensation seeking and impulsivity scores were also included, as previous research indicates that both variables are associated with use of ENDS (Case et al., 2017) and other tobacco products in young adults (Spillane, Smith, & Kahler, 2010). Furthermore, there is research to suggest that risk taking personality characteristics may underlie other factors that are associated with tobacco use behaviors such as peer tobacco use, attitudes, and harm perceptions (Banerjee & Greene, 2009; Doran et al., 2011; Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002). Sensation seeking was assessed using the Brief Sensation Seeking Scale 4, which consists of four items (e.g. “I like to do frightening things”) with four-point response options ranging from “strongly disagree” to “strongly agree” (Stephenson, Hoyle, Palmgreen, & Slater, 2003). Impulsivity was assessed using three items from the Substance Use Risk Profile Scale (e.g. “I usually act without stopping to think”) with four-point response options ranging from “strongly disagree” to “strongly agree” (Woicik, Stewart, Pihl, & Conrod, 2009). Mean scores were generated for both variables; higher scores reflect higher levels of sensation seeking and impulsivity. Both variables were treated as time-varying covariates and were lagged to the previous wave at which individuals participated.

2.4. Statistical analyses

First, Chi-Square analyses and t-tests were conducted to examine differences in demographic characteristics, tobacco use behaviors, impulsivity and sensation-seeking scores by initiation status for the outcome variables of interest. Two separate discrete-time survival analyses were then used to test study hypotheses and model the associations between past 30-day hookah use at the previous wave at which individuals participated (“previous wave”) and subsequent initiation of 1) other combustible tobacco product use, and 2) ENDS use after controlling for covariates. In order to assess our hypotheses, past 30-day hookah use was lagged to the previous wave for both models. Multilevel discrete-time hazard models were fit using Stata’s *melogit* command (Singer & Willett, 2003). Data were structured using the person-period format, and five dummy variables for each time period were included in the models. To account for school-level clustering, college was included as a random effect for both models.

3. Results

3.1. Other combustible tobacco use

As shown in Table 1, a significantly higher proportion of Wave 1 past 30-day hookah and ENDS users initiated other combustible tobacco use by Wave 6 as compared to non-users ($p < .001$). Those who initiated other combustible product use scored significantly higher on

both sensation seeking and impulsivity as compared to those who did not initiate use ($p < .001$).

The life table (Table 2) demonstrates the number of new initiators of other combustible tobacco products at each of the six survey waves. By Wave 6, 24% of Wave 1 non-other combustible tobacco product users had initiated use. The Kaplan-Meier Curves presented in Fig. 1 depict the proportion of non-other combustible tobacco products users at Wave 1 who became users at each wave by hookah use status. From the graph, it is evident that, at each wave, a higher proportion of past 30-day hookah users initiated other combustible tobacco use as compared to non-hookah users.

Results for the discrete-time survival analyses are presented in Table 3. After controlling for covariates, past 30-day hookah use at the previous wave was associated with significantly higher odds of initiating other combustible tobacco product use (Adjusted Odds Ratio “AOR” = 3.27, 95% CI = 2.37, 4.51). Significant covariates that were positively associated with initiating other combustible product use include other tobacco product use and higher sensation seeking and impulsivity scores. Each of the time intervals were inversely associated with initiation of other combustible tobacco product use indicating that, as time went on, the odds of initiating use among non-users decreased.

3.2. ENDS use

As shown in Table 1, among non-ENDS users at Wave 1, a higher percentage of those who initiated ENDS use by Wave 6 were male, and past 30-day users of hookah and other combustible products at Wave 1 as compared to those who did not initiate ENDS use. In addition, ENDS initiators reported significantly higher sensation seeking and impulsivity scores as compared to non-initiators ($p < .001$).

The prevalence of new initiators of ENDS products is presented in Table 2. By Wave 6, 24% of non-ENDS users at Wave 1 had initiated use. The Kaplan-Meier Curves presented in Fig. 1 depict the proportion of non-ENDS users at Wave 1 who became users at each wave by hookah use status. Similar to initiation of other combustible tobacco products, a higher proportion of past 30-day hookah users initiated ENDS use as compared to non-hookah users.

Results for the ENDS discrete-time survival analysis are presented in Table 3. Past 30-day hookah use at the previous wave predicted ENDS use initiation after controlling for covariates (AOR = 2.60, 95% CI = 2.04, 3.76). Significant covariates that were positively associated with ENDS initiation include other tobacco product use and higher sensation seeking and impulsivity scores. Similar to the results for other combustible tobacco use, each time interval was inversely associated with ENDS use initiation.

4. Discussion

This study is one of the first to examine hookah use as a predictor of initiation of other combustible tobacco product and ENDS among college students. Consistent with our hypotheses, past 30-day hookah use at the previous wave at which individuals participated

was associated with increased odds of initiating both other combustible tobacco products (cigarettes and cigars) and ENDS products during the study period. These results provide preliminary indication that hookah use may prime individuals to use other tobacco products. We hypothesize that there are several mechanisms through which hookah use may lead to other combustible tobacco product and ENDS use, including: nicotine dependence, similar product characteristics, and shared underlying risk factors.

The findings that hookah use was a significant predictor of the initiation of other combustible tobacco and ENDS products may be explained, in part, by the role of nicotine dependence. In a study comparing exposure to nicotine, tar, and carbon monoxide smoke from a single session of hookah versus conventional cigarette use, researchers found that hookah users had 1.7 times higher cumulative nicotine levels as compared to cigarette smokers. The reason for this higher exposure is due to the longer length of a typical hookah session relative to smoking a single cigarette (45 min versus 5 min) (Eissenberg & Shihadeh, 2009). Given the potential for high levels of nicotine exposure from hookah use, regular users may become dependent on nicotine and then transition to other tobacco/ENDS product use for a variety of reasons, including the limited portability of hookah and the cost of use, among others (Watkins et al., 2018). As noted by Heinz et al. (2013), a majority of college student users (54.4%) reported that they sometimes or always use hookah in a bar setting. Ultimately, regular use may be cost prohibitive for those who obtain their hookah from a “hookah bar” (Kassem et al., 2015) and those who use hookah on a more regular basis may switch to other more portable types of tobacco products.

With respect to our findings on the association between hookah and ENDS use initiation, the products share several characteristics that may explain study findings. Unlike other tobacco products, such as cigarettes, which are only available in tobacco or menthol flavors, both hookah and ENDS are available in a wide range of flavors which are particularly attractive to youth and young adults (Harrell et al., 2017; Nakkash, Khalil, & Afifi, 2011; Schubert, Luch, & Schulz, 2013; Zhu et al., 2014). In addition, given that tobacco smoke from hookah passes through water prior to inhalation (Maziak, 2011) and the nicotine from ENDS is not burned tobacco but a nicotine liquid that is inhaled as an aerosol (Grana, Benowitz, & Glantz, 2014), both methods are less harsh to the user than smoked tobacco. Therefore, hookah use may ease individuals into other tobacco use and they may transition to other products that share similar characteristics (flavors and less harsh smoke) such as ENDS.

Finally, the *common liability model* posits that there are similar clusters of personality, behavioral, and/or biological characteristics that influence the use of multiple substances (Creamer, Wilkinson, Hoelscher, & Kelder, 2017; Vanyukov et al., 2012). As noted in studies examining the transition from hookah to cigarette smoking among adolescent populations (Soneji et al., 2015; Watkins et al., 2018), one possible explanation is that these individuals share an underlying risktaking personality that may predispose them to use a variety of substances, including tobacco. Therefore, individuals who use hookah and then transition to other tobacco/ENDS use may do so as the result of a wide-range of factors that may predispose individuals to use multiple products. In addition to these intrapersonal factors, environmental factors, such as friends’ use or ease of access to tobacco/ENDS products may support the transition from hookah to other products (Jaber et al., 2015;

Watkins et al., 2018). Future research should further investigate potential mechanisms through which hookah use may lead to other tobacco or nicotine product use, including examining common genetic, biological, and environmental factors that may influence poly tobacco use.

4.1. Strengths and limitations

Our study builds upon the limited research investigating hookah use as a predictor of future tobacco use among college students (Doran et al., 2015; Fielder et al., 2013) in several ways. First, the previous research has been limited to examining hookah use at one *static* point in time as a predictor of future tobacco use. Specifically, Doran et al. (2015) examined baseline hookah use as a predictor of conventional cigarette use six months later, while Fielder et al. (2013) examined pre-college hookah use as a predictor of cigarette use during the first year of college. This is a notable limitation as college is a time of experimentation and previous research does not adequately account for individuals who initiate hookah use during college and then subsequently initiate other tobacco products. Furthermore, the current study also explored the association between hookah use and initiation of other tobacco products, including ENDS, not limited to conventional cigarettes. Research indicates that polytobacco and alternative tobacco use are particularly prevalent among college students (Butler, Ickes, Rayens, Wiggins, & Hahn, 2015; Loukas et al., 2016), therefore, limiting the analyses to those who initiate conventional cigarette smoking may miss those individuals who initiate other types of tobacco use. Finally, this is the first study to date to examine hookah use as a predictor of subsequent initiation of ENDS. Examining this association is particularly important as ENDS use has increased precipitously, particularly among young adults, since they were first introduced to the U.S. market in 2007. In addition, ENDS use is problematic as the long-term consequences of use are not known.

There are several limitations to the current study that warrant discussion. First, we analyzed the association between past 30-day hookah use and initiation of other combustible tobacco and ENDS products, however, we do not know if individuals transitioned to continued use of the other products, became multiple product users, or tried the other tobacco products once and discontinued use. Future research is needed to determine the trajectory of hookah use and whether initiators of other products become sustained users. Furthermore, given the nature of past 30-day use, an individual could cycle in and out of “current use”; participants could be past 30-day users at one wave and then discontinue use at the next wave. Therefore, more research is needed that examines other measures of frequency of use (days used in the past 30 days, sustained use, etc.) to examine if more frequent users of hookah are at an increased risk of initiation of other products.

4.2. Conclusions and implications

Results of the current study have important implications for future research and tobacco use intervention campaigns. First, our findings suggest that hookah use may prime individuals for other tobacco product use, which is alarming due to the harmful consequences of tobacco use (U.S. Department of Health and Human Services, 2014). In addition, while the current study did not examine whether hookah users used other tobacco/ENDS products in conjunction with hookah, or if they transitioned to the other products, the potential use of

multiple tobacco products warrants concern. Multiple tobacco product use may lead to an increased risk of nicotine dependence (Loukas et al., 2016; Post, Gilljam, Rosendahl, Bremberg, & Galanti, 2010; Soneji, Sargent, & Tanski, 2016), which is associated with greater difficulty in ultimately quitting tobacco use. Future research should examine if hookah users who initiate other tobacco products use those products in conjunction with hookah or if they switch completely to other products.

Acknowledgments

Role of funding sources

Research reported in this publication was supported by grant number [1 P50 CA180906] from the National Cancer Institute and the FDA Center for Tobacco Products (CTP). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or the Food and Drug Administration. NIH/FDA had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript, or the decision to submit the paper for publication.

References

- American College Health Association (2016). American college health association-national college health assessment II: Reference group executive summary spring 2016. Hanover, MD: American College Health Association.
- Arnett JJ (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *The American Psychologist*, 55(5), 469–480. [PubMed: 10842426]
- Banerjee SC, & Greene K (2009). Sensation seeking and adolescent cigarette smoking: Examining multiple pathways in cross-sectional data. *The Open Addiction Journal*, 2, 12–20.
- Berg CJ, Stratton E, Schauer GL, Lewis M, Wang Y, Windle M, & Kegler M (2015). Perceived harm, addictiveness, and social acceptability of tobacco products and marijuana among young adults: Marijuana, hookah, and electronic cigarettes win. *Substance Use & Misuse*, 50(1), 79–89. 10.3109/10826084.2014.958857. [PubMed: 25268294]
- Butler KM, Ickes MJ, Rayens MK, Wiggins AT, & Hahn EJ (2015). Poly tobacco use among college students. *Nicotine & Tobacco Research*, 18(2), 163–169. 10.1093/ntr/ntv056. [PubMed: 25770131]
- Case KR, Loukas A, Harrell MB, Wilkinson AV, Springer AE, Perez A, Perry CL (2017). The association between sensation seeking and e-cigarette use in Texas young adults: A cross-sectional study. *Journal of American College Health*, 65(4), 277–285. 10.1080/07448481.2017.1282487. [PubMed: 28095126]
- Corey CG, Holder-Hayes E, Nguyen AB, Delnevo CD, Rostron BL, Bansal-Travers M, Pearson JL (2017). US adult cigar smoking patterns, purchasing behaviors, and reasons for use according to cigar type: Findings from the Population Assessment of Tobacco and Health (PATH) Study, 2013–2014. *Nicotine & Tobacco Research*, 10.1093/ntr/ntx209.
- Creamer M, Wilkinson A, Hoelscher D, & Kelder S (2017). Special issue introduction: Youth at risk. *Journal of Applied Research on Children*, 8(2), 6.
- Creamer MR, Loukas A, Li X, Pasch KE, Case K, Crook B, & Perry CL (2016). College students' perceptions and knowledge of hookah use. *Drug and Alcohol Dependence*, 168, 191–195. <https://doi.org/10.1016/j.drugalcdep.2016.09.004>. [PubMed: 27689508]
- Doran N, Godfrey KM, & Myers MG (2015). Hookah use predicts cigarette smoking progression among college smokers. *Nicotine & Tobacco Research*, 17(11), 1347–1353. 10.1093/ntr/ntu343. [PubMed: 25586774]
- Doran N, Sanders PE, Bekman NM, Worley MJ, Monreal TK, McGee E, ... Brown SA (2011). Mediating influences of negative affect and risk perception on the relationship between sensation seeking and adolescent cigarette smoking. *Nicotine & Tobacco Research*, 13(6), 457–465. 10.1093/ntr/ntn025. [PubMed: 21436297]

- Eissenberg T, & Shihadeh A (2009). Waterpipe tobacco and cigarette smoking: Direct comparison of toxicant exposure. *American Journal of Preventive Medicine*, 37(6), 518–523. <https://doi.org/10.1016/j.amepre.2009.07.014>. [PubMed: 19944918]
- Fielder RL, Carey KB, & Carey MP (2013). Hookah, cigarette, and marijuana use: A prospective study of smoking behaviors among first-year college women. *Addictive Behaviors*, 38(11), 2729–2735. <https://doi.org/10.1016/j.addbeh.2013.07.006>. [PubMed: 23934004]
- Grana R, Benowitz N, & Glantz SA (2014). E-cigarettes: A scientific review. *Circulation*, 129(19), 1972–1986. 10.1161/CIRCULATIONAHA.114.007667. [PubMed: 24821826]
- Harrell MB, Weaver SR, Loukas A, Creamer MR, Marti CN, Jackson CD, ... Pechacek TF (2017). Flavored e-cigarette use: Characterizing youth, young adult, and adult users. *Preventive Medicine Reports*, 5, 33–40. <https://doi.org/10.1016/j.pmedr.2016.11.001>. [PubMed: 27896041]
- Heinz AJ, Giedgowd GE, Crane NA, Veilleux JC, Conrad M, Braun AR, ... Kassel JD (2013). A comprehensive examination of hookah smoking in college students: Use patterns and contexts, social norms and attitudes, harm perception, psychological correlates and co-occurring substance use. *Addictive Behaviors*, 38(11), 2751–2760. <https://doi.org/10.1016/j.addbeh.2013.07.009>. [PubMed: 23934006]
- Hoyle RH, Stephenson MT, Palmgreen P, Lorch EP, & Donohew RL (2002). Reliability and validity of a brief measure of sensation seeking. *Personality and Individual Differences*, 32(3), 401–414.
- Jaber R, Madhivanan P, Veledar E, Khader Y, Mzayek F, & Maziak W (2015). Waterpipe a gateway to cigarette smoking initiation among adolescents in Irbid, Jordan: A longitudinal study. *The International Journal of Tuberculosis and Lung Disease*, 19(4), 481–487. [PubMed: 25860006]
- Jarrett T, Blossnich J, Tworek C, & Horn K (2012). Hookah use among U.S. college students: Results from the national college health assessment II. *Nicotine & Tobacco Research*, 14(10), 1145–1153. 10.1093/ntr/nts003. [PubMed: 22318687]
- Kassem NO, Jackson SR, Boman-Davis M, Liles S, Dafifa RM, Yasmin R, ... Hovell MF (2015). Hookah smoking and facilitators/barriers to lounge use among students at a U.S. university. *American Journal of Health Behavior*, 39(6), 832–848. <https://doi.org/10.5993/AJHB.39.6.11>. [PubMed: 26450551]
- Latimer LA, Batanova M, & Loukas A (2014). Prevalence and harm perceptions of various tobacco products among college students. *Nicotine & Tobacco Research*, 16(5), 519–526. <https://doi.org/10.1093/ntr/ntt174>. [PubMed: 24212764]
- Loukas A, Chow S, Pasch KE, Li X, Hinds JT, III, Marti CN, Perry CL (2016). College students' polytobacco use, cigarette cessation, and dependence. *American Journal of Health Behavior*, 40(4), 514–522. 10.5993/AJHB.40.4.13. [PubMed: 27338998]
- Maziak W (2011). The global epidemic of waterpipe smoking. *Addictive Behaviors*, 36(1–2), 1–5. <https://doi.org/10.1016/j.addbeh.2010.08.030>. [PubMed: 20888700]
- Miech RA, Johnston LD, O'Malley PM, Bachman JG, & Schulenberg JE (2016). Monitoring the future national survey results on drug use, 1975–2015: Overview, key findings on adolescent drug use. Ann Arbor, MI: Institute for Social Research, The University of Michigan.
- Nakkash RT, Khalil J, & Afifi RA (2011). The rise in narghile (shisha, hookah) waterpipe tobacco smoking: A qualitative study of perceptions of smokers and non smokers. *BMC Public Health*, 11, 315 10.1186/1471-2458-11-315. [PubMed: 21569577]
- Post A, Gilljam H, Rosendahl I, Bremberg S, & Galanti MR (2010). Symptoms of nicotine dependence in a cohort of Swedish youths: A comparison between smokers, smokeless tobacco users and dual tobacco users. *Addiction*, 105(4), 740–746. 10.1111/j.1360-0443.2009.02852.x. [PubMed: 20148785]
- Schubert J, Luch A, & Schulz TG (2013). Waterpipe smoking: Analysis of the aroma profile of flavored waterpipe tobaccos. *Talanta*, 115, 665–674. 10.1016/j.talanta.2013.06.022. [PubMed: 24054646]
- Singer JD, & Willett JB (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. New York, NY: Oxford University Press.
- Soneji S, Sargent J, & Tanski S (2016). Multiple tobacco product use among U.S. adolescents and young adults. *Tobacco Control* 25(2), 174–180. 10.1136/tobaccocontrol-2014-051638. [PubMed: 25361744]

- Soneji S, Sargent JD, Tanski SE, & Primack BA (2015). Associations between initial water pipe tobacco smoking and snus use and subsequent cigarette smoking: Results from a longitudinal study of US adolescents and young adults. *JAMA Pediatrics*, 169(2), 129–136. [PubMed: 25485959]
- Spillane NS, Smith GT, & Kahler CW (2010). Impulsivity-like traits and smoking behavior in college students. *Addictive Behaviors*, 35(7), 700–705. [PubMed: 20381971]
- Sutfin EL, McCoy TP, Reboussin BA, Wagoner KG, Spangler J, & Wolfson M (2011). Prevalence and correlates of waterpipe tobacco smoking by college students in North Carolina. *Drug and Alcohol Dependence*, 115(1-2), 131–136. 10.1016/j.drugalcdep.2011.01.018. [PubMed: 21353750]
- U.S. Department Health and Human Services (2012). Preventing tobacco use among youth and young adults: A report of the surgeon general Atlanta, GA: Centers for disease control and prevention, national center for chronic disease prevention and health promotion. Office on smoking and health.
- U.S. Department of Health and Human Services (2014). The health consequences of smoking—50 years of progress: A report of the surgeon general. Atlanta, GA: National center for chronic disease prevention and health promotion. Office on smoking and health.
- Vanyukov MM, Tarter RE, Kirillova GP, Kirisci L, Reynolds MD, Kreek MJ, ... Bierut L (2012). Common liability to addiction and “gateway hypothesis”: Theoretical, empirical and evolutionary perspective. *Drug and Alcohol Dependence*, 123, S3–S17. <https://doi.org/10.1016/j.drugalcdep.2011.12.018>. [PubMed: 22261179]
- Watkins SL, Glantz SA, & Chaffee BW (2018). Association of noncigarette tobacco product use with future cigarette smoking among youth in the Population Assessment of Tobacco and Health (PATH) Study, 2013–2015. *JAMA Pediatrics*, 172(2), 181–187. 10.1001/jamapediatrics.2017.4173. [PubMed: 29297010]
- Waziry R, Jawad M, Bailout RA, Al Akel M, & Akl EA (2017). The effects of waterpipe tobacco smoking on health outcomes: An updated systematic review and meta-analysis. *International Journal of Epidemiology*, 46(1), 32–43. 10.1093/ije/dyw021. [PubMed: 27075769]
- White HR, Bray BC, Fleming CB, & Catalano RF (2009). Transitions into and out of light and intermittent smoking during emerging adulthood. *Nicotine & Tobacco Research*, 11(2), 211–219. 10.1093/ntr/ntn017. [PubMed: 19246434]
- Woicik PA, Stewart SH, Pihl RO, & Conrod PJ (2009). The substance use risk profile scale: A scale measuring traits linked to reinforcement-specific substance use profiles. *Addictive Behaviors*, 34(12), 1042–1055. [PubMed: 19683400]
- Zhu S-H, Sun JY, Bonnevie E, Cummins SE, Gamst A, Yin L, & Lee M (2014). Four hundred and sixty brands of e-cigarettes and counting: Implications for product regulation. *Tobacco Control* 23(Suppl. 3), iii3–iii9. [PubMed: 24935895]

HIGHLIGHTS

- Few studies have examined hookah use as a predictor of other tobacco product use.
- Hookah use predicted the subsequent initiation of other combustible tobacco products.
- Hookah use predicted subsequent initiation of ENDS among Texas college students.
- Hookah may prime individuals to use tobacco products, including emergent products.

Fig. 1.
Kaplan Meier Curves.

Table 1:

Descriptive Statistics of Non-initiators and Initiators of Other Combustible Tobacco and ENDS Products.

Non-other combustible tobacco users at Wave 1 (<i>n</i> = 2355)					Non-ENDS users at Wave 1 (<i>n</i> = 2590)				
Wave 1 Variables	All non-other combustible tobacco users (<i>n</i> = 2355) <i>n</i> (%)/ <i>m</i> (sd)	Non-initiators (<i>n</i> = 1881)	Initiators (<i>n</i> = 474)	<i>p</i> -value ^{<i>a</i>}	Wave 1 Variables	All non-ENDS users (<i>n</i> = 2590) <i>n</i> (%)/ <i>m</i> (sd)	Non-initiators (<i>n</i> = 1997)	Initiators (<i>n</i> = 593)	<i>p</i> -value ^{<i>a</i>}
Gender					Gender				
Male	741 (31.5)	575 (30.6)	166 (35.0)	0.06	Male	869 (33.5)	645 (32.3)	224 (37.8)	0.01
Female	1614 (68.5)	1306 (69.4)	308 (65.0)		Female	1721 (66.5)	1352 (67.7)	369 (62.2)	
Race					Race				
White	738 (31.3)	587 (31.2)	151 (31.9)	0.14	White	879 (33.9)	689 (34.5)	190 (32.0)	0.15
Hispanic	639 (27.1)	498 (26.5)	141 (29.7)		Hispanic	723 (27.9)	538 (26.9)	185 (31.2)	
African American	214 (9.1)	165 (8.8)	49 (10.3)		African American	219 (8.5)	169 (8.5)	50 (8.4)	
Asian	581 (24.7)	484 (25.7)	97 (20.5)		Asian	577 (22.3)	459 (23.0)	118 (19.9)	
Other	183 (7.8)	147 (7.8)	36 (7.6)		Other	192 (7.4)	142 (7.1)	50 (8.4)	
Age	19.7 (1.6)	19.7 (1.6)	19.6 (1.6)	0.31	Age	20.0 (1.8)	20.0 (1.8)	20.2 (2.0)	0.01
College Type					College Type				
Two-year	146 (6.2)	124 (6.6)	22 (4.6)	0.11	Two-year	171 (6.6)	132 (6.6)	39 (6.6)	0.98
Four-year	2209 (93.8)	1757 (93.4)	452 (95.4)		Four-year	2419 (93.4)	1865 (93.4)	554 (93.4)	
Hookah Use					Hookah Use				
Non-user	2227 (94.6)	1813 (96.4)	414 (87.3)	< 0.001	Non-user	2471 (95.4)	1948 (97.6)	523 (88.2)	< 0.001
Past 30-Day User	128 (5.4)	68 (3.6)	60 (12.7)		Past 30-Day User	119 (4.6)	49 (2.5)	70 (11.8)	
Other Tobacco Use ^{<i>b</i>}					Other Tobacco Use ^{<i>c</i>}				
Non-user	2259 (95.9)	1827 (97.1)	432 (91.1)	< 0.001	Non-user	2399 (92.6)	1919 (96.1)	480 (80.9)	< 0.001
Past 30-Day User	96 (4.1)	54 (2.9)	42 (8.9)		Past 30-Day User	191 (7.4)	78 (3.9)	107 (19.1)	
Sensation Seeking ^{<i>d</i>}	3.07 (0.94)	3.02 (0.92)	3.27 (0.99)	< 0.001	Sensation Seeking	3.09 (0.96)	3.03 (0.96)	3.31 (0.94)	< 0.001
Impulsivity ^{<i>d</i>}	2.11 (0.89)	2.07 (0.86)	2.25 (0.98)	< 0.001	Impulsivity	2.10 (0.98)	2.06 (0.87)	2.23 (0.96)	< 0.001

M = mean, sd = standard deviation.

^{*a*} *p*-value for difference in non-initiators versus initiators.^{*b*} Current use of ENDS or smokeless tobacco;^{*c*} Current use of cigarettes, cigar products, or smokeless tobacco.

d mean score of four items measured on a 1 (strongly disagree) to 4 (strongly agree) scale.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 2:

Life Table Depicting the Proportion of Initiators of Other Combustible Tobacco and ENDS Products at Each Time Period.

Other combustible tobacco products (cigarettes and cigar products)						
Survey wave	Interval period	Number entering interval	Number of initiators	Cumulative proportion of initiators (95% CI)	Cumulative proportion of non-initiations (95% CI)	Hazard ratio (95% CI)
2	1, 2	2339	149	0.06 (0.06, 0.08)	0.94 (0.92, 0.94)	0.07 (0.06, 0.08)
3	2, 3	2144	90	0.10 (0.09, 0.12)	0.90 (0.88, 0.91)	0.04 (0.03, 0.05)
4	3, 4	2016	88	0.14 (0.13, 0.16)	0.86 (0.84, 0.87)	0.05 (0.04, 0.05)
5	4, 5	1868	74	0.18 (0.16, 0.19)	0.82 (0.81, 0.84)	0.04 (0.03, 0.05)
6	5, 6	1742	73	0.24 (0.22, 0.27)	0.76 (0.73, 0.78)	0.08 (0.06, 0.10)
ENDS products						
2	1, 2	2557	197	0.08 (0.07, 0.09)	0.92 (0.91, 0.93)	0.08 (0.07, 0.09)
3	2, 3	2312	130	0.13 (0.12, 0.14)	0.87 (0.86, 0.88)	0.06 (0.05, 0.07)
4	3, 4	2144	129	0.18 (0.17, 0.20)	0.82 (0.80, 0.83)	0.06 (0.05, 0.07)
5	4, 5	1952	62	0.21 (0.19, 0.22)	0.79 (0.78, 0.81)	0.03 (0.02, 0.04)
6	5, 6	1835	75	0.24 (0.22, 0.26)	0.76 (0.74, 0.78)	0.04 (0.03, 0.05)

Table 3:

Discrete Survival Analyses of Initiation of Other Combustible Tobacco and ENDS Product Use.

Initiation of other combustible tobacco use				Initiation of ENDS use			
Variable	Adjusted odds ratio	95% CI	p-Value	Variable	Adjusted odds ratio	95% CI	p-Value
Hookah Use (W-1)				Hookah Use (W-1)			
Non-user (reference)	1	–		Non-user (reference)	1	–	
Past-30 Day User	3.27	2.37, 4.51	< 0.001	Past-30 Day User	2.60	1.92, 3.53	< 0.001
Other Tobacco Use (W-1) ^a				Other Tobacco Use (W-1) ^b			
Non-user (reference)	1			Non-user (reference)	1		
Past-30 Day User	2.46	1.69, 3.59	< 0.001	Past-30 Day User	4.56	3.56, 5.85	< 0.001
Gender				Gender			
Male (reference)	1			Male (reference)	1		
Female	0.84	0.68, 1.02	0.09	Female	0.90	0.75, 1.08	0.27
Race				Race			
White (reference)	1	–		White (reference)	1	–	
Hispanic	0.99	0.77, 1.26	0.96	Hispanic	1.15	0.92, 1.44	0.23
African American	1.24	0.88, 1.74	0.22	African American	1.00	0.70, 1.43	1.00
Asian	0.63	0.48, 0.83	0.001	Asian	0.88	0.69, 1.14	0.33
Other	0.78	0.53, 1.16	0.22	Other	1.22	0.87, 1.70	0.25
Age	0.98	0.92, 1.05	0.60	Age	1.03	0.98, 1.08	0.27
College Type				College Type			
Two-year (reference)	1	–		Two-year (reference)	1	–	
Four-year	1.34	0.85, 2.12	0.20	Four-year	0.97	0.66, 1.43	0.88
Sensation Seeking (W-1)	1.26	1.12, 1.41	< 0.001	Sensation Seeking (W-1)	1.15	1.04, 1.27	0.007
Impulsivity (W-1)	1.14	1.02, 1.27	0.02	Impulsivity (W-1)	1.12	1.02, 1.24	0.02
Time Interval				Time Interval			
Period 1	0.03	0.008, 0.13	< 0.001	Period 1	0.02	0.008, 0.08	< 0.001
Period 2	0.02	0.004, 0.08	< 0.001	Period 2	0.02	0.006, 0.05	< 0.001
Period 3	0.02	0.005, 0.08	< 0.001	Period 3	0.02	0.006, 0.06	< 0.001
Period 4	0.02	0.005, 0.08	< 0.001	Period 4	0.01	0.003, 0.03	< 0.001
Period 5	0.02	0.005, 0.08	< 0.001	Period 5	0.01	0.004, 0.04	< 0.001

W-1 = 1 wave prior to tobacco use behavior, CI = Confidence Interval, Bolded indicates significance.

^aCurrent use of ENDS or smokeless tobacco;^bCurrent use of cigarettes, cigar products, or smokeless tobacco.