

# Initiation, Progression, and Sustained Waterpipe Use: A Nationally Representative Longitudinal Study of U.S. Young Adults

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## Abstract

**Background:** Waterpipe tobacco smoking (WTS) is increasing in popularity despite evidence of harm and potential for dependence. Intervention development has been hampered by a lack of longitudinal, nationally representative data on usage patterns and factors independently associated with WTS initiation. Therefore, we aimed to characterize key transitions between WTS states in a nationally representative group of young adults, with particular attention to factors independently associated with initiation.

**Methods:** Participants were randomly selected from a national probability-based panel representing 97% of the United States. A total of 1,785 adults ages 18 to 30 at baseline completed two Web-based surveys 18 months apart in 2013 and 2014. Assessments included knowledge of waterpipe tobacco smoke composition, positive and negative attitudes toward WTS, normative beliefs, intention to use waterpipe, and WTS behavior. We used multivariable logistic regression to assess the association between predictive factors and subsequent WTS initiation.

**Results:** In fully adjusted models, overall knowledge about toxicants associated with WTS was not associated with subsequent WTS initiation. Similarly, negative attitudes and normative beliefs were not associated with WTS uptake. However, baseline positive attitudes were strongly and significantly associated with WTS initiation [adjusted OR (AOR) = 1.7; 95% confidence interval (CI), 1.2–2.3]. Similarly, baseline intention to use WTS was strongly associated with subsequent initiation (AOR = 7.0; 95% CI, 3.5–13.7).

**Conclusions:** Prevention efforts may be most successful if they target individuals with clear intentions to use WTS and challenge positive attitudes surrounding WTS.

**Impact:** Surveillance of WTS trajectories will help inform health care and policy surrounding this emerging risk behavior among U.S. young adults. *Cancer Epidemiol Biomarkers Prev*; 26(5); 748–55. ©2017 AACR.

## Introduction

As traditional cigarette smoking rates decrease in the United States (1), rates of new and emerging tobacco and nicotine product use have been steadily increasing (2). This includes waterpipe tobacco smoking (WTS, or "hookah"), which is increasingly popular among adolescent and young adult populations (3, 4). Although the FDA declared its intention to regulate WTS starting on August 8, 2016 (5), WTS remains exempt from many tobacco control policies (6). Moreover, the popular perception remains that WTS is a fun, relaxing, social activity with few negative associations and repercussions (7, 8). These beliefs and attitudes are concerning given our increasing understanding of the association of WTS with negative health effects, such as cancer,

cardiovascular disease, and decreased pulmonary function (9), and potential for dependence (10).

There are three major gaps in the literature that hinder our ability to optimally intervene in this area. First, little is known regarding transitions between various WTS usage states over time. For example, although current cigarette smokers (usually defined as having use at least once in the past 30 days; ref. 11) tend to remain current users, these patterns have not been established regarding WTS. It would be valuable to obtain a more nuanced picture of transitions between various stages of WTS to tailor interventions in terms of timing. Related to this, it will be beneficial to conduct longitudinal studies with longer follow-up periods than have been conducted in the past. To our knowledge, the highest quality longitudinal study was conducted over 6 months (12).

Second, there is a need for better understanding of initiation of WTS, which is generally defined as the transition from never use to ever use. Rates of WTS initiation among U.S. late adolescents and young adults are between 13% and 23%, and factors associated with WTS initiation are not clearly understood (13–15). One established factor that has been clearly associated with WTS initiation is other substance use at baseline; these associations are well-grounded in theory, and the empiric evidence base is strong (12, 15). However, what is not established is whether there are associations between baseline theory-based perceptual predictors, such as knowledge, attitudes, normative beliefs, and intentions, and subsequent initiation, as

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**doi:** 10.1158/1055-9965.EPI-16-0687-T

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would be predicted by relevant conceptual models (16). For example, some prior research suggests negative attitudes toward WTS protect against WTS initiation (13), whereas other studies suggest there may be more influence for positive attitudes and normative beliefs (12, 13). Likewise, studies examining knowledge of the harmful components of waterpipe tobacco and effects on WTS are inconclusive (13, 17). It will be important to elucidate associations between these types of predictive factors and initiation, because this will directly influence subsequent educational and policy initiatives.

Third, it is now important to conduct high-quality studies of WTS with large, nationally representative samples that include a broad cohort of emerging adults. Although research to date has been extremely valuable, the vast majority of it has been localized with limited external generalizability. In addition, emerging adulthood is increasingly recognized as a crucial time for the development and consolidation of lifelong habits and addictions (18). Although many studies have involved emerging adults, they have focused on college students (13, 14). Even though it is important to understand use among college students, it is also important to address these behaviors in emerging adults not in college, especially considering that other tobacco use is higher in noncollege young adults than their collegiate counterparts (19).

Therefore, we conducted a nationally representative longitudinal study of U.S. young adults over an 18-month period. We attempted to fill the specific gaps in the literature noted above by focusing on two key, specific aims. First, we aimed to characterize key transitions between WTS states (e.g., never use, ever use, and current use). Second, we aimed to assess independent associations between key predictors, such as knowledge, negative and positive attitudes, normative beliefs, and intentions and subsequent WTS initiation. On the basis of prior work in this area, we developed five *a priori* hypotheses: (i) Positive attitudes toward WTS will be associated with increased odds of WTS initiation; (ii) negative attitudes toward WTS will be associated with decreased odds of WTS initiation; (iii) favorable normative beliefs about WTS will be associated with increased odds of initiation; (iv) intention will be associated with increased odds of WTS initiation; and (v) WTS knowledge will be associated with WTS initiation.

## Materials and Methods

### Participants and procedures

Participants were members of KnowledgePanel, an online, non-volunteer access panel recruited and maintained by GfK (Growth from Knowledge, formerly Knowledge Networks). This panel was developed through both random digit dialing and address-based recruitment and was designed to be demographically representative of the U.S. population (20). At the time of the study, KnowledgePanel consisted of approximately 50,000 individuals ages 18 and older (20). Panel members are randomly selected to be invited to participate in online surveys and are supplied with e-mail addresses, computers, and Internet access if needed. However, considering the ubiquitous nature of electronic communications in today's world, facilitated access is rarely needed (20).

In March 2013, 3,254 panel members completed a baseline survey about WTS and other health behaviors. Approximately 18 months later, in October 2014, those individuals were invited to participate in the follow-up survey. Of the 3,254 individuals who

had completed the baseline survey, 2,170 were still on the panel, 878 had left the panel but were still available for contact, and 206 had left the panel and were unable to be contacted. Therefore, the follow-up survey was sent to the 3,048 individuals with updated contact information. This study was approved by the University of Pittsburgh Institutional Review Board, and all study participants gave informed consent.

### Conceptual framework

This study was guided by two relevant and complementary health behavior theories typically used to explore young adult substance use: the Theory of Reasoned Action (TRA) and the Health Belief Model (HBM). Consistent with the TRA, prior research demonstrates that those with more positive attitudes toward WTS have greater odds of current WTS, intention for future WTS, and WTS initiation, whereas those with more negative attitudes have lower odds of current WTS and WTS initiation (13, 21). Also consistent with the TRA, in a relatively small, regional sample, those with more favorable normative beliefs regarding WTS had greater odds of current WTS and WTS initiation (13, 21). These TRA constructs may in turn affect behavioral intention, which is believed to be a strong predictor of behavior (16). Indeed, self-reported intention to use tobacco products, including waterpipe tobacco, has been found to be an independent predictor of cigarette smoking initiation among young adults (22). The HBM has also been useful in understanding youth substance use, because increased perceptions related to severity and susceptibility have been associated with lower substance use (23). However, constructs such as knowledge that are part of the HBM have been inconsistently associated with outcomes related to WTS. For example, although both cross-sectional and longitudinal studies of college students have found no association between knowledge of the harmful components of waterpipe tobacco, a response of "don't know" has been shown to be protective against current WTS, intention to participate in WTS, and WTS initiation (13, 17).

### Measures

At both baseline and follow-up, we surveyed participants regarding sociodemographic factors, WTS behavior, and theory-based predictors, such as knowledge, attitudes, and normative beliefs. Both the baseline and follow-up questionnaires were extensively pretested, and median times for completion were 15 and 10 minutes, respectively.

**Sociodemographic factors.** GfK maintains a database of key demographic information about panel members, including age, sex, race/ethnicity, household income, and level of education. To supplement this information, we included items to assess living situation and relationship status.

**WTS behavior.** In the baseline survey, participants were asked to report on ever, past year, and current (i.e., within the past 30 days) WTS. Instructions immediately preceding the WTS items specifically instructed participants to answer about smoking tobacco from a hookah to differentiate from smoking other substances, such as marijuana. The term "hookah" was used instead of "waterpipe" for all WTS-related items, because it is the most common term used in the United States for this device (24). We used the WTS items to operationalize three key states of WTS. Never use was defined as answering "no" to the question, "Have

you ever smoked tobacco from a hookah?" Ever use was defined as answering "yes" to "Have you ever smoked tobacco from a hookah?" but answering "0" to "Within the past 30 days, on how many days did you smoke tobacco from a hookah?" Finally, current use was defined as smoking tobacco from a hookah at least 1 day in the past month. Participants were presented with the same items in the follow-up questionnaire. This information was used to chart the transitions between the key states of WTS. Participants who transitioned from never use to ever use or current use were defined as initiators, whereas those who transitioned from ever use to current use were defined as progressors.

**Theory-based predictors.** Attitudes toward WTS were assessed with a 6-item scale used in previous research studies (13, 21). These items asked participants whether they believed WTS was attractive, romantic, fun, relaxing, harmful, and addicting, each on a 5-point response scale (Definitely No, Probably No, Don't Know, Probably Yes, Definitely Yes). The four items assessing attitudes toward positive attributes (attractive, romantic, fun, relaxing) were grouped to reflect an overall positive attitude summary scale, whereas the two items assessing attitudes toward negative attributes (harmful, addicting) were grouped to reflect an overall negative attitude summary scale. A higher score on the positive attitude scale indicated a favorable attitude toward WTS, whereas a higher score on the negative attitude scale indicated a less favorable attitude toward WTS. Both summary scales demonstrated strong reliability (Cronbach's  $\alpha = 0.88$  and  $0.85$ , respectively).

Normative beliefs were measured in two complementary ways used in substance use research (13, 21, 25). The first asked participants to estimate the percentage of people their age that have ever smoked tobacco from a hookah, and the second asked participants to indicate how socially acceptable it is for people their age to smoke tobacco from a hookah. This item included a 4-point response scale ranging from "Very socially acceptable" to "Not socially acceptable."

WTS intention was assessed through the item, "Do you intend to smoke tobacco from a hookah at any time in the rest of your life?" The 4-item response scale for this item asked respondents to select "Definitely Yes," "Probably Yes," "Probably No," or "Definitely No." Consistent with prior research (26), for analysis, any answer other than "Definitely No" was defined as intention to participate in WTS.

Knowledge about the harmful components of waterpipe tobacco was measured using a set of items asking participants to compare smoking a single cigarette with a single hookah tobacco smoking session and estimate which contained more of the following: tar, nicotine, carcinogens, carbon monoxide, and heavy metals (13, 17). Although a typical hookah session is longer than smoking a single cigarette, this wording was used to be consistent with, and comparable with, other literature on this topic (13, 27, 28). A 4-item response scale allowed respondents to choose "Definitely Hookah," "Probably Hookah," "Probably Cigarettes," or "Definitely Cigarettes." On the basis of established research (27, 29), an answer of "Definitely Hookah" or "Probably Hookah" was considered to be correct, whereas an answer of "Definitely Cigarettes" or "Probably Cigarettes" was considered to be incorrect. Internal consistency was measured using Cronbach's  $\alpha$  and demonstrated strong reliability among items ( $\alpha = 0.87$ ).

**Analysis.** We included all individuals with complete data on the dependent variable at baseline and follow-up. Because less than

1% were excluded for incomplete data, this is unlikely to have affected results. We assessed differences in sociodemographic characteristics between responders and nonresponders using Rao- $\chi^2$  tests and Cramer's V. In addition, we calculated simple frequencies and percentages to characterize use patterns of the dependent variable from baseline to follow-up. We assessed associations between independent variables at baseline and our dependent variable at follow-up using logistic regression, adjusting for a comprehensive set of sociodemographic covariates in multivariable models. We conducted sensitivity analyses with a more parsimonious set of covariates to confirm the robustness of our results. All analyses were conducted using survey weights provided by GfK to estimate effects for the general U.S. population, as well as correct for any under- or oversampling. We defined statistical significance with a two-tailed  $\alpha$  of 0.05. Data were analyzed using Stata 14 (StataCorp; ref. 30).

## Results

### Sample characteristics

A total of 1,796 individuals completed the survey (RR = 59%). The final sample for analysis consisted of 1,785 individuals with complete data on WTS items for both baseline and follow-up. Responders and nonresponders did not significantly differ on WTS ( $P = 0.08$ ), age ( $P = 0.15$ ), sex ( $P = 0.07$ ), or race/ethnicity ( $P = 0.19$ ). Therefore, those with complete data represented the complete population in terms of basic sociodemographics. In addition, study-specific survey weights were applied to all analyses to adjust for nonresponses well as under- or oversampling.

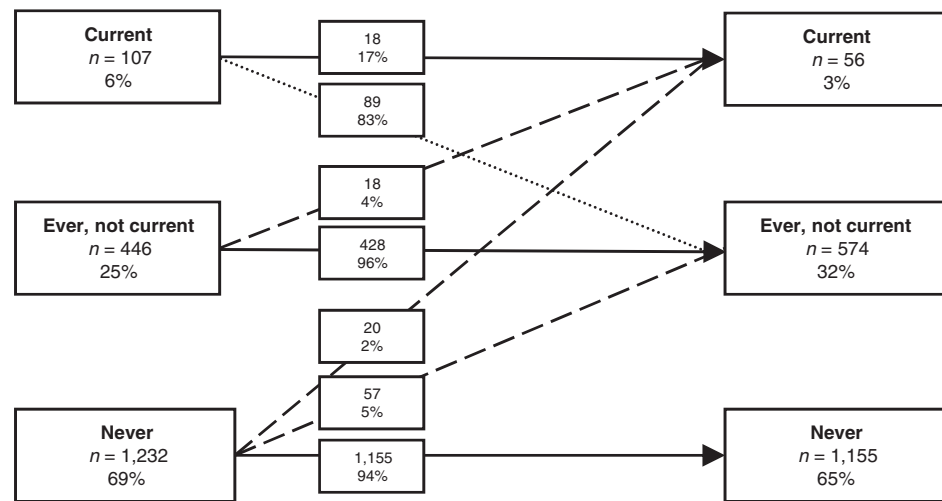
The weighted age distribution of our sample was approximately equal, with the largest group of 27 to 30 years (31%). The sample was 50% female, and just over half of the sample identified as White, non-Hispanic (57%); followed by Hispanic (22%), Black, non-Hispanic (13%); and Other (9%). In addition, half of the sample reported being single (50%), whereas a plurality reported living with a parent or guardian (40%), earning an income of \$75,000 or greater (47%), and having an education level of high school or less (43%; data not shown).

### WTS behavior

The trajectories of WTS behavior between baseline and follow-up are depicted in Fig. 1. Of the baseline never smokers ( $n = 1,232$ , 69%), 94% remained never smokers at follow-up. Similarly, 96% of ever smokers at baseline ( $n = 446$ , 25%) remained ever smokers at follow-up (i.e., they did not progress to current smoking). This is in contrast to baseline current smokers ( $n = 107$ , 6%), of whom 17% remained current smokers. Of note were the 4% of baseline ever smokers that progressed to current smoking at follow-up and were considered progressors. In addition, of the 1,232 participants reporting never WTS at baseline, 7% reported initiation at follow-up and were considered initiators.

### WTS initiation

Sociodemographic characteristics of baseline WTS nonsmokers (Table 1) are similar and consistent with whole sample characteristics. In bivariable analyses, we found significant associations between WTS initiation and race/ethnicity and yearly household income (Table 1). Those who initiated WTS were more often White, non-Hispanic individuals with an annual household income of \$30,000 to \$74,999.



**Figure 1.** Longitudinal WTS trajectories among U.S. young adults. WTS trajectories from baseline to an 18-month follow-up. Solid arrows, no change in status or the "sustainers"; dashed arrows, an increase from no or any WTS use or the "initiators" and "progressors"; and dotted arrow, a decrease in WTS use.

**Theory-based predictors of WTS initiation**

In multivariable analyses, participants with increased positive attitudes toward WTS had significantly greater odds of WTS initiation (Table 2). No significant associations were found between negative attitudes toward WTS and WTS initiation or WTS normative beliefs and WTS initiation. However, WTS inten-

tion, which was reported by 22% of baseline nonsmokers, was significantly associated with increased odds of WTS initiation [adjusted OR (AOR) = 7.0; confidence interval (CI), 3.5–13.7]. Of the five knowledge items, only the knowledge that WTS exposes the user to greater amounts of nicotine compared with cigarettes was significantly associated with WTS initiation (AOR = 2.8; CI,

**Table 1.** Sample characteristics by baseline and follow-up WTS status

Characteristics	Baseline WTS nonsmokers (n = 1,232) <sup>a</sup> n (%) <sup>b</sup>	WTS initiation		P <sup>c</sup>
		Yes (n = 77) % <sup>b</sup>	No (n = 1,155) % <sup>b</sup>	
Age, y				0.41
18–20	236 (27)	38	27	
21–23	388 (23)	20	23	
24–26	290 (19)	21	19	
27–30	318 (30)	21	31	
Sex				0.54
Female	765 (51)	47	52	
Male	467 (49)	53	48	
Race/ethnicity				0.02
White, non-Hispanic	787 (55)	36	57	
Black, non-Hispanic	135 (15)	29	14	
Hispanic	189 (19)	29	19	
Other <sup>d</sup>	121 (11)	7	11	
Relationship status				0.60
Single	592 (54)	58	53	
In a committed relationship	636 (46)	42	47	
Living situation				0.07
With a parent/guardian	428 (43)	30	44	
With a significant other	397 (28)	25	28	
Other <sup>e</sup>	405 (29)	45	28	
Yearly household income				0.04
Low (under \$30,000)	358 (20)	32	19	
Medium (\$30,000–\$74,999)	468 (36)	43	36	
High (\$75,000 or more)	406 (44)	25	45	
Education level				0.25
High school or less	386 (48)	46	49	
Some college	522 (35)	45	35	
Bachelor's degree or higher	324 (16)	9	17	

Abbreviation: y, year.

<sup>a</sup>This number includes participants who had WTS data for both baseline and follow-up.

<sup>b</sup>Individual characteristics summed may not equal the total sample size due to missing data; column percentages may not equal 100 due to rounding.

<sup>c</sup>P values were computed using Rao- $\chi^2$  tests.

<sup>d</sup>Includes multiracial.

<sup>e</sup>Defined as not living with a parent/guardian or significant other.

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**Table 2.** Bivariable and multivariable associations between attitudes, normative beliefs, intention, knowledge, and initiation of WTS

Attitude, subjective norm, and knowledge items	WTS initiation <sup>a</sup>	
	OR (95% CI)	AOR <sup>b</sup> (95% CI)
Positive attitudes <sup>c</sup>		
Hookah seems attractive	1.5 (1.1–2.1)*	1.5 (1.1–2.1)*
Hookah seems romantic	1.6 (1.1–2.3)*	1.6 (1.1–2.1)**
Hookah seems fun	1.4 (1.1–1.9)*	1.4 (1.1–1.9)**
Hookah seems relaxing	1.5 (1.1–2.0)**	1.5 (1.2–2.0)**
Overall positive attitude	1.7 (1.1–2.4)**	1.7 (1.2–2.3)**
Negative attitudes <sup>c</sup>		
Hookah seems harmful	0.8 (0.7–1.0)	0.8 (0.7–1.0)
Hookah seems addicting	0.8 (0.7–1.0)	0.8 (0.7–1.1)
Overall negative attitude	0.8 (0.7–1.0)	0.8 (0.7–1.0)
Normative beliefs		
Perceived prevalence of WTS among peers <sup>d</sup>	1.0 (0.9–1.1)	0.9 (0.8–1.1)
Perceived acceptability of WTS among peers <sup>e</sup>	1.3 (0.9–1.7)	1.3 (0.9–1.7)
Intention		
No	1.0 (Reference)	1.0 (Reference)
Yes	5.5 (2.8–11.0)***	7.0 (3.5–13.7)***
Knowledge		
Which has more tar?		
Incorrect	1.0 (Reference)	1.0 (Reference)
Correct	1.3 (0.4–4.5)	1.3 (0.4–3.8)
Which has more nicotine?		
Incorrect	1.0 (Reference)	1.0 (Reference)
Correct	2.6 (0.9–7.3)	2.8 (1.1–7.0)*
Which has more carcinogens?		
Incorrect	1.0 (Reference)	1.0 (Reference)
Correct	1.9 (0.6–6.7)	2.0 (0.6–6.2)
Which has more carbon monoxide?		
Incorrect	1.0 (Reference)	1.0 (Reference)
Correct	1.5 (0.6–4.0)	1.4 (0.5–3.6)
Which has more heavy metals?		
Incorrect	1.0 (Reference)	1.0 (Reference)
Correct	1.8 (0.7–4.7)	1.8 (0.7–4.6)
Overall knowledge score <sup>f</sup>	1.2 (0.9–1.6)	1.2 (1.0–1.6)

Abbreviation: CI, confidence interval.

Note: \* $P < .05$ ; \*\* $P < .01$ ; \*\*\* $P < .001$ .

<sup>a</sup>Only baseline waterpipe tobacco nonsmokers and those who had complete data on items assessing ever WTS were included in these analyses.

<sup>b</sup>Adjusted for age, sex, race/ethnicity, living situation, relationship status, household income, and education.

<sup>c</sup>Associated ORs represent the odds for each unit of increase in the independent variable.

<sup>d</sup>Each point on this scale corresponds with a 10-point increment in percentage.

<sup>e</sup>Responses to this item are based upon a 4-level response scale ranging from "not" to "very." Associated ORs represent the increase in odds for each unit of increase on this scale.

<sup>f</sup>The overall knowledge score was the number of items scored correct summed. Associated ORs represent the odds for each 1-point increase in the 6-point scale.

1.1–7.0). Overall knowledge was not significantly associated with WTS initiation. Sensitivity analyses using a more parsimonious set of covariates yielded consistent findings.

## Discussion

In this nationally representative longitudinal study of U.S. young adults, we found that, over an 18-month period, 4% of baseline ever smokers progressed to current smoking and that approximately 7% of baseline never smokers initiated WTS. A closer examination of WTS initiation found that positive attitudes toward WTS, knowledge of WTS-related nicotine exposure compared with cigarettes, and baseline WTS intention were significantly associated with initiation. In contrast, negative attitudes toward WTS, normative beliefs toward WTS, and knowledge of other WTS components were not significantly associated with WTS initiation.

We also found that the vast majority of baseline never smokers (94%) and ever smokers (96%) maintained their status at the 18-month follow-up. However, it is notable that the prevalence

of never smoking decreased by 4 percentage points over the 18-month period, whereas ever smoking increased by approximately 7 percentage points. This suggests that more individuals are being introduced to WTS in some capacity. In contrast to the sustained never and ever smoking, the majority of baseline current smokers (83%) reverted to ever smoking by follow-up. It is possible that some of these individuals quit WTS over the follow-up period. Indeed, in studies of U.S. waterpipe tobacco users, many have expressed intention to quit at some point in the future (31, 32). However, almost 17% of current smokers sustained their use through the 18-month period, consistent with some international studies (3). In addition, 4% of baseline ever smokers progressed to current smoking over the follow-up period. These findings suggest a potential for dependence on WTS. Some users of WTS report feeling "hooked" on WTS (33), and a recent study found that half of past year WTS users endorsed at least one dependence item on a 6-item WTS dependence scale (10).

Of the baseline nonsmokers, 7% initiated WTS at follow-up. Although this initiation rate is lower than in studies focused on college students, it is similar to the only other study of initiation

among a more general young adult population (12). A possible reason for the lower initiation rate in this study is that this sample was not limited solely to college students. College entry and progression through the initial years of college have been found to be associated with WTS (13, 15). Thus, by including noncollege populations, we may have reduced the number of higher risk individuals in our sample.

Positive attitudes toward WTS significantly predicted WTS initiation, whereas negative attitudes did not. The association between positive attitudes and WTS initiation is consistent with studies of college students (13). This is not surprising, as many U.S. waterpipe users view WTS to be a fun activity during which they can socialize, party, or relax (7). However, the lack of association between negative attitudes and WTS initiation is contrary to studies that found negative attitudes to be protective against WTS use or initiation (13, 21). This is akin to cigarette smokers, for whom negative outcome expectations of cigarette smoking may not influence the decision to start smoking (34). It is possible that, similar to some cigarette smokers, those who participate in WTS may rationalize their behavior by focusing on the positive aspects of WTS and modulating the negative aspects (35).

We also found that knowledge about greater nicotine exposure in WTS compared with cigarettes was associated with higher odds of smoking initiation. It is possible that individuals who had already begun to show interest in WTS were more knowledgeable about this fact than those who had not. Also, it is possible that the novelty and general positive appeal of WTS outweighs the knowledge of the presence of nicotine. This phenomenon has been noted among users of other non-cigarette nicotine and tobacco products, such as e-cigarettes, snus, and nicotine dissolvables (36). In a series of focus groups, about half of the young adult participants reported being willing to try the products despite knowledge of nicotine content and potential negative health effects, because they were perceived as attractive, modern, and fun (36).

The strongest association with WTS initiation was baseline intention. Those individuals who reported that they intended to smoke tobacco from a hookah at one point in the rest of their lives had approximately 7 times greater odds of initiating WTS compared with those who reported no intention to smoke tobacco from a hookah. This is especially concerning, because, consistent with other research (22), approximately one quarter of baseline nonsmokers reported an intention to initiate WTS at one point in the rest of their lives. Extrapolating this to the greater population, almost 9 million baseline nonsmokers ages 18 to 30 may have some intention to participate in WTS (2014 estimated U.S. Census population of 57,702,876  $\times$  69% baseline never smokers  $\times$  22% reporting intention; ref. 37). Considering the strong association between baseline intention to participate in WTS and subsequent initiation of WTS, it is clear that this is a ripe opportunity for primary prevention efforts among this particular age group.

Although certain theory-based predictors, which may be addressable through intervention, were associated with WTS initiation, the majority of sociodemographic factors were not. This suggests that primary prevention efforts to curb WTS initiation in the general 18- to 30-year-old population may be more effective if they address these theory-based predictors rather than focusing on any one group of individuals. This is consistent with recommendations for the college population, which also found

no association between sociodemographic factors and WTS initiation (13). However, this is in contrast to secondary prevention efforts addressing current or ever use, for which efforts may be more beneficial when focused on populations that are younger, white, and male (38). These findings provide important distinctions that can help guide targeting of interventions for future research or for the practice of health professionals.

The two strongest predictors of WTS initiation, positive attitudes and intention, may be addressed through similar prevention and intervention means. Despite the associated negative health effects and potential for addiction, WTS is still viewed as a fun, attractive social activity. This is especially true in online advertisements, where WTS is portrayed as social and pleasurable; however, health warnings or mention of nicotine content are rare (39). Likewise, studies have shown that the waterpipe tobacco industry uses questionable marketing and labeling practices, such as misleading descriptors on packaging and omission of health effects (40, 41).

This study was limited by its self-report survey design. Biochemical validation was not used to confirm WTS status. However, participants were assured of the confidentiality of their answers and had little incentive to be untruthful. This study was also limited by the fact that, despite having a large sample size, there was not enough power to fully examine factors associated with WTS progression (i.e., baseline use followed by increases). The progression from WTS experimentation to more regular use is an area that warrants deeper investigation, and future studies should seek to examine this trajectory specifically by recruiting a greater volume of baseline experimenters. Another limitation is the stem used for the knowledge item, which asked participants to compare their knowledge of toxicant exposure from a WTS session compared with smoking a single cigarette. Because a typical WTS session takes longer than smoking a single cigarette, this item could have confused participants, potentially leading them to answer incorrectly. In addition, this study examined the association between WTS initiation and certain theory-based predictors and did not include information about other substance use. Future studies may seek to examine both sets of factors simultaneously. Finally, although this study had a longitudinal design, data collection at more time points over a longer period would have yielded data that may have been amenable to more complete longitudinal analysis techniques, such as growth mixture modeling.

In conclusion, we found that almost 20% of current WTS users maintained their use through an 18-month follow-up period. We also found initiation and progression rates of 7% and 4%, respectively. Initiation was associated with certain theory-based predictors, such as positive attitudes toward WTS and intention to participate in WTS, but not most sociodemographic factors, suggesting specific targets for prevention efforts. These efforts may be most effective if they counteract positive attitudes toward WTS and intention to participate in WTS in the future.

#### Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

#### Disclaimer

The funding agency had no role in the design and conduct of the study, collection, management, analysis, and interpretation of the data, and preparation, review, or approval of the manuscript.

## Authors' Contributions

**Conception and design:** J.E. Sidani, A. Shensa, B.A. Primack  
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## Grant Support

This work was supported by the NCI at the NIH (R01-CA140150; awarded to B.A. Primack).

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Received August 29, 2016; revised November 28, 2016; accepted December 13, 2016; published OnlineFirst January 12, 2017.

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