Nicotine & Tobacco Research, Volume 16, Number 1 (January 2014) 93–99

ORIGINAL INVESTIGATION

An Observational Study of Group Waterpipe Use in a Natural Environment

Melissa D. Blank PhD[1], **Kirk Warren Brown** PhD[2], **Robert J. Goodman** MA[2], **Thomas Eissenberg** PhD[3]

[1]*Department of Psychology, Center for Neuroscience, West Virginia University, Morgantown, WV;* [2]*Department of Psychology, Virginia Commonwealth University, Richmond, VA;* [3]*Department of Psychology and Institute for Drug and Alcohol Studies, Virginia Commonwealth University, Richmond, VA*

Corresponding Author: Melissa D. Blank, PhD, Department of Psychology, Center for Neuroscience, West Virginia University, Morgantown, WV 26506-6040, USA. Telephone: 304-293-8341; Fax: 304-293-6606; E-mail: mdblank@mail.wvu.edu

Received March 24, 2013; accepted July 3, 2013

ABSTRACT

Introduction: To date research on tobacco smoking with a waterpipe (hookah, narghile, and shisha) has focused primarily on the individual user in a laboratory setting. Yet, waterpipe tobacco smoking is often a social practice that occurs in cafés, homes, and other natural settings. This observational study examined the behavior of waterpipe tobacco smokers and the social and contextual features of waterpipe use among groups in their natural environment.

Methods: Trained observers visited urban waterpipe cafés on multiple occasions during an 8-month period. Observations of 241 individual users in naturally formed groups were made on smoking topography (puff frequency, duration, and interpuff interval [IPI]) and engagement in other activities (e.g., food and drink consumption, other tobacco use, and media viewing).

Results: Most users were male in group sizes of 3–4 persons, on average, and each table had 1 waterpipe, on average. The predominant social features during observational periods were conversation and nonalcoholic drinking. Greater puff number was associated with smaller group sizes and more waterpipes per group, while longer IPIs were associated with larger group sizes and fewer waterpipes per group. Additionally, greater puff frequency was observed during media viewing and in the absence of other tobacco use.

Conclusions: Overall, the results suggest that waterpipe smoking behavior is affected by group size and by certain social activities. Discussion focuses on how these findings enhance our understanding of factors that may influence exposure to waterpipe tobacco smoke toxicants in naturalistic environments.

INTRODUCTION

Waterpipe smoking involves the inhalation of tobacco smoke after it has been drawn through water (Cobb, Ward, Maziak, Shihadeh, & Eissenberg, 2010; Knishkowy & Amitai, 2005). Though a centuries-old practice, waterpipe (hookah, narghile, and shisha) smoking appears to have increased in prevalence in the past decade (Maziak, 2011). Recent surveys demonstrate the present-day popularity of this form of tobacco use, particularly among younger populations. In Syria, 45% of university students reported having ever used a waterpipe (Maziak, Ward, Soweid, & Eissenberg, 2004), and in Lebanon, 23%–30% reported weekly waterpipe use (e.g., Chaaya et al., 2004; Tamim et al., 2003). In the United States, 15%–48% of university students recently reported lifetime use and 9.5%–20% reported past 30-day use (Eissenberg, Ward, Smith-Simone, & Maziak, 2008; Primack, Fertman, Rice, Adachi-Mejia, & Fine, 2010; Primack et al., 2013; Smith, Curbow, & Stillman, 2007; Sutfin et al., 2011). Likewise, among 12th graders in the United States, the percentage reporting past-year waterpipe use increased from 17% in 2010 to 18.5% in 2011 (Johnston, O'Malley, Bachman, & Schulenberg, 2011, 2012).

This resurgence of waterpipe tobacco smoking may be due in part to the mistaken belief that waterpipes are less harmful and less addictive than cigarettes (Aljarrah, Ababneh, & Al-Delaimy, 2009; Combrink et al., 2010; Jackson & Aveyard, 2008; Jamil, Elsouhag, Hiller, Arnetz, & Arnetz, 2010; Smith-Simone, Maziak, Ward, & Eissenberg, 2008). Evidence to the contrary reveals that, as with cigarette smoke, waterpipe smoke contains many toxicants: polycyclic aromatic hydrocarbons that cause cancer, volatile aldehydes that contribute to lung disease, carbon monoxide (CO) that contributes to cardiovascular disease, and nicotine that causes dependence (Al Rashidi, Shihadeh, & Saliba, 2008; Sepetdjian, Shihadeh, & Saliba, 2008; Shihadeh, 2003; Shihadeh & Saleh, 2005). Laboratory data confirm that users who engage in a single waterpipe use episode are exposed to physiologically active doses of nicotine and substantial amounts of CO compared to when they smoke a

doi:10.1093/ntr/ntt120
Advance Access publication August 13, 2013
© *The Author 2013. Published by Oxford University Press on behalf of the Society for Research on Nicotine and Tobacco. All rights reserved. For permissions, please e-mail: journals.permissions@oup.com.*

Downloaded from http://ntr.oxfordjournals.org/ at Virginia Commonwealth University on January 14, 2014

single cigarette (Blank et al., 2011; Cobb, Shihadeh, Weaver, & Eissenberg, 2011). Not surprisingly, smoking tobacco via waterpipe is linked to the same adverse health conditions as via cigarette (e.g., Akl et al., 2010; Raad et al., 2011).

Investigations of waterpipe user toxicant exposure generally focus on individuals (e.g., Blank et al., 2011; Cobb et al., 2011; Maziak et al., 2009; Rastam et al., 2011) even though waterpipe use is often a social practice (e.g., Roskin & Aveyard, 2009). Indeed, a convenience sample of university students from two U.S. cities showed that 95.8% endorsed smoking a waterpipe in the company of family members or friends and 97.9% stated that they usually share their waterpipe with others (Ward et al., 2007). A more recent survey of students from six North Carolina universities supports these findings, with 100% of respondents stating that they shared a waterpipe with others (Sutfin et al., 2011). Even among older, more established smokers, up to 44% prefer to share the same waterpipe (Asfar, Ward, Eissenberg, & Maziak, 2005; Maziak et al., 2004). These surveys also demonstrate that waterpipe smoking occurs primarily in cafés or restaurants for 24.5%–97.3% of respondents, with less-established smokers more likely to smoke in these social settings. Thus, group use is the norm for many waterpipe users.

Group use likely increases the complexity of the relationship between waterpipe smoking and toxicant exposure. For example, an individual's smoking topography (e.g., puff number, duration, and interpuff interval [IPI]) is known to predict their exposure to cigarette smoke toxicants. That is, when a smoker changes the manner in which they smoke a cigarette, such as increasing the number of puffs taken (higher puff number) or taking more closely spaced puffs (shorter IPIs), they often increase their exposure to toxicants such as nicotine and CO (Guyatt, Kirkham, Mariner, Baldry, & Cumming, 1989; Moody, 1984; Zacny, Stitzer, Brown, Yingling, & Griffiths, 1987). Similarly, patterns of waterpipe tobacco smoking predict users' exposure to nicotine (Maziak et al., 2011). Research has also shown that environment-specific factors influence cigarette smoking behavior: time of day (Morgan, Gust, Pickens, Champagne, & Hughes, 1985), workplace restrictions (Chapman, Haddad, & Sindhusake, 1997), and concurrent drug intake (Griffiths, Bigelow, & Liebson, 1976; Henningfield & Griffiths, 1981). Accordingly, group waterpipe use may result in a different topographical profile of smoking, and thus a different level of toxicant exposure, than singleton waterpipe use. For instance, individuals who smoke as part of a group may smoke more intensely and/or more rapidly given that their access to the hose is limited. Consequently, the IPI for each individual user may be decreased and/or the user may take more puffs per waterpipe. On the other hand, increased puffs may be more likely in smaller groups when the hose is more readily available.

The purpose of this study was to observe waterpipe use among groups varying in size in a naturalistic environment. Trained observers visited a random sample of waterpipe cafés in an American city. At each café, observations of naturally formed waterpipe smoking groups included the recording of individuals' smoking topography (puff frequency, duration, and IPI) and engagement in other activities (e.g., food and drink consumption and other tobacco use). Of particular interest was how topographical profiles differed as a function of group size. Other study goals included examining the role of demographic factors (smoker gender and gender composition of the group) and a number of contextual factors in smoking topography.

METHODS

Participants

Observation targets were 352 patrons (N = 204 [58%] male) in five waterpipe restaurants and bars in a midsized mid-Atlantic city. Other than gender, participant demographics were not recorded, as verifying such information with observation targets may have altered their behavior. Due to both a lack of waterpipe activity for some targets and the inability to objectively verify the presence or absence of particular contextual features for some targets (see Procedure section), some observation data were removed from analyses; this left 241 observation targets for the primary analyses.

Observer Training

Training was conducted in three stages. First, in the laboratory, trainees were familiarized with the observational tasks, the Palm Pilot coding scheme, and the various contingencies that may arise as an observer. Second, each trainee accompanied a team of observers to a café to learn how observations were conducted under various conditions and with a variety of targets. Third, each trainee made sample observations that were then checked for interobserver reliability, with further instruction given as needed. Once trainees demonstrated their ability to record target behaviors reliability, they began making observations that became record.

Procedure

Observation of waterpipe use and contextual features surrounding it were made on members of naturally formed groups of patrons. Research assistants made observations three nights per week—Friday, Saturday, and Sunday—between 8 p.m. and 12 a.m. because customer traffic was heavy on these nights and during this timeframe. Each team of observers made observations in 120-min time blocks. Observations were made for 18 weeks, spread over two academic terms.

A multistage randomization scheme was used to help ensure that observations were representative of waterpipe use. First, the restaurant or bar to be entered was randomly selected. Upon arrival at the location, an observation team leader randomly selected the first individual or social group to observe from among the currently occupied tables. The team leader then randomly selected an individual from among these tables to observe for the first 10-min observation period. This target was then simultaneously observed by two trained research assistants, so the reliability of observations could be determined. These two observers were separated to encourage independent, unobtrusive observations. Several other features of each restaurant/bar environment facilitated unobtrusiveness: subdued lighting, a large number of tables, the current ubiquity of cell phone usage, and, typically, a large number of individuals and groups during the observational evenings and timeframes. Additionally, observers were positioned at sufficient distance from targets to preclude their awareness of being observed. There was no indication that any target became aware of the observations.

Observations of each target were made for 10 consecutive minutes, after which the team leader performed the next, and each subsequent table and individual randomization (sampled without replacement of already observed tables), based on the

Downloaded from http://ntr.oxfordjournals.org/ at Virginia Commonwealth University on January 14, 2014

current patron configuration in the bar or restaurant. Up to twenty 10-min periods of observation were used each evening (according to the number of tables occupied at the locations selected), with 2-min breaks between successive observation periods.

For each individual observed, observers first recorded, using handheld computers (Palm Z22; Palm, Inc.) loaded with customized software (Experience Sampling Program; Barrett & Feldman Barrett, 2000), the gender of the individual, the size of the group, the gender composition of the group (number of males), and the number of waterpipes at the table. The number and duration of waterpipe puffs were then recorded, and the IPI was determined using software-generated timestamps. The number and duration of waterpipe puffs were determined by observation of the onset and offset, respectively, of water bubbles in the target's pipe. At the end of the observation period, the presence/absence of each of the following contextual events during the 10-min period was recorded: whether the individual was consuming food (yes, no, unsure) or drink (yes, no, unsure), whether the drink was alcoholic (yes, no, unsure), whether the target used another form of tobacco during the observation period (cigarette, cigar, pipe, chew; yes, no, unsure), engaged in conversation (yes, no), and viewed a video or television screen (the primary media entertainment in each restaurant/bar; yes, no, unsure).

If the target left his/her table, a 2-min waiting period was initiated. If the target returned during this timeframe, observations continued for the remainder of the 10-min observation period. If the target did not return during the 2-min period, the observation period was terminated and the next target was selected. All observation records were automatically date- and time stamped and uploaded to a laboratory computer within 3 days of observation.

Statistical Analyses

Interrater reliability was calculated on each categorical variable using Cohen's Kappa (κ), while intraclass correlation (ICC) was used to determine interrater reliability on the continuous variables. For each observation period, one of the two observers' data was randomly selected for inclusion in the analyses. Least squares standard multiple regression analyses using the REG procedure in SAS 9.1 were conducted to examine the relations of target gender, group size, group gender composition, and six dummy coded contextual events (consumption of food, drink, and nonwaterpipe tobacco, conversation, and video/television viewing) on mean number of waterpipe puffs, mean duration of puffs, and mean IPI (three separate models). For events in which observers were unsure of their occurrence (e.g., alcoholic drink), the observation data were removed from analyses. All continuous data were checked for normality and the predictor variables were checked for collinearity. Due to high outlier values on the three outcome variables, as well as on the three continuous predictors (number of people in target group, number of waterpipes/table, and number of males in the target group), the data were winsorized to achieve normality before analysis (Tabachnick & Fidell, 2007).

RESULTS

Interrater reliability was generally high across the continuous observational variables. On the three outcome variables, ICCs were .99 for puff frequency, .79 for puff duration, and .99 for IPI. On the three continuous predictors, ICCs ranged from .90 to .96. Regarding the categorical variables, κ was acceptably high for target gender (.95) and for food consumption (.68). On the remaining variables, κ ranged from .35 to .50. However, inspection of the data on these variables showed that these lower values were due to the fact that most data for both observers were clustered in a single cell of the observation frequency tables. Thus, interrater agreement was quite high on these variables, ranging from .69 (drink consumption) to .95 (conversation). Given these results, all observation variables were included in the analyses.

Table 1 presents sociodemographic characteristics of all observation targets. As already noted, most targets were male, and table groups were largely composed of males. On average, each table observed had one shared waterpipe. Table 2 presents the waterpipe puff and contextual characteristics on the observation targets. For most target patrons, the focal activities during the observation periods were waterpipe use and conversation (91.5% of targets). Only a minority consumed food (14.9%) or nonalcoholic drinks (36.1%). Few used other tobacco (7.6%) and even fewer consumed alcohol (2.4%). Due to the low level of alcohol consumption, this variable was removed from further analyses. Approximately one in five targets watched videos/television (21.9%).

Before turning to the prediction of waterpipe puff characteristics, we examined the extent to which the three outcomes represented independent features of waterpipe use. Pearson correlation analyses showed that puff frequency and duration were inversely correlated at a low level ($r = -.12$, $p = .04$). Puff frequency and IPI were moderately and inversely correlated ($r = -.57$, $p < .0001$), while puff duration and IPI were uncorrelated ($r = .05$, $p = .36$). These findings supported separate predictive analyses of the three outcomes.

The puff frequency prediction model was significant, $F(9, 240) = 4.24$, $p < .0001$, $R^2 = .14$. Table 3 shows that smaller group size ($p = .003$) and more waterpipes/group ($p = .02$) were associated with greater puff frequency. The absence of other forms of tobacco ($p = .02$) and the presence of media viewing ($p = .002$) were also related to greater puff frequency. The puff duration prediction model was nonsignificant, $F(9, 236) = 1.59$, $p = .12$, $R^2 = .06$. However, examination of the predictors showed that male targets took longer waterpipe puffs than female targets ($p = .03$), and the presence of conversation was marginally related to longer duration of puffs ($p = .07$). Finally, the IPI prediction model was significant, $F(9, 240) = 2.61$, $p = .007$, $R^2 = .09$. Table 4 shows that larger group

Table 1. Sociodemographic Characteristics of Observation Targets

Variable	*N*	%	*M*	*SD*	Median	Range
Target gender						
Male	204	58				
Female	148	42				
Group size[a]			3.4	1.6	3.0	1–10
Group gender (male)[a]			2.8	1.4	3.0	1–10
Pipes per table[a]			1.3	0.5	1.0	1–5

Note. $N = 352$ targets across five restaurants/bars.
[a]Data shown are uncorrected for nonnormality.

Downloaded from http://ntr.oxfordjournals.org/ at Virginia Commonwealth University on January 14, 2014

Table 2. Activity Characteristics of Observation Targets

Variable	% Yes	% No	% Unknown	*M*	*SD*	Median	Range
Puff frequency[a]				9.1	7.4	7.0	1.0–63.0
Puff duration (s)[a]				4.1	3.8	3.3	0.2–67.6
Interpuff interval (s)[a]				71.6	73.1	48.9	0.5–535.9
Food consumed?	14.9	83.2	1.9				
Nonalcoholic consumed?	36.1	60.8	3.2				
Alcoholic consumed?	2.4	90.3	7.3				
Other tobacco consumed?	7.6	90.5	1.9				
Conversation?	91.5	8.5	0.0				
Media viewing?	21.9	68.0	10.0				

Note. $N = 352$ targets across five restaurants/bars.
[a]Based on 2,691 waterpipe puffs observed within and across targets. Data shown are uncorrected for nonnormality.

Table 3. Multiple Regression Testing Prediction of Waterpipe Puff Frequency

Predictor	*B*	*SE*	*β*	*p* Value
Target gender	−0.99	1.03	−0.07	.34
Group size	−1.27	0.43	−0.26	.003
Group gender composition	−0.21	0.48	−0.04	.67
Pipes per table	2.17	0.91	0.17	.02
Food consumption	1.60	1.29	0.08	.22
Drink consumption	0.75	0.86	0.06	.38
Other tobacco consumption	3.67	1.55	0.15	.02
Conversation	0.33	1.88	0.01	.86
Media viewing	−2.98	0.96	−0.20	.002

Note. $N = 241$ targets across five restaurants/bars.

Table 4. Multiple Regression Testing Prediction of Waterpipe Interpuff Interval

Predictor	*B*	*SE*	β	*p* Value
Target gender	−433.96	832.89	−0.04	.6
Group size	1075.35	347.44	0.28	.002
Group gender composition	−282.52	391.32	−0.07	.47
Pipes per table	−1900.68	738.56	−0.18	.01
Food consumption	711.75	1041.69	0.05	.5
Drink consumption	−1151.90	696.59	−0.11	.1
Other tobacco consumption	43.03	1249.59	0.00	.97
Conversation	−1353.70	1522.36	−0.06	.38
Media viewing	1430.28	772.44	0.12	.07

Note. $N = 241$ targets across five restaurants/bars.

size (p = .002) and a smaller number of waterpipes/group (p = .01) were related to longer IPI. The absence of media viewing was marginally associated with longer IPI (p = .07).

DISCUSSION

This study is among the first to measure unobtrusively the topographic patterns of waterpipe tobacco smoking in a natural environment (see Katurji, Daher, Sheheitli, Saleh, & Shihadeh, 2010). Naturally formed groups of waterpipe users at local cafés were observed for their smoking behavior (e.g., puff number, duration, and IPI) and concurrent engagement in other activities. Results showed that increased puff number was observed for smaller group sizes and more waterpipes per group. For IPI, longer delays between puffs were observed for larger group sizes and fewer waterpipes per table. One explanation for these findings is that smokers are able to take more puffs, and more often, when the hose is readily accessible. Alternatively, individuals who share waterpipes with a large number of people may be novice users with a different smoking profile. This idea is consistent with other work where university students in the early stages of waterpipe use were likely to share a waterpipe with friends, whereas more established smokers were likely to share with family members or to smoke alone (Asfar et al., 2005). Occasional waterpipe users may change their patterns of smoking as they progress to more regular use, possibly as a result of tobacco/nicotine dependence development. In fact, similar observations have been made with adolescent cigarette smokers in that certain aspects of their smoking patterns differ from adult cigarette smokers with a longer history of use and a greater level of nicotine dependence (e.g., Kassel et al., 2007).

The present study also revealed that puff number varied as a function of several contextual factors. Greater puff frequency was observed during media viewing and when other tobacco use was absent, findings that are generally consistent with observations made for cigarette smoking. One study reported changes in cigarette smoking behavior in response to television watching, including increased puff number for some participants (Hatsukami, Morgan, Pickens, & Champagne, 1990). The latter finding, that users puffed more frequently when waterpipe was their sole method of nicotine/tobacco delivery, may be evidence for nicotine titration. For example, cigarette smokers who are preloaded with nicotine via gum (Herning, Jones, & Fischman, 1985; Nemeth-Coslett, Henningfield, O'Keeffe, & Griffiths, 1987) or nasal spray (Perkins, Grobe, Stiller, Fonte, & Goettler, 1992) often decrease the total number of cigarettes smoked and/or the total number of puffs per cigarette. Of course, the present users may simply have taken fewer turns at the waterpipe hose when engaged in other activities, though notable is that consumption of food and drink or talking with others did not influence puff number.

Comparison of topography parameters revealed that puff frequency was significantly and inversely related to both duration and IPI. That is, as the number of puffs increased, participants took shorter and more closely spaced puffs. For comparison, cigarette smokers also appear to take shorter puffs as the number increases though IPIs become longer

Downloaded from http://ntr.oxfordjournals.org/ at Virginia Commonwealth University on January 14, 2014

(Griffiths & Henningfield, 1982; Griffiths, Henningfield, & Bigelow, 1982; Veilleux et al., 2011). However, these findings in cigarette smokers are often the product of observations made over the course of smoking an entire cigarette and thus take into account increases in the temperature that occur toward the end of the rod (Nemeth-Coslett & Griffiths, 1984). The temperature of waterpipe tobacco has also been shown to increase with each puff (Shihadeh, 2003), though it is not known whether the randomly selected 10-min sampling periods are representative of the entire course of waterpipe smoking (e.g., beginning, middle, and end).

Also unknown is whether the topographic smoking profile reported here (i.e., averages of 9.1 puffs/10-min period, 4.1-s puff durations, and 71.6-s IPIs) is representative of waterpipe smoking in general. Other available studies on the puffing topography of waterpipe smokers focused on individual use. In one study (Shihadeh, Azar, Antonios, & Haddad, 2004), smokers who visited a café in Beirut, Lebanon, took an average of 4.0 puffs per minute for more than 30 min, with an average duration of 2.6 s and an average IPI of 15.5 s. A slightly different pattern of results has been revealed from U.S. laboratory-based studies (Blank et al., 2011; Cobb et al., 2011) for puff frequency (66.3 and 84.9, respectively), duration (3.9 and 4.0 s, respectively), and IPI (47.5 and 35.4 s, respectively). Of course, the methodological and study population differences across studies preclude close comparisons.

Limitations

The study findings must be interpreted in the context of certain limitations. First, the smoking assessment periods were limited to 10-min blocks. As such, changes in individuals' topographic patterns of smoking across an entire waterpipe episode were not measured. Second, observational measurement of smoking topography does not allow for the recording of puff volume, a valuable index of smoke constituent intake (e.g., Herning, Jones, Bachman, & Mines, 1981; Zacny et al., 1987). Third, the present study did not measure other factors that likely influence smoking topography, such as individuals' demographic characteristics, waterpipe use history (frequency and duration of use), concurrent and regular use of other tobacco (e.g., daily cigarette smoking), and nicotine content of the waterpipe tobacco used. The complex interplay between such waterpipe use features likely accounts for the small amounts of variance explained by the predictors in this study. Fourth, our observations were limited to waterpipe smokers in one city in the mid-Atlantic region, and study results may not generalize to waterpipe smokers in other U.S. regions. Finally, while café patrons were sampled at random, assignment to group sizes was not randomized and thus causal inferences cannot be made. Future work should consider an evaluation of waterpipe smoking topography as a function of group size in a controlled, laboratory setting. Despite these limitations, this study is the first to shed light on key aspects of waterpipe smoking as it occurs among groups in a naturalistic environment.

CONCLUSIONS AND FUTURE WORK

Study findings indicate that smoking topography is dependent upon group size and certain social features, both of which may be relevant to intervention and prevention efforts. In this study, environmental cues observed to be related to waterpipe smoking—socialization and setting factors—are similar to those reported in focus group and survey work (for reviews, see Maziak, Eissenberg, & Ward, 2005; Maziak, Ward, & Eissenberg, 2007). These cues may be those most salient for the promotion and/or maintenance of waterpipe smoking and thus should be targeted in future work. For example, the development of interventions for dependent waterpipe smokers may be informed by an understanding of such contextual factors, similar to that for behavioral and social interventions developed for cigarette smokers (e.g., Christakis & Fowler, 2008; García-Rodríguez et al., 2012). Of course, future work is also needed to understand how the interplay between contextual, social, and pharmacological factors predicts exposure to waterpipe tobacco smoke toxicants. These factors might be subject to experimental study to better understand their influence on waterpipe smoking in vivo.

FUNDING

Support for this work was provided by National Cancer Institute (R01CA120142).

DECLARATION OF INTERESTS

None declared.

ACKNOWLEDGMENTS

We thank the research assistants, too many to name here, whose work was invaluable in the conduct of this study. All work performed at Virginia Commonwealth University.

REFERENCES

Akl, E. A., Gaddam, S., Gunukula, S. K., Honeine, R., Jaoude, P. A., & Irani, J. (2010). The effects of waterpipe tobacco smoking on health outcomes: A systematic review. *International Journal of Epidemiology*, *39*, 834–857. doi:10.1093/ije/dyq002

Aljarrah, K., Ababneh, Z. Q., & Al-Delaimy, W. K. (2009). Perceptions of hookah smoking harmfulness: Predictors and characteristics among current hookah users. *Tobacco Induced Diseases*, *5*, 16. doi:10.1186/1617-9625-5-16

Al Rashidi, M., Shihadeh, A., & Saliba, N. A. (2008). Volatile aldehydes in the mainstream smoke of the narghile waterpipe. *Food & Chemical Toxicology*, *46*, 3546–3549. doi:10.1016/j.fct.2008.09.007

Asfar, T., Ward, K. D., Eissenberg, T., & Maziak, W. (2005). Comparison of patterns of use, beliefs, and attitudes related to waterpipe between beginning and established smokers. *BMC Public Health*, *5*, 19.

Barrett, D. J., & Feldman Barrett, L. (2000). The experience-sampling program (ESP). Retrieved from http://www.experience-sampling.org/

Blank, M. D., Cobb, C. O., Kilgalen, B., Austin, J., Weaver, M. F., Shihadeh, A., & Eissenberg, T. (2011). Acute effects of waterpipe tobacco smoking: A double-blind, placebo-control study. *Drug and Alcohol Dependence*, *116*, 102–109. doi:10.1016/j.drugalcdep.2010.11.026

Downloaded from http://ntr.oxfordjournals.org/ at Virginia Commonwealth Universtiy on January 14, 2014

Chaaya, M., El-Roueiheb, Z., Chemaitelly, H., El Azar, G., Nasr, J., & Al-Sahab, B. (2004). Argileh smoking among university students: A new tobacco epidemic. *Nicotine & Tobacco Research*, *6*, 457–463.

Chapman, S., Haddad, S., & Sindhusake, D. (1997). Do workplace smoking bans cause smokers to smoke "harder"? Results from a naturalistic observational study. *Addiction*, *92*, 607–610.

Christakis, N. A., & Fowler, J. H. (2008). The collective dynamics of smoking in a large social network. *The New England Journal of Medicine*, *358*, 2249–2258. doi:10.1056/NEJMsa0706154

Cobb, C. O., Shihadeh, A., Weaver, M. F., & Eissenberg, T. (2011). Waterpipe tobacco smoking and cigarette smoking: A direct comparison of toxicant exposure and subjective effects. *Nicotine & Tobacco Research*, *13*, 78–87. doi:10.1093/ntr/ntq212

Cobb, C. O., Ward, K. D., Maziak, W., Shihadeh, A. L., & Eissenberg, T. (2010). Waterpipe tobacco smoking: An emerging health crisis in the United States. *American Journal of Health Behavior*, *34*, 275–285.

Combrink, A., Irwin, N., Laudin, G., Naidoo, K., Plagerson, S., & Mathee, A. (2010). High prevalence of hookah smoking among secondary school students in a disadvantaged community in Johannesburg. *South African Medical Journal*, *100*, 297–299.

Eissenberg, T., Ward, K. D., Smith-Simone, S., & Maziak, W. (2008). Waterpipe tobacco smoking on a U.S. College campus: Prevalence and correlates. *The Journal of Adolescent Health*, *42*, 526–529. doi:10.1016/j.jadohealth.2007.10.004

García-Rodríguez, O., Pericot-Valverde, I., Gutiérrez-Maldonado, J., Ferrer-García, M., & Secades-Villa R., (2012). Validation of smoking-related virtual environments for cue exposure therapy. *Addictive Behaviors*, *37*(6), 703–703. doi:10.1016/j.addbeh.2012.02.013

Griffiths, R. R., Bigelow, G. E., & Liebson, I. (1976). Facilitation of human tobacco self-administration by ethanol: A behavioral analysis. *Journal of the Experimental Analysis of Behavior*, *25*, 279–292.

Griffiths, R. R., & Henningfield, J. E. (1982). Experimental analysis of human cigarette smoking behavior. *Federation Proceedings*, *41*, 234–240.

Griffiths, R. R., Henningfield, J. E., & Bigelow, G. E. (1982). Human cigarette smoking: Manipulation of number of puffs per bout, interbout interval, and nicotine dose. *The Journal of Pharmacology and Experimental Therapeutics*, *220*, 256–265.

Guyatt, A. R., Kirkham, A. J., Mariner, D. C., Baldry, A. G., & Cumming, G. (1989). Long-term effects of switching to cigarettes with lower tar and nicotine yields. *Psychopharmacology*, *99*, 80–86.

Hatsukami, D. K., Morgan, S. F., Pickens, R. W., & Champagne, S. E. (1990). Situational factors in cigarette smoking. *Addictive Behaviors*, *15*, 1–12.

Henningfield, J. E., & Griffiths, R. R. (1981). Cigarette smoking and subjective response: Effects of d-amphetamine. *Clinical Pharmacology and Therapeutics*, *30*, 497–505.

Herning, R. I., Jones, R. T., Bachman, J., & Mines, A. H. (1981). Puff volume increases when low-nicotine cigarettes are smoked. *British Medical Journal*, *283*, 187–189.

Herning, R. I., Jones, R. T., & Fischman, P. (1985). The titration hypothesis revisited: Nicotine gum reduces smoking intensity. *NIDA Research Monograph*, *53*, 27–41.

Jackson, D., & Aveyard, P. (2008). Waterpipe smoking in students: Prevalence, risk factors, symptoms of addiction, and smoke intake. Evidence from one British university. *BMC Public Health*, *8*, 174. doi:10.1186/1471-2458-8-174

Jamil, H., Elsouhag, D., Hiller, S., Arnetz, J. E., & Arnetz, B. B. (2010). Sociodemographic risk indicators of hookah smoking among Caucasian Americans in Southeast Michigan. *Nicotine & Tobacco Research*, *12*, 525–529. doi:10.1093/ntr/ntq026

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2011). *Monitoring the future national results on adolescent drug use: Overview of key findings, 2010*. Ann Arbor (MI): Institute for Social Research, The University of Michigan. Retrieved from www.drugabuse.gov/related-topics/trends-statistics/monitoring-future

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2012). *Monitoring the future: National results on adolescent drug use: Overview of key findings, 2011*. Ann Arbor (MI): Institute for Social Research, The University of Michigan. Retrieved from www.drugabuse.gov/related-topics/trends-statistics/monitoring-future

Kassel, J. D., Greenstein, J. E., Evatt, D. P., Wardle, M. C., Yates, M. C., Veilleux, J. C., & Eissenberg, T. (2007). Smoking topography in response to denicotinized and high-yield nicotine cigarettes in adolescent smokers. *Journal of Adolescent Health*, *40*, 54–60.

Katurji, M., Daher, N., Sheheitli, H., Saleh, R., & Shihadeh, A. (2010). Direct measurement of toxicants inhaled by water pipe users in the natural environment using a real-time in situ sampling technique. *Inhalation Toxicology*, *22*, 1101–1109. doi:10.3109/08958378.2010.524265

Knishkowy, B., & Amitai, Y. (2005). Water-pipe (narghile) smoking: An emerging health risk behavior. *Pediatrics*, *116*, 113–119.

Maziak, W. (2011). The global epidemic of waterpipe smoking. *Addictive Behaviors*, *36*, 1–5. doi:10.1016/j.addbeh.2010.08.030

Maziak, W., Eissenberg, T., & Ward, K. D. (2005). Patterns of waterpipe use and dependence: Implications for intervention development. *Pharmacology, Biochemistry, and Behavior*, *80*, 173–179.

Maziak, W., Rastam, S., Ibrahim, I., Ward, K. D., Shihadeh, A., & Eissenberg, T. (2009). CO exposure, puff topography, and subjective effects in waterpipe tobacco smokers. *Nicotine & Tobacco Research*, *11*, 806–811. doi:10.1093/ntr/ntp066

Maziak, W., Rastam, S., Shihadeh, A. L., Bazzi, A., Ibrahim, I., Zaatari, G. S., … Eissenberg, T. (2011). Nicotine exposure in daily waterpipe smokers and its relation to puff topography. *Addictive Behaviors*, *36*, 397–399. doi:10.1016/j.addbeh.2010.11.013

Maziak, W., Ward, K. D., & Eissenberg, T. (2007). Interventions for waterpipe smoking cessation. *Cochrane Database of Systematic Reviews*, *4*, CD005549.

Maziak, W., Ward, K. D., Soweid, R. A., & Eissenberg, T. (2004). Tobacco smoking using a waterpipe: A re-emerging strain in a global epidemic. *Tobacco Control*, *13*, 327–333.

Moody, P. M. (1984). Human smoking patterns and smoke deliveries. *The International Journal of the Addictions*, *19*, 431–439.

Morgan, S. F., Gust, S. W., Pickens, R. W., Champagne, S. E., & Hughes, J. R. (1985). Temporal patterns of smoking topography in the natural environment. *The International Journal of the Addictions*, *20*, 613–621.

Nemeth-Coslett, R., & Griffiths, R. R. (1984). Determinants of puff duration in cigarette smokers. *Pharmacology, Biochemistry, and Behavior*, *20*, 965–971.

Nemeth-Coslett, R., Henningfield, J. E., O'Keeffe, M. K., & Griffiths, R. R. (1987). Nicotine gum: Dose-related effects on cigarette smoking and subjective ratings. *Psychopharmacology*, *92*, 424–430.

Perkins, K. A., Grobe, J. E., Stiller, R. L., Fonte, C., & Goettler, J. E. (1992). Nasal spray nicotine replacement

Downloaded from http://ntr.oxfordjournals.org/ at Virginia Commonwealth University on January 14, 2014

suppresses cigarette smoking desire and behavior. *Clinical Pharmacology and Therapeutics*, *52*, 627–634.

Primack, B. A., Fertman, C. I., Rice, K. R., Adachi-Mejia, A. M., & Fine, M. J. (2010). Waterpipe and cigarette smoking among college athletes in the United States. *The Journal of Adolescent Health*, *46*, 45–51. doi:10.1016/j.jadohealth.2009.05.004

Primack, B. A., Shensa, A., Kim, K. H., Carroll, M. V., Hoban, M. T., Leino, E. V., … Fine, M. J. (2013). Waterpipe smoking among U.S. university students. *Nicotine & Tobacco Research*, *15*, 29–35. doi:10.1093/ntr/nts076

Raad, D., Gaddam, S., Schunemann, H. J., Irani, J., Jaoude, A., Honbeine, R., & Akl, E. A. (2011). Effects of waterpipe tobacco smoking on lung function: A systematic review and meta-analysis. *Chest*, *139*, 764–774. doi:10.1378/chest.10-0991

Rastam, S., Eissenberg, T., Ibrahim, I., Ward, K. D., Khalil, R., & Maziak, W. (2011). Comparative analysis of waterpipe and cigarette suppression of abstinence and craving symptoms. *Addictive Behaviors*, *36*, 555–559. doi:10.1016/j.addbeh.2011.01.021

Roskin, J., & Aveyard, P. (2009). Canadian and English students' beliefs about waterpipe smoking: A qualitative study. *BMC Public Health*, *9*, 10. doi:10.1186/1471-2458-9-10

Sepetdjian, E., Shihadeh, A., & Saliba, N. A. (2008). Measurement of 16 polycyclic aromatic hydrocarbons in narghile waterpipe tobacco smoke. *Food Chemistry*, *46*, 1582–1590. Retrieved from www.journals.elsevier.com/food-chemistry/

Shihadeh, A. (2003). Investigation of mainstream smoke aerosol of the argileh water pipe. *Food and Chemical Toxicology*, *41*, 143–152.

Shihadeh, A., Azar, S., Antonios, C., & Haddad, A. (2004). Towards a topographical model of narghile waterpipe café smoking: A pilot study in a high socioeconomic status neighborhood of Beirut, Lebanon. *Pharmacology, Biochemistry, and Behavior*, *79*, 75–82.

Shihadeh, A., & Saleh, R. (2005). Polycyclic aromatic hydrocarbons, carbon monoxide, "tar", and nicotine in the mainstream smoke aerosol of the narghile water pipe. *Food and Chemical Toxicology*, *43*, 655–661.

Smith, S. Y., Curbow, B., & Stillman, F. A. (2007). Harm perception of nicotine products in college freshmen. *Nicotine & Tobacco Research*, *9*, 977–982.

Smith-Simone, S., Maziak, W., Ward, K. D., & Eissenberg, T. (2008). Waterpipe tobacco smoking: Knowledge, attitudes, beliefs, and behavior in two U.S. samples. *Nicotine & Tobacco Research*, *10*, 393–398. doi:10.1080/14622200701825023

Sutfin, E. L., McCoy, T. P., Reboussin, B. A., Wagoner, K. G., Spangler, J., & Wolfson, M. (2011). Prevalence and correlates of waterpipe tobacco smoking by college students in North Carolina. *Drug and Alcohol Dependence*, *115*, 131–136. doi:10.1016/j.drugalcdep.2011.01.018

Tabachnick, G. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). New York (NY): Pearson Education.

Tamim, H., Terro, A., Kassem, H., Ghazi, A., Khamis, T. A., Hay, M. M., & Musharrafieh, U. (2003). Tobacco use by university students, Lebanon, 2001. *Addiction*, *98*, 933–939.

Veilleux, J. C., Kassel, J. D., Heinz, A. J., Braun, A., Wardle, M., Greenstein, J., … Conrad, M. (2011). Predictors and sequelae of smoking topography over the course of a single cigarette in adolescent light smokers. *Journal of Adolescent Health*, *48*, 176–181. doi:10.1016/j.jadohealth.2010.06.015

Ward, K. D., Eissenberg, T., Gray, J. N., Srinivas, V., Wilson, N., & Maziak, W. (2007). Characteristics of U.S. waterpipe users: A preliminary report. *Nicotine & Tobacco Research*, *9*, 1339–1346.

Zacny, J. P., Stitzer, M. L., Brown, F. J., Yingling, J. E., & Griffiths, R. R. (1987). Human cigarette smoking: Effects of puff and inhalation parameters on smoke exposure. *The Journal of Pharmacology and Experimental Therapeutics*, *240*, 554–564.

Downloaded from http://ntr.oxfordjournals.org/ at Virginia Commonwealth University on January 14, 2014