

Original Investigation

Waterpipe Smoking Among U.S. University Students

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Abstract

Introduction: While cigarette use is declining, smoking tobacco with a waterpipe is an emerging trend. We aimed to determine the prevalence of waterpipe use in a large diverse sample of U.S. university students and to assess the association of waterpipe use with individual and institution-related characteristics.

Methods: We assessed students from 152 U.S. universities participating in the National College Health Assessment during 2008–2009. We used multivariable regression models to determine independent associations between individual and institutional characteristics and waterpipe tobacco use in the past 30 days and ever.

Results: Of 105,012 respondents included in the analysis, most were female (65.7%), White (71.2%), and attending public (59.7%) nonreligious (83.1%) institutions. Mean age was 22.1 years. A total of 32,013 (30.5%) reported ever using a waterpipe to smoke tobacco. Rates for current tobacco use were 8.4% for waterpipes, 16.8% for cigarettes, 7.4% for cigars (including cigarillos), and 3.5% for smokeless tobacco. Of current waterpipe users, 51.4% were not current cigarette smokers. Although current waterpipe use was reported across all individual and institutional characteristics, fully adjusted multivariable models showed that it was most strongly associated with younger age, male gender, White race, fraternity/sorority membership, and nonreligious institutions in large cities in the western United States.

Conclusions: After cigarettes, waterpipe use was the most common form of tobacco use among university students. Because waterpipe use affects groups with a wide variety of individual and institutional characteristics, it should be included with other forms of tobacco in efforts related to tobacco surveillance and intervention.

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Introduction

While cigarette use has declined over the past two decades (Kilmer et al., 2008; National Association of Attorneys General, 2006), smoking tobacco with a waterpipe (hookah, narghile, or shisha-pipe) is an emerging trend (Martinasek, McDermott, & Martini, 2011; Maziak, 2011; Primack et al., 2008). Many smokers perceive the harm from waterpipe tobacco use to be low (Aljarrah, Ababneh, & Al-Delaimy, 2009; Primack, Walsh, Bryce, & Eissenberg, 2009; Smith-Simone, Maziak, Ward, & Eissenberg, 2008). However, the World Health Organization (2005) estimates that one session of waterpipe use delivers as much as 100 times the smoke volume of a single cigarette, and studies indicate that the smoke from one waterpipe session contains about 40 times the tar (Katurji, Daher, Sheheitli, Saleh, & Shihadeh, 2010; Shihadeh & Saleh, 2005), 30 times the carcinogenic polycyclic aromatic hydrocarbons (Sepetdjian, Shihadeh, & Saliba, 2008), 10 times the carbon monoxide (Katurji et al., 2010; Shihadeh & Saleh, 2005), and 2 times the nicotine (Katurji et al., 2010; Shihadeh & Saleh, 2005) of a single cigarette. Waterpipe users are exposed to these toxicants when they smoke (Eissenberg & Shihadeh, 2010; El-Nachef & Hammond, 2008; Maziak et al., 2011), and blood nicotine levels of daily users are similar to those of individuals who smoke 10 cigarettes a day (Neergaard, Singh, Job, & Montgomery, 2007).

Despite preliminary reports associating waterpipe tobacco smoking with cancer, cardiovascular disease, decreased pulmonary function, and nicotine dependence (Akl et al., 2010; Raad et al., 2010), the public health impact of waterpipe use remains unclear. Although studies have estimated the lifetime prevalence of waterpipe use among young adults in the United States to be 20%–40% (Eissenberg, Ward, Smith-Simone, & Maziak, 2008; Primack et al., 2008; Smith, Curbow, & Stillman, 2007) and

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documented the concomitant use of other tobacco products (Primack, Fertman, Rice, Adachi-Mejia, & Fine, 2010; Sutfin et al., 2011), these studies have generally been conducted among small or localized samples of the population. Accurate prevalence data from large diverse samples and comparisons with other types of tobacco use are needed to determine whether waterpipe use is a serious threat to the public health or whether it is a localized phenomenon without substantial national implications.

Each year, the National College Health Assessment (NCHA) of the American College Health Association (ACHA, 2011) assesses a wide variety of content areas, including substance use, in over 100,000 university students. In 2008, the NCHA became the first large survey to assess waterpipe tobacco smoking. Here, we report the results of our secondary analysis of data derived during fall 2008 and spring 2009, the first full school year in which waterpipe use was assessed.

The broad objective of our analysis was to determine the frequency and pattern of waterpipe tobacco smoking in this large heterogeneous sample of U.S. university students. Our specific aims were to compare the prevalence of waterpipe use and other tobacco use and to determine independent associations between various individual and institutional factors and waterpipe use.

Methods

Participants and Procedures

Approximately 150 institutions administer the NCHA to their students annually. All responses are confidential. Each institution is responsible for securing human subjects approval, and the ACHA keeps copies of the approvals on file. Our analysis of the ACHA data was approved by the University of Pittsburgh's Institutional Review Board.

The survey was administered in two forms (American College Health Association, 2011). A paper-based form was administered to students in randomly selected classrooms, and a Web-based form was sent via an e-mail invitation to a random sample of students whose e-mail addresses were provided by their institution to the ACHA. The e-mail invitation included an embedded unique respondent identification number, which allowed the ACHA to prevent duplicate responses from the same student or responses from students outside the random sample. The paper-based survey accounted for about 20% of respondents and had a mean response rate of approximately 90%. Although the Web-based survey accounted for about 80% of respondents, it had a mean response rate of only about 22%. Despite its lower response rate, the Web-based survey is favored by institutions because it is less labor-intensive to administer and its results are virtually identical to those of the paper-based survey (Dillman, Smyth, & Christian, 2008).

Participating institutions typically encourage survey completion by providing a small incentive to students or having a random drawing for a larger prize. Web-based surveys were generally administered over a period of 2–4 weeks, and nonresponders were periodically sent reminders.

Measures

The NCHA survey assessed four types of tobacco use: waterpipe, cigarette, cigar, and smokeless tobacco. Regarding waterpipe

use, the survey asked, "Within the past 30 days, on how many days did you use tobacco from a waterpipe (hookah)?" The response options were (a) never used; (b) have used, but not in the past 30 days; (c) 1–2 days; (d) 3–5 days; (e) 6–9 days; (f) 10–19 days; (g) 20–29 days; and (h) all 30 days. For the three other types of tobacco use, the questions were similarly worded, and the response options are identical (ACHA, 2011). The question related to cigar smoking specifically included "little cigars" which are commonly used in the young adult population (Bombard, Rock, Pederson, & Asman, 2008).

For each type of tobacco use, we grouped response options c through h into the category called "current use," and we grouped response options b through h into the category called "ever use."

To assess individual characteristics associated with tobacco use, we used sociodemographic and other survey data routinely collected from the student. These data included age, gender, sexual orientation, year in school, race/ethnicity, full-time (vs. part-time) status, international status, relationship status, living arrangement, fraternity/sorority membership, and estimated current grade point average.

A representative from each institution participating in the NCHA was required to complete a survey describing a variety of institutional characteristics. Measures from this survey that were relevant for our study were geographic region of the United States, population of the campus locale (e.g., the population of Pittsburgh, for the University of Pittsburgh), institution type (public vs. private), religious affiliation, status as a 2-year (vs. 4-year) institution, and student population.

Analyses

We used descriptive statistics to determine the characteristics of respondents and institutions, to determine the prevalence of current use and ever use for each of the four types of tobacco, and to determine the number of individuals who had engaged in more than one type of tobacco use. We used area-proportional Venn diagrams (Chow & Rodgers, 2005) to depict the overlap between the three major types of smoked tobacco use (cigarette, waterpipe, and cigar). These three types of tobacco were compared because of similarities in toxin exposures, disease etiology, and public health implications.

To assess bivariable associations between waterpipe use and individual and institutional characteristics, we used two-way chi-square tests. To compute effect sizes, we used Cramér's (1999) *V* statistic.

To assess multivariable associations, we performed logistic regression analyses with generalized estimating equations which accounted for nesting of students within universities. We included in our models individual and institutional characteristics that existing research suggests may have an association to waterpipe tobacco smoking (Supplementary Table 1; Martinasek et al., 2011; Smith et al., 2011). Because the variables age and year in school were highly correlated, model instability resulted when we included both of these variables in multivariable models. Therefore, we dichotomized year in school by grouping the undergraduates together and distinguishing them from other students, which did not result in model instability. In multivariable

analyses, we dropped the transgender variable because of its extremely small size (146 respondents or 0.1%) and the potential for model instability if the variable were included. Rather than using imputation for missing data, we excluded the individuals with missing covariates (6,885 respondents or 6.6%) from the multivariable analyses only (i.e., those with outcome data but missing covariates were included in the bivariable analyses).

To confirm the robustness of our results, we conducted additional analyses. Although earlier studies of NCHA data did not show differences in outcome or predictor variables for respondents completing the paper-based versus Web-based form of the survey (Leino, 2004), we tested whether this held true for our multivariable analyses and found that it did. We also performed influence analysis to examine standardized DFBETA values for extreme cases, and we found that these values were all below our a priori cutoff of 1.96, indicating that our results were not unduly influenced by extreme cases. In addition, we conducted sensitivity analyses using bootstrapping methods with 1,000 repetitions. Because all the results (point estimates, *SDs*, and levels of significance) were similar in our primary analyses and bootstrapping analyses, we are reporting only the results of primary analyses.

Statistical analyses were performed with Stata 11.1 (Stata Corp, College Station, Texas), and two-tailed *p* values of $<.05$ were considered to be significant.

Results

Study Sample

A total of 107,921 students from 152 U.S. institutions completed surveys. Completion rates were 78% for paper-based and 21% for Web-based surveys. The exclusion of 2,909 respondents (2,447 of whom were over 60 years old and 743 of whom had missing data concerning primary study outcomes) yielded a complete study sample of 105,012. In this sample, the mean age was 22.1 years (*SD* 5.5), and the majority of respondents were female (65.7%), White (71.2%), studying full-time (92.7%), and noninternational (91.1%). Most of them attended public (59.7%), nonreligious (83.1%) institutions, with roughly equal representation from the midwestern, northeastern, southern, and western regions of the United States (Supplementary Table 1).

Prevalence of Tobacco Use

Regarding waterpipe tobacco smoking, 8,846 respondents (8.4%) reported current use and 32,013 (30.5%) reported use in the past ("ever use"; Supplementary Table 1). Of the current users, the majority (64.1%) had used a waterpipe on 1–2 days during the past 30-day period. In contrast, during this same period, 17.5% had used a waterpipe for 3–5 days, 8.1% for 6–9 days, 5.5% for 10–19 days, 2.8% for 20–29 days, and 2.1% for all 30 days.

Regarding cigarette smoking, 17,591 respondents (16.8%) reported current use and 36,315 (34.6%) reported ever use. Of those who reported current use, about one-third (31.6%) had used cigarettes 1–2 days during the past 30-day period, whereas 13.0% had used them for 3–5 days, 8.2% for 6–9 days, 10.0% for 10–19 days, 7.0% for 20–29 days, and 30.2% for all 30 days.

While cigarette use had the highest prevalence rates, waterpipe use had the second highest rates in both the current use and ever use categories (Figure 1).

Of the 104,434 respondents who had complete data for cigarette, waterpipe, and cigar use, 8,733 (8.4%) were current waterpipe users (Figure 2, top panel). In this group, 4,492 (51.4%) reported no current use of cigarettes and 3,609 (41.3%) reported no current use of other forms of tobacco. In contrast, of the 104,434 respondents, 31,749 (30.4%) had used a waterpipe at some time (Figure 2, bottom panel). In this group, 9,423 (29.7%) reported never using cigarettes and 6,198 (19.5%) reported never using tobacco of any kind.

Bivariable Analyses of Factors Associated With Waterpipe Use

In bivariable analyses of individual characteristics, current waterpipe use was associated with younger age, male and transgender sex, bisexual orientation, first- and second-year class membership, White race, full-time student status, lack of a relationship or cohabitation with a significant other, living in a fraternity/sorority house, and a non-A grade point average (Supplementary Table 1). Among individual variables, Cramer's *V* was highest for age ($V = 0.119$), year in school ($V = 0.097$), relationship status ($V = 0.085$), and gender ($V = 0.071$).

In bivariable analyses of institutional characteristics, current waterpipe use was most strongly associated with geographic region ($V = 0.036$), population of the campus locale ($V = 0.035$), and student population ($V = 0.027$). The highest rates of current waterpipe use were found in both the smallest ($<2,500$) and largest ($\geq 20,000$) student populations and among institutions in the western United States (Supplementary Table 1).

Multivariable Analysis of Factors Associated With Waterpipe Use

In fully adjusted multivariable models, current waterpipe use was associated with younger age, male gender, White and other race, international student status, lack of a relationship, living in

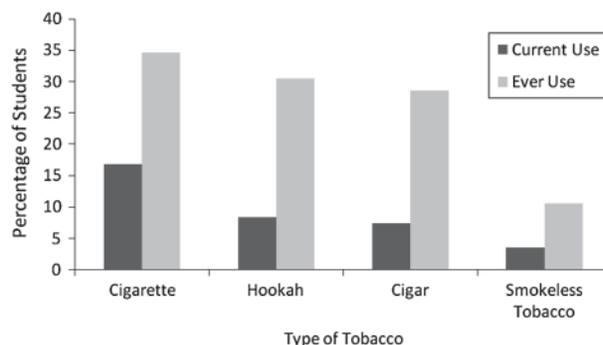
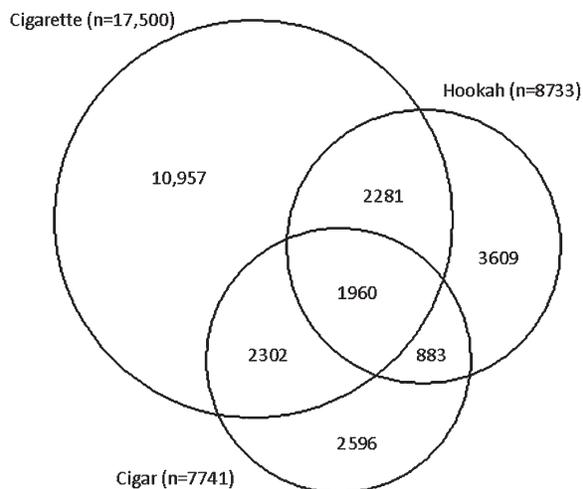


Figure 1. Percentage of students using different types of tobacco in the past 30 days (current use) and ever (ever use). For both periods, waterpipe smoking was the second most common type of tobacco use. We conducted two-sample tests of proportions comparing each pair of behaviors (e.g., current waterpipe smoking vs. current cigarette smoking, current waterpipe smoking vs. current cigar smoking, ever waterpipe smoking vs. ever cigarette smoking, etc.). Each of these tests indicated that the proportions were significantly different at the level $p < .001$.

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Current Use



Ever Use

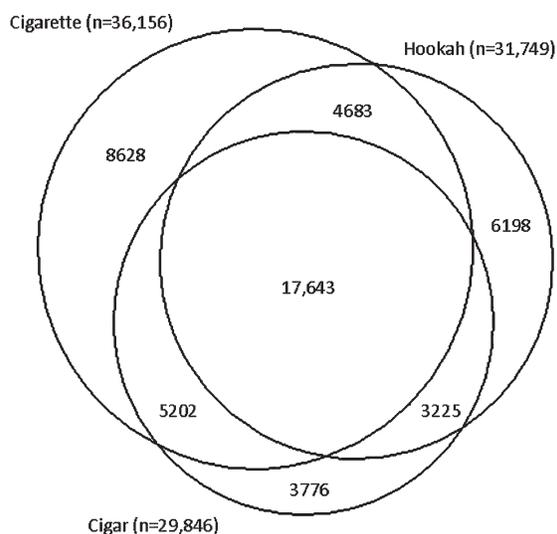


Figure 2. Area-proportional Venn diagrams showing overlap in types of tobacco use in the past 30 days (current use) and ever (ever use). Numbers are shown for the 104,434 students who provided data for the three major types of tobacco use (cigarette, waterpipe, and cigar). Data for smokeless tobacco use are not shown.

a fraternity/sorority or off-campus housing, being a member of a fraternity/sorority, and having lower grades (Supplementary Table 1).

Individual factors most strongly associated with higher odds of current waterpipe use were bisexual orientation (vs. heterosexual; *OR*, 1.90; 95% *CI*, 1.69–2.13), male gender (vs. female; *OR*, 1.70; 95% *CI*, 1.62–1.78), and living in a fraternity/sorority house (vs. a campus residence hall; *OR*, 1.68; 95% *CI* = 1.41–1.99). Individual factors most strongly associated with reduced odds of current waterpipe use were age of 31 years or more (vs. age 18; *OR*, 0.08; 95% *CI*, 0.06–0.11), being married (vs. not in

a relationship; *OR*, 0.38; 95% *CI*, 0.31–0.46), Black race (vs. White; *OR*, 0.41; 95% *CI*, 0.35–0.49), and graduate or other student status (vs. undergraduate; *OR*, 0.58; 95% *CI*, 0.51–0.66).

Patterns were similar for the waterpipe use ever category. However, a comparison of international and U.S. students indicated that international students had a slightly higher odds of current waterpipe use (*OR*, 1.11; 95% *CI*, 1.02–1.22) and a somewhat lower odds of ever waterpipe use (*OR*, 0.85; 95% *CI*, 0.81–0.90).

Institutional factors independently associated with current waterpipe use included western region of the United States (vs. midwestern; *OR*, 1.54; 95% *CI*, 1.22–1.96), larger population of campus locale (e.g., $\geq 500,000$ vs. $< 10,000$; *OR*, 2.27; 95% *CI*, 1.62–3.20), and religious affiliation (vs. nonaffiliation; *OR*, 0.72; 95% *CI*, 0.55–0.95). Patterns were similar for the waterpipe use ever category.

Discussion

Our analysis of data from the NCHA survey of over 100,000 respondents estimated the prevalence of waterpipe smoking among college and university students to be 8.4% during the past 30 days (current use) and 30.5% ever (ever use). The data on various forms of tobacco use indicated that waterpipe use was the second most frequent after cigarette use and that over half of current waterpipe users are not also current cigarette smokers. While waterpipe use was prevalent across a wide variety of factors, it was independently associated with several individual factors (younger age, male gender, White race, lack of a relationship, fraternity/sorority membership and housing, and living off campus) and several institutional factors (western U.S. location, larger population of campus locale, and nonreligious institutional affiliation).

Our prevalence rate for ever use was consistent with previous reports demonstrating ever use to be 20%–40% in various U.S. populations (Eissenberg et al., 2008; Primack et al., 2008; Smith-Simone et al., 2008). Although the prevalence rate for current use was somewhat lower than previously reported in small samples (Primack et al., 2009; Smith-Simone et al., 2008; Smith et al., 2007), it was consistent with previous estimates in relatively large samples (Primack et al., 2010).

Our findings suggested that there is substantial overlap between waterpipe and cigarette smoking. For example, 58.7% (5,124/8,733) of current hookah tobacco smokers had also smoked another form of tobacco (cigarettes or cigars). However, this also indicates that 41.3% (3,609/8,733) of current hookah users were not users of any other form of smoked tobacco and may have otherwise remained tobacco naïve. This may indicate that students who engage in these activities perceive waterpipe and cigarette smoking differently, despite their both involving tobacco consumption. Qualitative assessments, as well as future surveys of knowledge, normative beliefs, attitudes, and other known predictors of substance use, may help clarify if and why these activities are perceived differently. Because there is substantial overlap between waterpipe and cigarette smoking, it may be valuable for current prevention programs aimed at cigarette smokers to also include information about waterpipe tobacco smoking. However, because focusing solely on

concomitant tobacco users would fail to reach about 40% of hookah tobacco smokers, programing should also be developed specifically for individuals who only use hookah tobacco.

Among students who consume tobacco, waterpipe use appeared to occur less frequently than cigarette use, with only 35.9% of current waterpipe users versus 68.4% of current cigarette smokers reporting tobacco consumption on more than two of the past 30 days. On the one hand, cigarette smokers traditionally smoke many cigarettes per day, while waterpipe users may smoke few sessions per day. On the other hand, because one waterpipe session involves inhalation of about 100 times the smoke volume of a single cigarette, even infrequent waterpipe users may be exposed to a greater amount of toxicants than cigarette smokers (World Health Organization, 2005). In future assessments, more details about frequency of use and levels of toxicants will be necessary to estimate and compare the total exposure to toxicants associated with the different tobacco consumption behaviors.

Although tobacco-related surveillance and interventions among adolescents have universally involved cigarette, cigar, and smokeless tobacco use (Centers for Disease Control and Prevention, 2010; Johnston, O'Malley, Bachman, & Schulenberg, 2010; Kilmer et al., 2008), they have not tended to involve waterpipe use. However, the findings in our study suggest that waterpipe use is common enough among U.S. university students to be of concern and to be included in future efforts.

Our results regarding individual and institutional factors associated with waterpipe use suggest that efforts toward intervention should primarily target young White men in universities located in large cities in the western United States. However, "White" in this study included those of Middle Eastern ethnicity who may be particularly at risk. Therefore, it would be valuable for future studies to more carefully assess ethnic origin. Our results also indicate that there are several specific groups of individuals who are at especially high risk and for whom targeted educational approaches may be particularly valuable, such as bisexual individuals, fraternity/sorority members, and students with relatively poor academic achievement. But a closer examination of the data, which highlight ever use rates over 20% in nearly all sociodemographic subgroups, suggests that focusing solely on particular groups or particular types of institutions would result in missed opportunities to educate thousands of college-aged waterpipe users about the potential harms of waterpipe use.

The prevalence rates of waterpipe use suggest that it may be valuable to address this problem from a policy perspective. Today, several well-intentioned policies may actually be contributing to increases in waterpipe use (Rutten, Augustson, Doran, Moser, & Hesse, 2009; Stulhofer, Busko, & Landripet, 2010). For example, clean air laws provide specific exemptions for "tobacco retail establishments" (Tobacco Control Legal Consortium, 2011), a category under which many waterpipe-smoking establishments fall. Furthermore, while the recently enacted Family Smoking Prevention and Tobacco Control Act (signed into law in 2009) bans flavoring of cigarettes, the act does not ban flavoring of shisha, the special form of tobacco used in a waterpipe. Thus, waterpipe users can consume chocolate, strawberry, or caramel tobacco in waterpipes. Finally, while

traditional bars often deny the entrance of individuals under the age of 21, the age limit at waterpipe-smoking establishments is 18. Research on the impact that these and similar policies have on waterpipe use will be a crucial precursor to the development of improved policies that dissuade use of and exposure to all types of tobacco.

Our analysis has several limitations that deserve mention. First, although the study sample was national and large, it was not necessarily nationally representative. Schools self-select to participate, so findings may not be broadly generalizable. For example, the ACHA sample has a high proportion of female students, who are generally less likely to be tobacco users. This means that our overall estimates for waterpipe use are likely to be conservative. Second, the overall response rate for the Web-based form of the survey was only about one in five, and sociodemographic data on nonresponders are not available. However, this is a standard response rate for e-mail surveys (Morrell, Cohen, Bacchi, & West, 2005; Sax, Gilmartin, & Bryant, 2003; White, Jamieson-Drake, & Swartzwelder, 2002), prior studies have shown that ACHA data tend to match nationally representative data (Leino, 2004), and our Web-based results were similar to those of paper results, which had nearly 80% response rates. Third, the ACHA survey relied on self-report of waterpipe use and sociodemographic factors. But because the survey was confidential and waterpipe use is legal for individuals over 18 years old, students would have had little reason to be dishonest.

In conclusion, our analysis of data from a large-scale survey performed by the ACHA in 2008–2009 indicated that waterpipe tobacco smoking was common among university students in the United States. Although waterpipe users tended to be young White men in large cities of the western region of the country, use was widespread among members of multiple sociodemographic groups and in various geographic locations. Increased surveillance of this form of tobacco use and the development of interventions to curb it will be necessary to decrease the overall use of tobacco among U.S. university students.

Supplementary Material

Supplementary Tables 1 and 2 can be found online at <http://www.ntr.oxfordjournals.org>

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Declaration of Interests

The authors have no conflicts of interest to declare.

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