HOOKAH TOBACCO SMOKING AMONG U.S. COLLEGE STUDENTS

by

Brian Adam Primack

B.A., Yale University, 1991

Ed.M., Harvard University, 1993

M.D., Emory University, 1999

M.S., University of Pittsburgh, 2008

Submitted to the Graduate Faculty of

the School of Medicine in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy in Clinical and Translational Science

UNIVERSITY OF PITTSBURGH

SCHOOL OF MEDICINE

This dissertation was presented

by

Brian Adam Primack

It was defended on

September 23, 2011

and approved by

Tracey Barnett, Ph.D., Assistant Professor, University of Florida School of Public Health

Julie M. Donohue, Ph.D., Associate Professor, University of Pittsburgh School of Public Health

Michael J. Fine, M.D., M.Sc., Professor, University of Pittsburgh School of Medicine

Kevin H. Kim, Ph.D., Associate Professor, University of Pittsburgh School of Education

Dissertation Advisor: Galen E. Switzer, Ph.D., Professor, University of Pittsburgh School of Medicine

HOOKAH TOBACCO SMOKING AMONG U.S. COLLEGE STUDENTS

Brian Adam Primack, M.D., Ph.D.

University of Pittsburgh, 2011

Although cigarette smoking is decreasing in the U.S., hookah tobacco smoking (HTS) is an emerging trend associated with substantial toxicant exposures. While HTS is popular among various socio-demographic groups, it is most common among university students. Therefore, three interrelated studies were conducted to better understand this health behavior and inform future interventions to reduce it.

Cross-sectional data from over 100,000 students in 152 U.S. universities participating in the National College Health Assessment during 2008-2009 were analyzed. These data demonstrated that 30.5% and 8.4% of the sample reported HTS ever and in the past 30 days, respectively, making HTS the second most common source of tobacco. Fully adjusted multivariable models accounting for clustering of individuals within institutions showed that HTS was most strongly associated with younger age, male gender, white race, fraternity/sorority membership, and non-religious institutions in large cities in the western United States.

The sample was then partitioned using two-step cluster analysis according to current use of HTS, cigarettes, cigars, marijuana, and alcohol. A 6-cluster solution was found, and in one cluster all members had used HTS in the past 30 days. Three individual factors (gender,

undergraduate status, and fraternity/sorority membership)—but no institutional factors—were significantly associated with cluster membership.

Finally, municipal, county, and state legal texts from the largest 100 cities in the U.S. were examined in order to characterize each city's policies related to HTS. Although 73 of the 100 largest cities in the U.S. have laws that disallow cigarette smoking in bars, HTS may be allowed due to exemptions in 69 of these 73 cities. Multinomial logistic regression was used to demonstrate that, compared with cities without clean air legislation, the cities in which HTS may be exempted had denser and more politically liberal populations.

These findings suggest that, after cigarettes, HTS is now the most common form of tobacco use among university students. Because hookah use affects groups with a wide variety of individual and institutional characteristics, and because the current policy environment is permissive, it should be included with other forms of tobacco in efforts related to tobacco surveillance and intervention.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

I would like to thank my primary research mentors, Michael Fine and Madeline Dalton, for their confidence in me and their support; the members of my dissertation committee, Galen Switzer, Kevin Kim, Julie Donohue, and Tracey Barnett, for providing me with an ideal balance of challenge and encouragement; my talented and hard-working staff, Kristen Rice, Mary Carroll, Ariel Shensa, and Jaime Sidani, for making this work both possible and enjoyable; Wishwa Kapoor for providing me a supportive environment to pursue research; my parents for being outstanding role models in balancing work and family; and Micah, Sadie, and Linda for making my home a wonderful place to be. But most of all, I would like to thank Jen, my soul-mate and partner of 10 years, for all her love and support.

1.0 INTRODUCTION

The prevalence of cigarette smoking has declined in the U.S. over the past two decades.[1-3] However, tobacco smoking using a hookah (also known as a water-pipe or narghile) is an emerging trend in the U.S. that may diminish successes in reducing U.S. tobacco use.[4-7] Hookah tobacco smoke contains large amounts of toxicants. The World Health Organization estimates that one session of hookah use delivers 50-100 times the smoke volume of a single cigarette,[4] and studies indicate that the smoke from one hookah session contains about 40 times the tar,[8,9] 20 times the carcinogenic polycyclic aromatic hydrocarbons,[10] 10 times the carbon monoxide,[8,9] and 2 times the nicotine [8,9] of a single cigarette. Hookah users are exposed to these toxicants when they smoke, [11-16] and blood nicotine levels of daily users are similar to those of individuals who smoke 10 cigarettes a day.[13] As would be expected, early clinical and epidemiological studies suggest that it is associated with substantial harm and addictiveness.[4,6] Second-hand smoke exposure is also a concern: expired air from non-smokers in a hookah tobacco café is 3 times as concentrated with carbon monoxide compared with non-smokers in a regular bar allowing cigarette smoking.[17]

Despite these potential harms, multiple factors threaten to enhance widespread adoption of this form of tobacco use, including the aesthetically pleasing nature of the ritual, the belief that water somehow “filters” toxins, and lenient public health policies related to the

practice.[18,19] Because of this confluence of factors, as many as 50% of hookah tobacco users may have otherwise been nicotine naïve,[5,20,21] and it has become popular across socio-demographic factors such as gender, age, race, geographic location, and socio-economic status.[5,22-24]

To develop interventions to curb this behavior, it will be necessary to determine what characteristics are most strongly associated with hookah tobacco smoking. Although HTS is also increasing substantially among high school students and non-college populations,[21,25,26] Initially focusing on University-aged individuals is warranted because of the relative centrality of hookah tobacco smoking among this population.[19,27,28] Preliminary research among small samples suggests that about 20-40% of U.S. University students report hookah tobacco smoking in the past year, while 5-20% report use in the past 30 days.[5,22,23] Early work also suggests that the typical University user is more likely to be male, in early college, Caucasian, and living in a fraternity.[5,22,23] However, these socio-demographic associations with hookah tobacco smoking have only been reported in small, local populations; thus, it is necessary to study these associations in larger populations with stronger external validity.

In order to develop interventions, it will also be valuable to assess associations between hookah tobacco smoking and other risk behaviors such as cigarette, marijuana, and alcohol use. This is particularly important to assess in this area because prior research among small samples suggests that those who smoke hookah tobacco perceive it as very different from cigarette smoking. For example, one study demonstrated that, while most student-athletes were far *less* likely than their counterparts to smoke cigarettes, they were *more* likely than non-athletes to smoke hookah tobacco. Thus, comprehensive assessment of the clustering of hookah smoking

and other risk-taking behaviors is likely to help us characterize the at-risk population and develop maximally effective interventions.

Finally, the Social Ecological Model of health suggests that behaviors such as hookah tobacco smoking are likely to be influenced not only by individual, relationship, and community factors but also by policy-level factors.[29] Policy measures are especially important to study in this area because policy changes have been important methods of intervention for reducing cigarette use. Despite this, hookah tobacco smoking establishments are generally not affected by policy regulations aimed at reducing Americans' exposure to cigarette smoke through taxation, labeling, and/or clean air laws. Thus, a valuable first step in this area will be to perform a descriptive assessment of current tobacco-related policy measures and how they do or do not pertain to hookah tobacco smoking.

The purposes of this project are (1) to determine—in a large, national sample of U.S. University students—associations between hookah tobacco smoking and a variety of personal and environmental factors; (2) to determine in this population associations between hookah tobacco smoking and other risk-taking behaviors, such as cigarette smoking, cigar smoking, marijuana smoking, and alcohol use; and (3) to broadly assess a representative sample of current US, state, and local policies, focusing on their potential application to hookah tobacco smoking.

2.0 PREVALENCE OF AND ASSOCIATIONS WITH HOOKAH TOBACCO SMOKING AMONG COLLEGE STUDENTS IN THE U.S.

2.1 INTRODUCTION

Despite preliminary reports associating hookah tobacco smoking with cancer, cardiovascular disease, decreased pulmonary function, and nicotine dependence,[30-34] the public health impact of hookah use remains unclear. Although studies have estimated the lifetime prevalence of hookah use among young adults in the United States to be 20%-40%, these studies have generally been conducted among small or localized samples of the population.[22,23,35,36] Accurate prevalence data from large, diverse samples and comparisons with other types of tobacco use are needed to determine whether hookah 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) assesses a wide variety of content areas, including substance use, in over 100,000 university students.[37] In 2008, the NCHA became the first large survey to assess hookah 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 hookah use was assessed.

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

2.2 METHODS

2.2.1 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. This analysis of the NCHA data was approved by the University of Pittsburgh's Institutional Review Board.

The survey was administered in 2 forms.[37] 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 students outside the random sample. The paper-based survey accounted for about 20% of respondents and had a mean response rate of 78%. 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.[38]

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 non-responders were periodically sent reminders.

2.2.2 Measures

The NCHA survey assessed 4 types of tobacco use: hookah, cigarette, cigar, and smokeless tobacco. Regarding hookah use, the survey asked, "Within the past 30 days, on how many days did you use tobacco from a water pipe (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 3 other types of tobacco use, the questions were similarly worded, and the response options are identical.[37] The question related to cigar smoking specifically included "little cigars" which are commonly used in the young adult population.[39]

For each type of tobacco use, response options c through h were grouped 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, socio-demographic and other survey data routinely collected from the student were used. These data included age, gender, sexual orientation, year in school, race/ethnicity, full-time (versus part-time) status, international status, relationship status, living arrangement, fraternity/sorority membership, and estimated current grade point average in ordered categorical format (A, B, or C and below).

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 the current study were geographic region of the United States, population of the campus locale, institution type (public vs private), religious affiliation, status as a 2-year (vs 4-year) institution, and student population.

2.2.3 Analyses

Descriptive statistics were used to determine the characteristics of respondents and institutions, to determine the prevalence of current use and ever use for each of the 4 types of tobacco, and to determine the number of individuals who had engaged in more than 1 type of tobacco use. We used area-proportional Venn diagrams [40] to depict the overlap between the 3 major types of tobacco use (cigarette, hookah, and cigar).

To assess bivariable associations between hookah use and individual and institutional characteristics, we used 2-way chi-square tests. To compute effect sizes, we used Cramer's *V* statistic.[41]

To assess multivariable associations, logistic regression analyses were performed with generalized estimating equations which accounted for nesting of students within universities. Included in the models were individual and institutional characteristics that were found to have bivariable associations of $p<.10$. Because of the potential for multi-collinearity, I did not include both age and year in school. Instead, year in school was dichotomized by grouping the undergraduates together and distinguishing them from graduate students. In multivariable analyses, the transgender variable was dropped because of its extremely small frequency (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 (6885 respondents, or 6.6%).

To confirm the robustness of these results, additional analyses were conducted. 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,[42] it was tested whether this held true for multivariable analyses. Influence analysis was used to examine standardized DFBETA values for extreme cases, and it was found that these values were all below the a priori cutoff of 1.96, indicating that results were not unduly influenced by extreme cases. In addition, sensitivity analyses using bootstrapping methods were conducted with 1000 repetitions. Because all of the results (point estimates, standard deviations, and levels of significance) were similar in primary analyses and bootstrapping analyses, only the results of primary analyses are reported here.

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.

2.3 RESULTS

2.3.1 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 2909 respondents (2447 of whom were over 60 years old and 743 of whom had missing data concerning primary study outcomes) yielded a 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 non-international (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 (**Table 1**).

2.3.2 Prevalence of Tobacco Use

Regarding hookah tobacco smoking, 8846 respondents (8.4%) reported current use and 32,013 (30.5%) reported use in the past (ever use) (**Table 1**). Of the current users, the majority (64.1%) had used a hookah on 1-2 days during the past 30-day period. In contrast, during this same period, 17.5% had used a hookah 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, hookah 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, hookah, and cigar use, 8733 (8.4%) were current hookah users (**Figure 2**). In this group, 4492 (51.4%) reported no current use of cigarettes and 3609 (41.3%) reported no current use of other forms of tobacco. Of all respondents, 17,500 (16.8%) were current cigarette smokers (**Figure 2**). Among this group, 10,957 (62.6%) reported no other use of tobacco. Finally, 7741 (7.4%) reported cigar use, and 2596 (33.5%) of these individuals had not used other forms of tobacco in the past 30 days (**Figure 2**).

Of the 104,434 respondents, 31,749 (30.4%) had used a hookah at some time (**Figure 3**). In this group, 9423 (29.7%) reported never using cigarettes and 6198 (19.5%) reported never using tobacco of any kind. Of all respondents, 36,156 (34.6%) had smoked cigarettes, and 8628 (23.9%) of these cigarette smokers had not ever smoked other forms of tobacco (**Figure 3**). Of the 29,846 individuals (28.6% of the complete sample) who had smoked cigars, only 3776 (12.7%) had not smoked other forms of tobacco (**Figure 3**). In all, nearly half of the sample had ever smoked some form of tobacco (49,355, or 47.3%), and over one-third of this group (17,643, or 35.7%) had used all three forms of tobacco (cigarettes, hookah, and cigars) at least once (**Figure 3**).

Table 1. Bivariable Associations with Hookah Tobacco Smoking

Characteristic	Total Sample, No. (Column %) [*] (N = 105,012)	Current Hookah Users [†]			Ever Hookah Users [‡]		
		Row % (n = 8846)	*p* Value	Cramer's *V* Statistic	Row % (n = 32,013)	*p* Value	Cramer's *V* Statistic
Individual characteristic							
Age, y			<.001	0.119		<.001	0.134
18	15,513 (14.8)	11.3			27.2		
19	19,558 (18.6)	10.9			31.3		
20	18,127 (17.3)	11.2			35.7		
21	16,258 (15.5)	8.7			35.9		
22-25	20,729 (19.7)	6.0			31.6		
26-30	8087 (7.7)	2.9			26.2		
≥31	6740 (6.4)	0.8			10.5		
Gender			<.001	0.071		<.001	0.074
Female	68,585 (65.7)	7.0			28.1		
Male	35,688 (34.2)	11.1			35.1		
Transgender	146 (0.1)	18.5			45.2		
Sexual orientation			<.001	0.033		<.001	0.054
Heterosexual	98,653 (94.8)	8.3			30.0		
Gay/lesbian	2397 (2.3)	8.7			36.6		
Bisexual	3010 (2.9)	13.7			43.5		
Year in school			<.001	0.097		<.001	0.078
Undergraduate, year 1	25,804 (24.9)	10.8			27.4		
Undergraduate, year 2	20,176 (19.4)	10.5			32.6		
Undergraduate, year 3	20,538 (19.8)	9.0			33.5		
Undergraduate, year 4	16,445 (15.8)	7.6			34.6		
Undergraduate, year 5 or more	5006 (4.8)	5.6			31.1		

Characteristic	Total Sample, No. (Column %) [*] (N = 105,012)	Current Hookah Users [†]			Ever Hookah Users [‡]		
		Row % (n = 8846)	*p* Value	Cramer's *V* Statistic	Row % (n = 32,013)	*p* Value	Cramer's *V* Statistic
Graduate or professional	14,973 (14.4)	3.0			24.9		
Nondegree/ noncredit-seeking	912 (0.9)	3.6			21.6		
Race/ethnicity			<.001	0.049		<.001	0.105
White, non-Hispanic [§]	74,712 (71.2)	8.6			32.2		
Black, non-Hispanic	5206 (5.0)	3.6			12.9		
Hispanic	6499 (6.2)	8.9			30.3		
Asian	10,323 (9.8)	7.0			23.7		
Other [‖]	8230 (7.8)	10.9			34.9		
Full-time student			<.001	0.042		<.001	0.050
No	7537 (7.2)	4.2			22.2		
Yes	96,521 (92.7)	8.7			31.1		
International student			.02	–0.007		<.001	–0.026
No	94,569 (91.1)	8.5			30.9		
Yes	9245 (8.9)	7.8			26.6		
Relationship/marital status			<.001	0.085		<.001	0.107
Not in a relationship	50,192 (49.0)	9.9			31.9		
In a relationship, not cohabitating	37,126 (36.2)	8.6			32.2		
In relationship and cohabitating	6759 (6.6)	5.7			32.2		
Married/ partnered and cohabitating	8362 (8.2)	1.4			14.0		
Residence			<.001	0.064		<.001	0.076
Campus residence	41,554 (39.9)	10.0			29.9		

Characteristic	Total Sample, No. (Column %) [*] (N = 105,012)	Current Hookah Users [†]			Ever Hookah Users [‡]		
		Row % (n = 8846)	*p* Value	Cramer's *V* Statistic	Row % (n = 32,013)	*p* Value	Cramer's *V* Statistic
hall							
Fraternity/ sorority house	1288 (1.2)	16.9			47.4		
Parent/guardian's home	10,671 (10.2)	5.4			22.3		
Off-campus housing [¶]	50,741 (48.7)	7.5			32.3		
Member of fraternity/sorority			<.001	0.042		<.001	0.062
No	93,798 (90.5)	8.0			29.6		
Yes	9830 (9.5)	12.0			39.3		
Grades			<.001	0.053		<.001	0.055
A	40,441 (38.9)	6.6			27.3		
B	48,705 (46.8)	9.5			32.6		
C and below	14,879 (14.3)	10.0			32.2		
Institutional characteristic							
Region			<.001	0.036		<.001	0.057
Midwest	25,512 (24.3)	7.3			27.3		
Northeast	32,617 (31.1)	8.3			31.8		
South	25,807 (24.6)	8.3			28.8		
West	21,076 (20.1)	10.2			34.5		
Population of the campus locale			<.001	0.035		<.001	0.080
<10,000	9429 (9.0)	6.0			22.1		
10,000-49,999	18,331 (17.5)	8.8			30.5		
50,000-249,999	44,625 (42.5)	9.0			30.2		
250,000-499,999	5715 (5.4)	6.4			24.9		
≥500,000	26,912 (25.6)	8.5			35.0		
Institution type			.33	–0.003		<.001	–0.048

Characteristic	Total Sample, No. (Column %) [*] (N = 105,012)	Current Hookah Users [†]			Ever Hookah Users [‡]		
		Row % (n = 8846)	*p* Value	Cramer's *V* Statistic	Row % (n = 32,013)	*p* Value	Cramer's *V* Statistic
Private	42,289 (40.3)	8.5			33.2		
Public	62,723 (59.7)	8.4			28.7		
Religious affiliation			.04	0.006		.06	0.006
No	87,292 (83.1)	8.3			30.4		
Yes	17,720 (16.9)	8.8			31.1		
Two-year institution			.22	–0.004		<.001	–0.036
No	99,107 (94.4)	8.5			30.9		
Yes	5905 (5.6)	8.0			23.7		
Student population			<.001	0.027		<.001	0.054
<2,500	9745 (9.3)	9.6			33.1		
2,500-4,999	12,089 (11.5)	6.6			26.0		
5,000-9,999	21,242 (20.2)	8.4			29.3		
10,000-19,999	25,015 (23.8)	8.4			28.9		
≥20,000	36,921 (35.2)	8.7			33.0		

[*] Because of missing information, data do not always sum to the total sample size. Percentages are based on the total for each category and may not total 100 because of rounding.
[†] Defined as having smoked tobacco from a hookah during the past 30 days.
[‡] Defined as ever having smoked tobacco from a hookah.
[§] Includes Middle Eastern ethnicity.
[‖] Alaskan Native, American Indian, Hawaiian Native, biracial, and multiracial.
[¶] Includes institution-owned noncampus student residences.

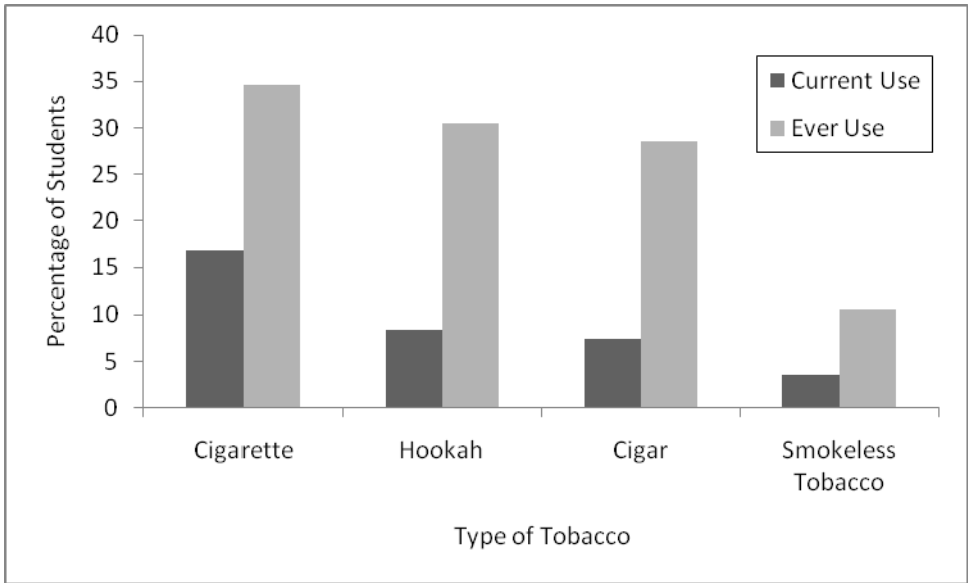

Figure 1. Tobacco Use Among College Students

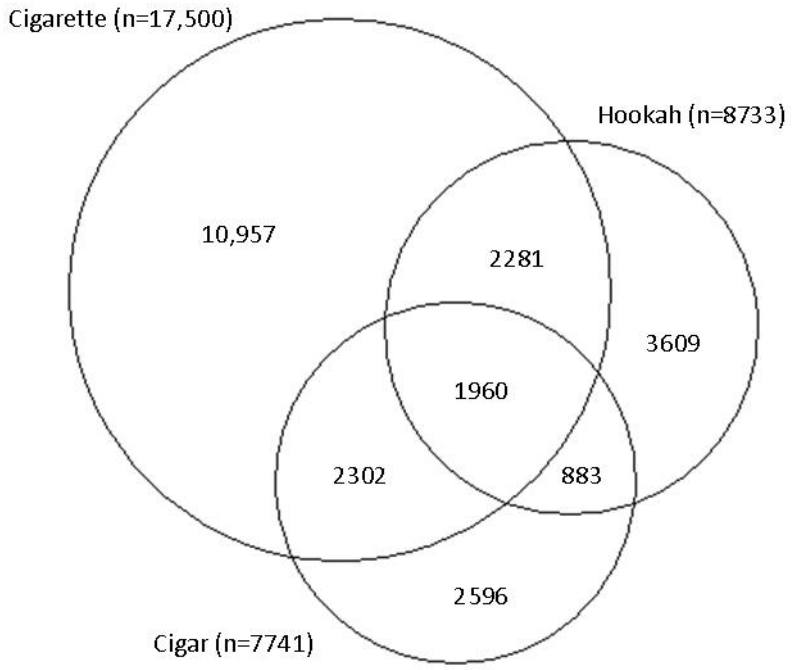

Figure 2. Area-Proportional Venn Diagram for Current Use

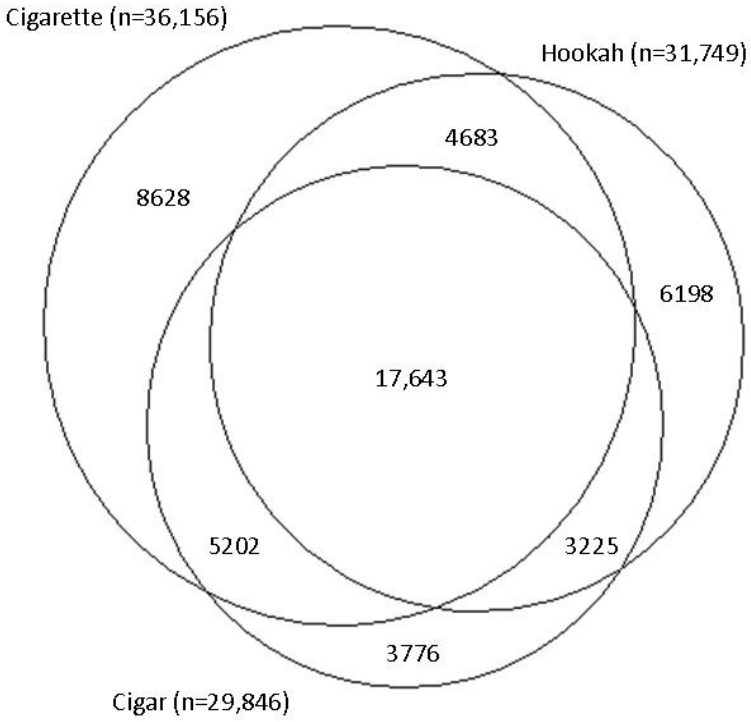

Figure 3. Area-Proportional Venn Diagram for Ever Use

2.3.3 Bivariable Analyses of Factors Associated with Hookah Use

In bivariable analyses of individual characteristics, current hookah 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 (**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 hookah 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 hookah use were found in both the smallest (<2,500) and largest (≥20,000) student populations and among institutions in the western United States (**Table 1**).

2.3.4 Multivariable Analysis of Factors Associated with Hookah Use

In fully adjusted multivariable models, current hookah use was associated with younger age, male gender, white and other race, international student status, lack of a relationship, living in a fraternity/sorority or off-campus housing, being a member of a fraternity/sorority, and having lower grades (**Table 2**).

Individual factors most strongly associated with higher odds of current hookah use were bisexual orientation (versus heterosexual; odds ratio [OR], 1.90; 95% confidence interval [CI], 1.69-2.13), male gender (versus female; OR, 1.70; 95% CI, 1.62-1.78), and living in a fraternity/sorority house (versus a campus residence hall; OR, 1.68; 95% CI=1.41-1.99). Individual factors most strongly associated with lower odds of current hookah use were age of 31 years or more (vs age 18; OR, 0.08; 95% CI, 0.06-0.11), being married (versus not in a relationship; OR, 0.38; 95% CI, 0.31-0.46), black race (versus white; OR, 0.41; 95% CI, 0.35-0.49), and graduate or other student status (versus undergraduate; OR, 0.58; 95% CI, 0.51-0.66).

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

Institutional factors independently associated with current hookah use included western region of the United States (versus midwestern; OR, 1.54; 95% CI, 1.22-1.96), larger population of campus locale (e.g., ≥500,000 vs <10,000; OR, 2.27; 95% CI, 1.62-3.20), and religious affiliation (versus no affiliation; OR, 0.72; 95% CI, 0.55-0.95). Patterns were similar for the hookah use ever category.

Table 2. Multivariable Associations with Hookah Tobacco Smoking

Characteristic	Odds Ratio (95% Confidence Interval)	
	Current Hookah Users [†]	Ever Hookah Users [‡]
Individual characteristic		
Age, y		
18	1 [Reference]	1 [Reference]
19	0.94 (0.87-1.01)	1.14 (1.08-1.20)
20	0.87 (0.81-0.94)	1.24 (1.18-1.31)
21	0.66 (0.61-0.73)	1.20 (1.13-1.27)
22-25	0.49 (0.44-0.54)	1.02 (0.96-1.09)
26-30	0.28 (0.24-0.34)	0.80 (0.74-0.87)
≥31	0.08 (0.06-0.11)	0.32 (0.29-0.36)
Gender [§]		
Female	1 [Reference]	1 [Reference]
Male	1.70 (1.62-1.78)	1.43 (1.39-1.48)
Sexual orientation		
Heterosexual	1 [Reference]	1 [Reference]
Gay/lesbian	1.02 (0.87-1.19)	1.20 (1.10-1.32)
Bisexual	1.90 (1.69-2.13)	1.81 (1.67-1.97)
Year in school		
Undergraduate	1 [Reference]	1 [Reference]
Other [‖]	0.58 (0.51-0.66)	0.75 (0.70-0.80)
Race/ethnicity		
White, non-Hispanic [¶]	1 [Reference]	1 [Reference]
Black, non-Hispanic	0.41 (0.35-0.49)	0.34 (0.31-0.37)
Hispanic	0.91 (0.83-1.01)	0.83 (0.78-0.88)
Asian	0.73 (0.67-0.80)	0.56 (0.53-0.59)
Other [**]	1.10 (1.01-1.20)	0.99 (0.94-1.04)
Full-time student		
No	1 [Reference]	1 [Reference]
Yes	1.05 (0.92-1.19)	1.08 (1.01-1.15)

Characteristic	Odds Ratio (95% Confidence Interval)	
	Current Hookah Users [†]	**Ever Hookah Users** [‡]
International student		
No	1 [Reference]	1 [Reference]
Yes	1.11 (1.02-1.22)	0.85 (0.81-0.90)
Relationship/marital status		
Not in a relationship	1 [Reference]	1 [Reference]
In a relationship, not cohabitating	0.93 (0.89-0.98)	1.04 (1.01-1.08)
In a relationship and cohabitating	0.70 (0.62-0.79)	0.95 (0.90-1.01)
Married/partnered and cohabitating	0.38 (0.31-0.46)	0.53 (0.49-0.57)
Residence		
Campus residence hall	1 [Reference]	1 [Reference]
Fraternity/sorority house	1.68 (1.41-1.99)	1.58 (1.39-1.80)
Parent/guardian's home	0.62 (0.56-0.69)	0.74 (0.70-0.79)
Off-campus housing [††]	1.35 (1.26-1.44)	1.47 (1.41-1.53)
Member of fraternity/sorority		
No	1 [Reference]	1 [Reference]
Yes	1.44 (1.33-1.55)	1.45 (1.38-1.52)
Grades		
A	1 [Reference]	1 [Reference]
B	1.30 (1.22-1.36)	1.28 (1.24-1.32)
C and below	1.48 (1.37-1.59)	1.42 (1.35-1.49)
Institutional characteristic (No. of institutions) [‡‡]		
Region		
Midwest (42)	1 [Reference]	1 [Reference]
Northeast (44)	1.20 (0.95-1.53)	1.28 (1.04-1.56)
South (38)	1.08 (0.87-1.34)	1.13 (0.94-1.36)
West (28)	1.54 (1.22-1.96)	1.62 (1.32-1.99)
Population of the campus locale		
<10,000 (24)	1 [Reference]	1 [Reference]

Characteristic	Odds Ratio (95% Confidence Interval)	
	Current Hookah Users [†]	Ever Hookah Users [‡]
10,000-49,999 (9)	1.64 (1.21-2.23)	1.66 (1.28-2.15)
50,000-249,999 (66)	1.69 (1.27-2.25)	1.66 (1.30-2.11)
250,000-499,999 (33)	1.65 (1.09-2.52)	1.58 (1.11-2.26)
≥500,000 (20)	2.27 (1.62-3.20)	2.36 (1.77-3.15)
Institution type		
Private (60)	1 [Reference]	1 [Reference]
Public (92)	0.84 (0.64-1.11)	0.72 (0.57-0.90)
Religious affiliation		
No (124)	1 [Reference]	1 [Reference]
Yes (28)	0.72 (0.55-0.95)	0.75 (0.60-0.94)
Two-year institution		
No (142)	1 [Reference]	1 [Reference]
Yes (10)	0.98 (0.69-1.40)	0.80 (0.60-1.08)
Student population		
<2,500 (24)	1 [Reference]	1 [Reference]
2,500-4,999 (21)	0.84 (0.61-1.15)	0.76 (0.58-0.99)
5,000-9,999 (33)	0.82 (0.61-1.10)	0.77 (0.60-0.99)
10,000-19,999 (40)	0.85 (0.62-1.18)	0.86 (0.65-1.14)
≥20,000 (34)	0.93 (0.66-1.32)	0.97 (0.72-1.32)

[*] Analyses were adjusted for all variables listed in the table.
[†] Defined as having smoked tobacco from a hookah during the past 30 days.
[‡] Defined as ever having smoked tobacco from a hookah.
[§] Because of the small sample size, transgender was not included in multivariable analyses.
[||] Graduate, professional, and nondegree/noncredit-seeking students.
[¶] Includes Middle Eastern ethnicity.
[**] Alaskan Native, American Indian, Hawaiian Native, biracial, and multiracial.
[††] Includes institution-owned noncampus student residences.
[‡‡] The total number of institutions was 152.

2.4 DISCUSSION

This analysis of data from the NCHA survey of over 100,000 respondents estimated the prevalence of hookah tobacco 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 hookah use was the second most frequent after cigarette use and that over half of current hookah users are not also current cigarette smokers. While hookah 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).

The prevalence rate for ever use was consistent with previous reports demonstrating ever use to be 20%-40% in various U.S. populations.[22,23,35,36] Although the prevalence rate for current use was somewhat lower than previously reported in small samples,[22,23,35,36] it was consistent with previous estimates in relatively large samples.[43] The findings are also consistent with previous reports suggesting that many hookah users are not engaged in other forms of tobacco use. In this study population, for example, over half (51.4%) of current hookah users were not also current cigarette smokers. This suggests that students perceive the 2 activities as different, despite their both involving tobacco consumption. However, when examining the outcome of ever use, there was substantial overlap between the different forms of tobacco. For example, of the many individuals (47,355) who had smoked at least one form of tobacco in

her/her lifetime, over one-third had used all three major forms (cigarettes, cigars, and hookah) at least once. Qualitative assessments, as well as future surveys of knowledge, normative beliefs, attitudes, and other known predictors of substance use, may help clarify whether and in what ways these activities are perceived differently.

Among students who consume tobacco, hookah use appeared to occur less frequently than cigarette use, with 64.1% of current hookah users versus 31.6% of current cigarette smokers reporting tobacco consumption during only 1-2 of the past 30 days. On the one hand, cigarette smokers traditionally smoke many cigarettes per day, while hookah users may smoke few sessions per day. On the other hand, because one hookah session involves inhalation of 50-100 times the smoke volume of a single cigarette, even infrequent hookah users may be exposed to a greater amount of toxicants than cigarette smokers.[4] 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,[2,44-46] they have not tended to involve hookah use. However, the findings in our study suggest that hookah use is common enough among U.S. university students to be of concern and to be included in future efforts.

Results regarding individual and institutional factors associated with hookah use suggest that efforts toward intervention should primarily target young white men in universities located in large cities in the western United States. They 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 socio-demographic subgroups, suggests that focusing solely on particular groups or particular types of institutions would result in missed opportunities to educate thousands of college-aged hookah users about the potential harms of hookah use.

The prevalence rates of hookah 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 hookah use. For example, clean air laws provide specific exemptions for "tobacco retail establishments"[47] – a category under which many hookah-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 hookah. Thus, hookah users can consume chocolate, strawberry, or caramel shisha in hookahs. Finally, while traditional bars often deny the entrance of individuals under the age of 21, the age limit at hookah-smoking establishments is 18. Research on the impact that these and similar policies have on hookah use will be a crucial precursor to the development of improved policies that dissuade use of and exposure to all types of tobacco.

2.4.1 Limitations

This 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 hookah use are likely to be conservative. Second, the overall response rate for the Web-based form of the survey was only about 1 in 5. However, this is a standard response rate for e-mail surveys,[48-50] prior studies have shown that ACHA data tend to match nationally representative data,[42] 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 hookah use and socio-demographic factors. But because the survey was confidential and hookah use is legal for individuals over 18 years old, students would have had little reason to be dishonest.

Additionally, it is important to acknowledge limitations of the primary outcome measures selected. Although ever use and current (30-day use) are frequently used outcomes for assessing adolescent substance use,[2,44-46] these measures do not capture frequency of use, which can be a more accurate representation of problem use. It may therefore be valuable for future studies of hookah tobacco smoking to focus on measures assessing frequency and/or heavy use as outcomes.

2.4.2 Conclusion

In conclusion, this analysis of data from a large-scale survey performed by the ACHA in 2008-2009 indicated that hookah tobacco smoking was common among university students in the United States. Although hookah users tended to be young white men in large cities of the western region of the country, use was widespread among members of multiple socio-demographic 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.

3.0 HOOKAH TOBACCO SMOKING AND OTHER RISK BEHAVIORS AMONG U.S. COLLEGE STUDENTS

3.1 INTRODUCTION

Tobacco, alcohol, and marijuana are the substances most abused by university students.[51-53] They are also substantial sources of morbidity and mortality in this population.[54-57] Because individuals who use one of these substances often use others, many public health interventions aimed at university students address multiple substances simultaneously.[58-61] These interventions often target specific types of individuals, such as white male fraternity students, who are at higher risk for substance use in general.[61-63]

However, it is also the case that many individuals use one of these substances but not the others.[54,64-68] For example, over the past decade, tobacco use has differentiated into different forms, each of which draws a distinct set of users. While cigarette use has recently declined,[2,3] smoking tobacco with a hookah (waterpipe, narghile, or shisha-pipe) is an emerging trend among college students, and as many as 50% of hookah smokers do not smoke cigarettes.[22,23,35] Similarly, cigar and little cigar (cigarillo) use are increasing in this population, and cigar use only partially overlaps with cigarette use.[69,70]

Social marketing, a framework for the development of public health interventions,

applies the principles of commercial marketing to promote healthier behaviors, such as avoidance of substance abuse. This framework states that, in order for interventions to be maximally effective, it is important to carefully tailor to "target markets" for intervention according to socio-demographic, personal, and environmental characteristics.[71-74] For example, tobacco industry documents describe the use of segmentation of the US population into specific subgroups for whom different, successful products were developed.[75-77] In order to optimally develop and target public health related campaigns to reduce substance use, it is similarly important to segment populations by substance use behaviors and then carefully describe the socio-demographic, personal, and environmental characteristics of each "market." A specific statistical technique called cluster analysis is one method, commonly used by commercial marketers, to reliably divide a large group of observations into subsets according to selected characteristics.[78-80]

This study had two primary purposes. First, it aimed to utilize the systematic method of cluster analysis in order to group individuals in a large, national sample of college students according to profiles based on substance use behavior. Second, it aimed to compare the individual and institutional makeup of these groups.

3.2 METHODS

3.2.1 Participants and Procedures

Each year, the National College Health Assessment (NCHA) of the American College Health Association (ACHA) assesses a wide variety of content areas, including substance use, in over 100,000 university students.[37] The NCHA is considered to be a reliable and valid assessment of college student health perceptions and behaviors, and its data has been examined frequently in peer-reviewed journal articles. [35,43,81]

In 2008, the NCHA became the first large survey to assess hookah tobacco smoking along with cigarette, cigar, marijuana, and alcohol use. 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 hookah use was assessed.

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

The survey was administered in 2 forms.[37] A paper 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 identified by their institution. The e-mail invitation included an embedded unique respondent identification number, which allowed the ACHA to prevent duplicate responses from the same student or students outside the random sample. The paper-

based survey accounted for about 20% of respondents and had a mean response rate of 78%. 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.[38]

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 non-responders were periodically sent reminders.

3.2.2 Measures

3.2.2.1 Smoking Behavior

The survey assessed cigarette, hookah, cigar, and marijuana use with similarly-worded items assessing frequency of use over the past 30 days. The response options for each substance 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.[37] The question related to cigar smoking specifically included "little cigars" which are commonly used in the young adult population.[39] For each of these substance use types, we grouped response options c through h into the category called "current use" (at least one day over the past month) which is considered the gold standard of substance use behavior in this population.[82]

3.2.2.2 Alcohol Bingeing

The primary measure of alcohol use was bingeing, defined as having consumed ≥4 drinks in a single sitting for females—and ≥5 for males—in the past 30 days.[81,83,84] This outcome was selected instead of ever use or current use because bingeing is more clinically relevant.[81,83,84]

3.2.2.3 Individual Variables

To assess individual characteristics associated with substance use profiles, socio-demographic and other survey data routinely collected from students on the NCHA were used. These data included age, gender, sexual orientation, enrollment status (i.e. undergraduate vs. non-undergraduate), race/ethnicity, full-time (vs. part-time) status, international status, relationship status, living arrangement, fraternity/sorority membership, and self-reported estimated current grade point average.

3.2.2.4 Institutional Variables

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

3.2.3 Analyses

The Two-Step cluster analysis within SPSS was used to partition the sample.[85,86] This algorithm, which has been available in SPSS versions 11.5 and above, was specifically developed to correct methodological limitations of two prior algorithms: *k*-means clustering and hierarchical agglomerative techniques.[86] It was also designed to accommodate particularly large

data sets.[86] The sample was partitioned based on five dichotomous variables representing each of the behaviors of interest in the past 30 days: smoking of cigarettes, hookah, cigars, and marijuana, and alcohol bingeing. The algorithm utilizes a log-likelihood distance measure.[85,86]

In order to determine the optimal number of clusters, the Two-Step cluster analysis automatic clustering function was used. Output associated with the algorithm provides Schwarz's Bayesian Criterion (BIC) for each potential number of clusters, the change in BIC from the prior to the current number of clusters, the ratio of BIC changes, and the subsequent ratio of those distance measures. The optimal number of clusters is usually associated with the largest ratio of distance measures.[85,86] In this case, the largest ratio of distance measures was associated with a two-cluster solution only separating ever-users of any substance from non-users (**Table 3**). Because this solution did not help achieve the study goal of partitioning the sample according to various types of substance use, we selected the six-cluster solution, which was associated with the second-largest ratio of distance measures (**Table 3**). I verified the face-validity of the six-cluster solution by computing proportions of dependent variables in each cluster. Each cluster contained at least one 100% or 0% figure, suggesting good face validity.

To assess associations between cluster membership and individual and institutional characteristics, 2-way chi-square tests were used. Cramer's *V* was also computed in order to examine effect sizes. Statistical analyses were performed with Stata 11.1 (Stata Corporation, College Station, Texas), and two-tailed *p* values of <.05 were considered to be significant.

Table 3. Determination of Clusters

Number of Clusters	Schwarz's Bayesian Criterion (BIC)	BIC Change from Prior Cluster	Ratio of BIC Changes	Ratio of Distance Measures
1	460,283			
2	279,190	-181,094	1.000	2.467*
3	205,820	-73,369	0.405	1.923
4	167,695	-38,126	0.211	1.099
5	133,020	-34,675	0.191	1.244
6	105,147	-27,873	0.154	2.144†
7	92,179	-12,968	0.072	1.225
8	81,604	-10,575	0.058	1.077
9	71,794	-9,811	0.054	1.020
10	62,172	-9,622	0.053	1.054
11	53,042	-9,130	0.050	1.343
12	46,260	-6,781	0.037	1.396
13	41,420	-4,841	0.027	1.000
14	36,580	-4,839	0.027	1.160
15	32,417	-4,164	0.023	1.097

* This was the largest ratio. However, because two clusters were not sufficient to achieve study aims, this solution was not acceptable.

† This was the second-largest ratio. Therefore, it was selected as the solution.

3.3 RESULTS

3.3.1 Participants

The sample consisted of the 111,245 individuals from 158 institutions who had complete data for each of the five dichotomous outcomes of interest. In this sample, the mean age was 22.1 years (SD=5.5), and the majority of respondents were female (65.9%), white (71.1%), full-time (92.9%), and non-international (91.1%). Most of them attended public (61.9%), nonreligious (84.0%) institutions. A minority attended universities outside the US (5.2%), with the remainder roughly equally representing the midwestern, northeastern, southern, and western regions of the U.S. (**Table 4**).

3.3.2 Description of Clusters

Cluster analysis yielded a six-cluster solution (**Table 5**). The largest cluster, labeled "Abstainers," represented more than half of the sample (n=59,041, 54.0%); none of them reported any of the five behaviors of interest. The second-largest cluster was labeled "Drinkers" and consisted of the 18,718 (17.1%) individuals who had binged on alcohol in the past 30 days but had not smoked any substance. All individuals in the third-largest cluster, "Marijuana Users," had smoked marijuana. Although none of these 10,135 individuals (9.3%) had smoked hookah tobacco or cigars, 38% and 69% had smoked cigarettes or binged on alcohol,

respectively. All 7,945 (7.3%) members of the next-largest cluster, “Cigar Smokers,” had smoked cigars in the past 30 days, and subsets of this group ranging in size from 36% to 70% had used each of the other substances. The 7,561 (6.9%) “Traditional Smokers” had all smoked cigarettes. Just over half (54%) of these individuals had binged on alcohol, yet none of them smoked any other substance. Finally, “Drawn to Hookah” was the smallest cluster, consisting of 6,015 (5.5%) from the sample. All of these individuals had smoked hookah tobacco in the past 30 days and none had smoked cigars. However, cigarette, marijuana, and binge alcohol use were reported among 39%, 43%, and 62% of them, respectively.

Table 4. Demographic Variables by Cluster Membership

	All Partici-pants	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**		
		Abstain-ers	**Drawn to hookah**	**Mari-juana Users**	**Tradi-tional Smokers**	**Drinkers**	**Cigar Aficion-ados**		
	N = 111,245	**n = 59,041 (54.0%)**	**n = 6,015 (5.5%)**	**n = 10,135 (9.3%)**	**n = 7,561 (6.9%)**	**n = 18,718 (17.1%)**	**n = 7,945 (7.3%)**	***P***	***V***
Personal characteristic	**n (%)**								
Age								<.001	0.096
18	16,311 (14.7)	16.0	18.5	13.6	7.4	11.4	18.1		
19	20,691 (18.6)	18.7	23.1	19.8	11.5	16.8	23.5		
20	19,199 (17.3)	16.5	23.0	19.1	13.5	17.3	20.3		
21	17,088 (15.4)	13.2	16.7	17.5	14.5	21.0	15.6		
22-25	22.197 (20.0)	19.0	15.2	21.0	25.9	23.2	16.7		
26-30	8,617 (7.8)	8.2	3.0	6.4	15.3	7.1	3.8		
>= 31	7,142 (6.4)	8.5	0.6	2.8	11.9	3.3	2.1		
Gender*								<.001	0.182
Female	72,760 (65.9)	71.5	62.6	63.0	68.4	61.4	39.0		
Male	37,703 (34.1)	28.5	37.4	37.0	31.7	38.6	61.0		
Sexual orientation								<.001	0.055
Heterosexual	104,508 (94.8)	95.7	93.0	92.1	91.5	96.3	93.3		
Gay/Lesbian	2,540 (2.3)	2.0	2.6	2.9	4.2	1.9	2.4		
Bi-sexual	3,176 (2.9)	2.3	4.5	5.0	4.3	1.8	4.2		

	All Partici-pants	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**		
		Abstain-ers	**Drawn to hookah**	**Mari-juana Users**	**Tradi-tional Smokers**	**Drinkers**	**Cigar Aficion-ados**		
	N = 111,245	**n = 59,041 (54.0%)**	**n = 6,015 (5.5%)**	**n = 10,135 (9.3%)**	**n = 7,561 (6.9%)**	**n = 18,718 (17.1%)**	**n = 7,945 (7.3%)**	***P***	***V***
Enrollment Status								<.001	0.121
Undergraduate	93,128 (84.6)	81.9	93.4	89.9	79.9	85.6	94.1		
Non-under-graduate[†]	16,902 (15.4)	18.1	6.6	10.1	20.1	14.4	5.9		
Race/ethnicity								<.001	0.081
White, Non-Hispanic[‡]	79,075 (71.1)	65.8	72.6	78.1	75.9	79.7	76.8		
Black, Non-Hispanic	5,383 (4.8)	6.5	2.1	3.3	2.2	2.7	3.6		
Hispanic	6,634 (6.0)	6.6	6.1	5.3	5.0	4.9	5.4		
Asian	11,247 (10.1)	13.1	8.9	4.3	9.2	6.9	5.0		
Other[§]	8,863 (8.0)	8.1	10.3	9.1	7.8	5.8	9.1		
Full-time student								<.001	0.070
No	7,845 (7.1)	8.0	3.4	5.9	11.0	5.4	4.8		
Yes	102,395 (92.9)	92.0	96.6	94.1	89.0	94.6	95.2		
International student								<.001	0.056
No	100,160 (91.1)	90.1	90.9	94.1	88.8	92.4	93.9		
Yes	9,823 (8.9)	9.9	9.1	5.9	11.3	7.7	6.1		
Relationship/ marital status								<.001	0.087
Not in a relationship	53,185 (49.1)	47.4	56.5	50.5	45.1	49.5	56.4		

	All Partici-pants	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**		
		Abstain-ers	**Drawn to hookah**	**Mari-juana Users**	**Tradi-tional Smokers**	**Drinkers**	**Cigar Aficion-ados**		
	N = 111,245	**n = 59,041 (54.0%)**	**n = 6,015 (5.5%)**	**n = 10,135 (9.3%)**	**n = 7,561 (6.9%)**	**n = 18,718 (17.1%)**	**n = 7,945 (7.3%)**	***P***	***V***
In a relationship, not cohabitating	39,228 (36.2)	35.6	37.7	37.0	32.6	39.2	34.9		
In a relationship and cohabitating	7,108 (6.6)	5.9	4.4	8.9	11.1	6.5	5.7		
Married/ partnered and cohabitating	8,904 (8.2)	11.1	1.5	3.6	11.2	4.8	3.1		
Residence								<.001	0.091
Campus residence hall	42,665 (38.6)	40.6	45.4	35.6	23.5	35.9	44.3		
Fraternity/ sorority house	1,301 (1.2)	0.6	2.0	1.7	1.1	2.0	2.5		
Parent/ guardian's home	12,692 (11.5)	14.1	7.9	8.8	10.6	8.0	7.7		
Other[‖]	53,785 (48.7)	44.8	44.8	53.8	64.9	54.1	45.5		
Member of fraternity/ sorority								<.001	0.104
No	99,758 (90.9)	93.5	87.9	89.2	90.8	86.3	87.3		
Yes	10,014 (9.1)	6.5	12.1	10.8	9.2	13.7	12.7		
Grades								<.001	0.085
A	42,214 (38.3)	43.2	32.4	31.3	33.9	36.1	26.4		
B	51,584 (46.8)	43.5	51.7	51.0	49.5	50.0	53.6		
C and below	16,367	13.4	15.9	17.8	17.6	14.0	20.0		

	All Partici-pants	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**		
		Abstain-ers	**Drawn to hookah**	**Mari-juana Users**	**Tradi-tional Smokers**	**Drinkers**	**Cigar Aficion-ados**		
	N = 111,245	**n = 59,041 (54.0%)**	**n = 6,015 (5.5%)**	**n = 10,135 (9.3%)**	**n = 7,561 (6.9%)**	**n = 18,718 (17.1%)**	**n = 7,945 (7.3%)**	***P***	***V***
	(14.9)								
Environmental characteristic									
(n Institutions)[¶]									
Region								<.001	0.055
Midwest (42)	25,604 (23.0)	21.0	19.4	20.0	28.5	29.1	25.4		
Northeast (44)	32,748 (29.4)	29.3	31.9	32.9	29.6	29.4	24.8		
South (38)	25,941 (23.3)	24.4	22.3	21.2	22.2	20.3	26.9		
West (28)	21,181 (19.0)	20.1	23.6	19.1	15.2	15.4	19.3		
Outside U.S. (6)	5,771 (5.2)	5.3	2.8	6.9	4.5	5.8	3.7		
Locale population								<.001	0.040
<10,000 (28)	9,460 (8.5)	9.3	5.5	5.9	7.3	8.5	9.9		
10,000-49,999 (9)	18,401 (16.5)	15.6	16.8	17.5	16.0	18.1	19.0		
50,000-249,999 (68)	46,851 (42.1)	40.7	44.3	45.9	43.7	41.6	45.6		
250,000-499,999 (33)	5,736 (5.2)	5.7	4.0	3.7	5.3	4.9	4.9		
>= 500,000 (20)	30,797 (27.7)	28.8	29.4	27.0	28.9	26.9	20.6		
Institution type								<.001	0.034
Private (60)	42,444 (38.2)	38.9	41.0	36.4	34.6	38.8	35.1		

	All Partici-pants	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6		
		Abstain-ers	Drawn to hookah	Mari-juana Users	Tradi-tional Smokers	Drinkers	Cigar Aficion-ados		
	N = 111,245	n = 59,041 (54.0%)	n = 6,015 (5.5%)	n = 10,135 (9.3%)	n = 7,561 (6.9%)	n = 18,718 (17.1%)	n = 7,945 (7.3%)	*P*	*V*
Public (98)	68,801 (61.9)	61.1	59.0	63.6	65.4	61.2	64.9		
Religious affiliation								<.001	0.040
No (130)	93,466 (84.0)	83.7	83.5	87.5	86.6	82.8	82.2		
Yes (28)	17,770 (16.0)	16.3	16.5	12.5	13.4	17.2	17.8		
Two-year institution								<.001	0.061
No (148)	105,293 (94.7)	95.0	95.6	93.9	90.3	96.1	94.0		
Yes (10)	5,952 (5.4)	5.0	4.4	6.1	9.7	3.9	6.0		
Student population								<.001	0.033
< 2,500 (24)	9,790 (8.8)	8.6	10.0	10.3	6.8	7.8	11.3		
2,500-4,999 (21)	12,134 (10.9)	11.3	8.4	9.2	11.5	11.6	10.2		
5,000-9,999 (34)	22,200 (20.0)	20.1	19.2	19.4	16.6	20.7	22.2		
10,000-19,999 (42)	26,828 (24.1)	23.1	23.3	24.7	27.6	25.3	25.1		
>= 20,000 (37)	40,293 (36.2)	36.9	39.1	36.5	37.5	34.6	31.3		

[*] Because of the small sample size, transgender was not included in multivariable analyses.
[†] Graduate, professional, and nondegree/noncredit-seeking students.
[‡] Includes Middle Eastern ethnicity.
[§] Alaskan Native, American Indian, Hawaiian Native, biracial, and multiracial.
[||] Includes institution-owned noncampus student residences.
[¶] The total number of institutions was 158.

3.3.3 Comparison with the Complete Sample of College Students

Compared with those in the complete sample, Abstainers had a higher percentage that was female (71.5% vs. 65.9%). They also had a higher percentage that were non-undergraduates (18.1% vs. 15.4%), Asian (13.1% vs. 10.1%), international students (9.9% vs. 8.9%) and those who were married (11.1% vs. 8.2%). Compared with those in the complete sample, they had a lower percentage that were White (65.8% vs. 71.1%) or members of fraternities/sororities (6.5% vs. 9.1%). In addition, compared with the complete sample Abstainers had a higher percentage that estimated their grade point average as "A" (43.2% vs. 38.3%). The institutional demographics of Abstainers were not substantially different from those of the complete sample (**Table 4**).

"Drawn to Hookah" was the youngest cluster. While 81.3% of the Drawn to Hookah cluster was aged 21 and under, this was only true for 66% of the complete sample. The Drawn to Hookah cluster also had a lower percentage of students that were non-undergraduate (6.6% vs. 15.4%), Black (2.1% vs. 4.8%), part-time (3.4% vs. 7.1%), or married (1.5% vs. 8.2%). Compared with the whole sample, they had more involvement in fraternities/sororities and poorer grades (**Table 4**). In addition, a higher percentage of these students attended institutions located in the West (23.6% vs. 19.0%).

The "Marijuana Users" cluster had a higher percentage of White (78.1% vs. 71.1%) and bisexual (5.0% vs. 2.9%) students compared with the complete sample. In addition, this cluster had a lower percentage of international (5.9% vs. 8.9%), married (3.6% vs. 8.2%), or "A" students (31.3% vs. 43.2%). Compared with the complete sample, a higher percentage of

students within this cluster attended institutions from the Northeast (32.9% vs. 29.3%) (**Table 4**).

"Traditional Smokers" were the oldest group, with a higher percentage of students aged 22 and older (53.1%) compared to the complete sample (35.7%). Additionally, this cluster had a greater percentage of students who were female (68.4% vs. 65.9%), non-undergraduate (20.1% vs. 15.4%), and/or part-time (11.0% vs. 7.1%) students. They were also more likely to be married or cohabitating (11.2% vs. 8.2%) off-campus (64.9% vs. 48.7%). Interestingly, they had poorer self-reported grades than the sample as a whole (**Table 4**). In addition, there were a greater percentage of students from this cluster in the Midwest (28.5% vs. 23.0%) and in the West (15.2% vs. 19.0%).

Compared with those in the complete sample, "Drinkers" were more commonly ages 21 (21.0% vs. 15.4%) or 22-25 (23.2% vs. 20.0%). They were more frequently male (38.6% vs. 34.1%), White (79.7% vs. 71.1%), fraternity/sorority members (13.7% vs. 9.1%). In addition, there were a smaller percentage of these students who were Asian (6.9% vs. 10.1%) or married (4.8% vs. 8.2%). Compared with the complete sample, these individuals were more frequently from the Midwest (29.1% vs. 23.0%) and less frequently from the West (15.4% vs. 19.0%).

"Cigar Smokers" were substantially male (61.0% vs. 34.1%) when compared with the overall sample. This cluster also had a smaller percentage of non-undergraduate students (5.9% vs. 15.4%), Asians (5.0% vs. 10.1%), international students (6.1% vs. 8.9%), or married/partnered students (3.1% vs. 8.2%). Compared to the complete sample, however, there was a greater percentage of these students living in a campus residence hall (44.3% vs.

38.6%) or a fraternity/sorority house (2.5% vs. 1.2%), reporting grades "C" or below (20.0% vs. 14.9%), or attending institutions in the South (26.9% vs. 23.3%).

3.3.4 Associations of Cluster Membership with Individual and Institutional Variables

Two-way chi-square analyses were conducted for each of the 11 personal variables as well as for the 6 institutional yielded significant results ($p<0.001$) for all variables, suggesting a significant relationship between each variable and cluster membership. However, due to the large size of the data set, Cramer's *V* effect sizes were also computed to assess the magnitude, producing small effect sizes for only three personal factors: gender (V=0.182); enrollment status (V=0.121); and fraternity/sorority membership (V=0.104). Among the six clusters, the group with the highest percentage of males was "cigar Smokers" (61%) and the group with the highest percentage of females was the "Abstainers" (71.5%). "Cigar Smokers" also had the highest percentage of undergraduate students (94.1%), while the "traditional smokers" group had the highest percentage of non-undergraduates, who were mainly graduate students (20.1%). The "Drinkers" cluster had the highest percentage of fraternity/sorority members (13.7%), while the "Abstainers" had the highest percentage of non-fraternity/sorority members (93.5%). All other variables, both personal and institutional, had negligible effect sizes, and thus little practical significance (**Table 4**).

Table 5. Description of the Six Clusters

Cluster	N (Column %)	Hookah*	Cigarette*	Cigar*	Marijuana*	Binge Alcohol†	Label
1	59,041 (54.0)	0%	0%	0%	0%	0%	Abstainers
2	6,015 (5.5)	100%	39%	0%	43%	62%	Drawn to Hookah
3	10,135 (9.3)	0%	38%	0%	100%	69%	Marijuana Users
4	7,561 (6.9)	0%	100%	0%	0%	54%	Traditional Smokers
5	18,718 (17.1)	0%	0%	0%	0%	100%	Drinkers
6	7,945 (7.3)	36%	55%	100%	44%	70%	Cigar Smokers

*Use of the substance in the past 30 days.
†Five or more drinks in a single sitting (four for females) in the past 2 weeks.

3.4 DISCUSSION

This analysis of a large group of university students finds that about half can be grouped into one large cluster, none of whom had any of our substance use outcomes of interest in the past 30 days. It finds that the remaining individuals can be divided into smaller clusters, each of which was characterized by 100% having used a particular substance. Although three personal factors (gender, enrollment status, and fraternity/sorority membership) were associated with cluster membership in small effect sizes, the remaining personal factors and the institutional factors were found to have little to no practical significance when examining the demographics of cluster membership.

Our results are consistent with others who have found that many of these risk behaviors cluster together[51-53,87] in that the clustering algorithm first separated those with any substance use from those with none. However, ultimately the algorithm revealed a number of clusters of individuals who exhibited specific risk behavior profiles. For example, “Traditional Smokers”

had all smoked cigarettes in the past thirty days, but none of them had used marijuana, hookah and cigars. However, half (54%) of them had participated in binge drinking. This suggests that students belonging to this cluster might not only benefit from education and intervention focused on cigarette smoking, but may also benefit from simultaneous alcohol-related materials. Similar prevention and intervention efforts might be aimed at the "Cigar Smokers," of whom 100% smoked cigars within the past 30 days, but also 70% who had binged on alcohol, 44% who had used marijuana, and 91% who had used one of the other forms of tobacco (i.e., hookah and cigarettes).

It is interesting to note that more than half of the sample fell into the "Abstainers" category. While popular press can emphasize the relative universality of substance use among college students, the "Abstainers" category was by far the largest cluster obtained. Consistent with prior research, membership in this cluster was associated with female gender, while also containing higher percentages of Asian students and students with better grades compared to the general student population.[51,65,69,82,84]

Findings regarding the "Drawn to Hookah" cluster may help guide development of interventions to curb this emerging form of substance use. Knowing that this cluster had higher percentages of young, White, male, single undergraduates compared to the student population as a whole may help target educational materials so they will reach those at most risk. Fraternity/sorority members may also be valuable to target. However, it is important to note that these are only tendencies, and that many members of other socio-demographic groups also use hookah tobacco. Ultimately, comprehensive intervention will require a multifaceted approach aimed at reaching a large variety of individuals.

It is interesting that, among the many institutional variables, none was consistently associated with cluster membership. For example, although we found that individuals in the Western US seemed less involved with more established forms of substance use ("Traditional Smokers" and "Drinkers") but more likely to embrace the new phenomenon of hookah tobacco smoking, association between cluster membership and geographic region was weak, with a Cohen's *V* of 0.055. It presents a challenge for public health practitioners to reach individuals in various cities and types of institutions.

3.4.1 Limitations

This analysis has several limitations that deserve mention. First, although the study sample was national and large, it was not necessarily nationally representative, because schools self-select to participate. Second, the overall response rate for the Web-based form of the survey was only about 1 in 5. However, this is a standard response rate for e-mail surveys,[48-50] prior studies have shown that ACHA data tend to match nationally representative data,[42] and the 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 substance use and socio-demographic factors. Because the survey was confidential, however, students would have had little reason to be dishonest. Fourth, it should be emphasized that the cross-sectional nature of these data limits ability to make causal inferences. For example, compared to the total college population, a higher number of traditional smokers live off campus. Although this may indicate that cigarette smokers are more likely to seek out off-campus housing, it may also indicate that

individuals who live off campus are subsequently exposed to environmental cues and opportunities that lead to increased cigarette smoking. Finally, the sample analyzed for this study was large, thus resulting in many statistically significant relationships when analyzing the personal and institutional factors associated with cluster membership. However, for this reason I examined the practical significance of the findings using an established measure of effect size.

3.4.2 Conclusions

In conclusion, this study finds that half of a large sample of university students had not smoked tobacco or marijuana or engaged in binge drinking in the past 30 days. Furthermore, the remaining students were reliably clustered into groups based on specific risk-behavior patterns. Although gender, year in school and fraternity/sorority membership varied with cluster membership, the other personal and institutional factors had less practical significance. These findings may help inform various substance abuse prevention and treatment programs targeting particular health behaviors.

4.0 U.S. HEALTH POLICIES AROUND HOOKAH TOBACCO SMOKING

4.1 INTRODUCTION

The decline in cigarette smoking in the U.S.[2,3] has been linked primarily to policy changes limiting tobacco smoking in public and private places. As of July 1, 2011, 35 states and thousands of local municipalities had passed smoking bans. It is not known, however, whether HTS is affected by laws such as these or whether provisions included in these laws may have intentionally or unintentionally exempted HTS.[88,89] Because of the importance of HTS establishments for promoting use of these products, these exemptions are likely to contribute to the prevalence of HTS.[15,16]

Thus, it would be valuable to systematically assess extant clean air laws, with special attention to implications for HTS. Furthermore, it may be valuable to determine what community factors are associated with HTS policy status; this information may ultimately help focus interventions on communities for which there is greatest need. The purposes of this study were to assess how a representative sample of U.S. tobacco control policies may apply to HTS and to determine associations between community-level socio-demographic factors and HTS policy status.

4.2 METHODS

4.2.1 Data Source

Data were obtained on tobacco-related policies from the U.S. Tobacco Control Laws Database© maintained by the American Nonsmokers' Rights Foundation (ANRF). This database of 8795 policies categorizes each U.S. municipality, county, and state law that relates to tobacco, including clean air, youth access, advertising, and taxation. Laws included in the database are identified through a variety of means, including systematic scanning of tobacco control publications, websites and list-servers, bi-annual solicitation of tobacco control professionals, and partnerships with the National Association of City and County Health Officials (NACCHO) and the National Association of Local Boards of Health (NALBOH). Senior staff members utilize standardized guidelines and codebooks to abstract tobacco control laws identified. ANRF reports and data have been instrumental in guiding implementation of policies shown to reduce tobacco use.[90] The current study focused on clean air legislation. Although factors such as taxation and advertising regulations are also relevant to HTS, clean air laws seem to be the largest policy-related contributor to public health.[21,88,89,91]

4.2.2 Selection of Municipalities

Tobacco-related clean air policies were assessed for each of the 100 U.S. cities with the largest population according to the 2010 census (**Figure 4**). As have others in similar policy analyses,[92] I used this approach to maintain feasibility while still assessing policies that apply to

a substantial population (59,849,899 individuals). For each city, laws were examined at the municipality, county, and state levels. It was also important to assess which laws were dominant in each municipality; for example, while many municipal laws are stronger than state laws, some state laws preempt municipal legislation.[91]

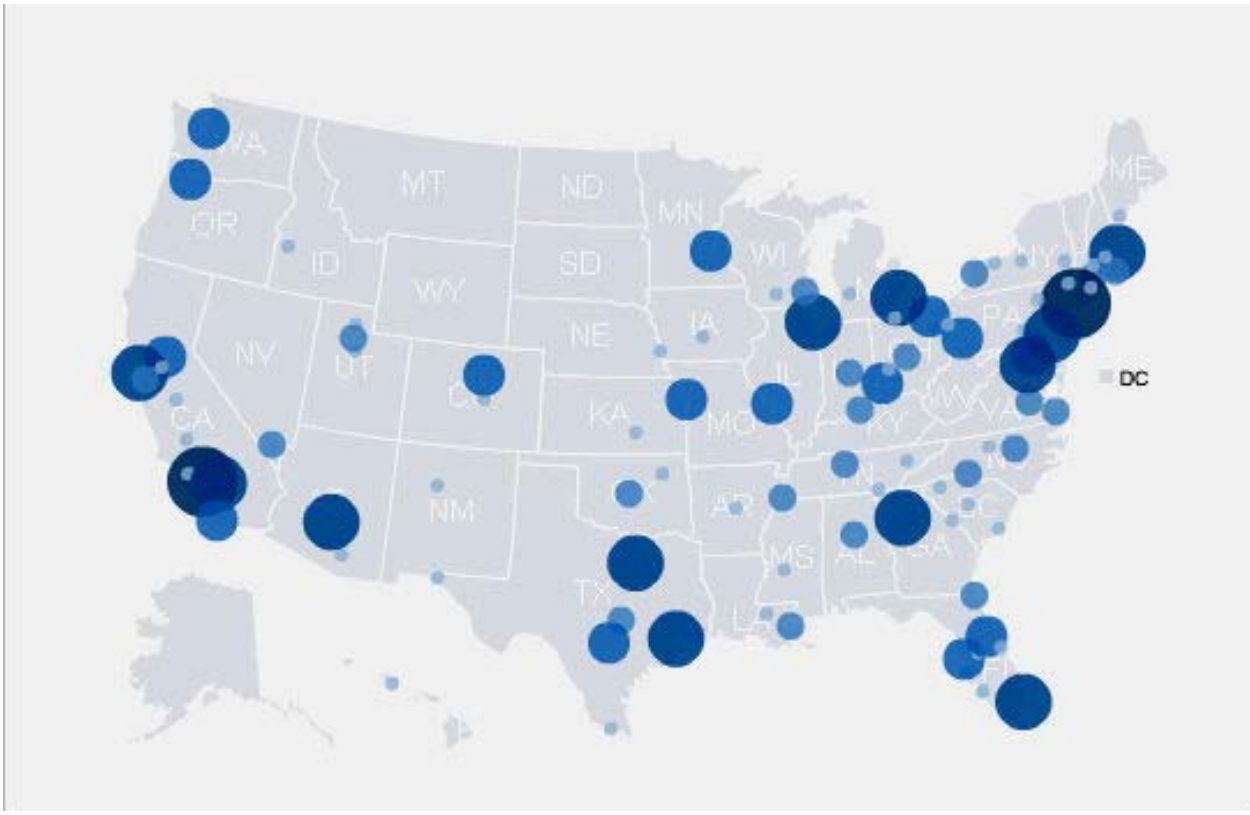

Figure 4. 100 Most Populous Cities in the U.S.

4.2.3 Abstraction Process

ANR staff had previously obtained the legislative documents, which included municipal, county, and state laws for all 100 cities, for prior assessment. Two research team members developed a codebook assessing new variables focused on components of clean air laws relevant to HTS, such as restriction of smoking in bars and presence of exemptions to these

laws that may apply to HTS. ANR staff then re-examined all texts using the codebook. Four research team members met after initial abstraction to refine the codebook and determine if it was necessary to extract additional variables. Via this iterative approach, a final codebook was developed, and final codes were confirmed based on re-examination of texts.

4.2.4 Measures

4.2.4.1 Clean Air Regulations

Clean air laws vary widely in terms of whether they apply to private workspaces, public workspaces, restaurants, or freestanding bars (i.e., a bar not attached to a restaurant). I focused on freestanding bars because current concerns related to HTS seem to center on HTS smoking establishments that are similar to freestanding bars.[17,88,89] Three separate dichotomous variables were developed assessing whether there are currently comprehensive clean air regulations prohibiting tobacco smoking in free-standing bars on the municipal, county, and state levels. In order to be coded as having a comprehensive clean air legislation, the law had to be unambiguous and without qualifications. For example, many clean air laws provide for "mostly" clean air but allow for a "fully enclosed and separately ventilated smoking room." For purposes of this analysis, I did not consider these laws strong enough to be considered comprehensive, because in practice this situation still exposes both patrons and staff to second-hand smoke.

4.2.4.2 Special Exemptions

When a municipal, county, or state law did provide for comprehensive clean air in freestanding bars, we generated dichotomous variables describing whether each law allowed exemptions for HTS mentioned by name; "tobacco retail establishments"; and/or "cigar bars." These latter two categories are the major categories of exemption.[89]

4.2.4.3 Composite Clean Air Variables

Based upon these basic policy-related variables, relevant composite variables were developed. Specifically, three dichotomous variables assessed the overall policy environment in that city (i.e., if any municipal, county, or state law was present, this was coded as 1; otherwise, it was coded as 0). Three other variables assessed whether there were exemptions on any policy level (municipal, county, or state) for HTS, tobacco retail establishments, and/or cigar bars.

4.2.4.4 Final Dependent Variable

For ultimate use in analyses, a single summary policy variable was developed that distinguishes cities without clean air legislation preventing cigarette or HTS in freestanding bars; with anti-smoking legislation exempting HTS by name; with anti-smoking legislation providing for a different exemption under which HTS may fall; and with anti-smoking legislation and no clear exemption governing HTS (**Table 6**). I developed this variable because of its strong face validity in comparing different types of policy environments. For example, I felt it was important

to compare cities that specifically exempted HTS by name (category 2) compared with those that had general exemptions under which HTS may fall (category 3). However, it was not deemed relevant to differentiate whether the laws specifically exempted tobacco retail establishments, cigar bars, or both.

4.2.4.5 Independent Variables

2010 U.S. census records were searched to categorize each city according to population. Because population density figures were not yet available for 2010, 2000 Census data were utilized for this variable. Data from the census bureau over the years 2004-2009 were used to determine median income, median age, and racial and ethnic diversity. Finally, I utilized published data on city voting records for the 2004 presidential election to approximate liberal vs. conservative leanings.[93]

4.2.5 Analysis

I computed the number of cities with each policy type and summarized socio-demographic characteristics (e.g., population, mean age, percent Hispanic) in each group of cities. Multinomial logistic regression was used to determine associations between socio-demographic independent variables and the summary outcome policy variable. Cities without clean air legislation comprehensively preventing cigarette or HTS in freestanding bars were used as the reference group. For the one categorical predictor variable (geographic region), chi-squared testing was used to determine whether there was an overall association between geographic region and policy type. Statistical significance was defined using a two-tailed

α=0.05.

4.3 RESULTS

According to the 2010 U.S. census, 59,849,899 individuals live in the 100 cities of the sample. Of these 100 cities, 27 are without clean air legislation comprehensively preventing cigarette or HTS in freestanding bars (**Table 6**). The remaining 73 cities have comprehensive anti-tobacco legislation in place on the municipal, county, and/or state level that disallows tobacco smoking in freestanding bars. In 65 of these 73 cities (89.0%), the law provides for specific exemptions for tobacco retail establishments and/or cigar bars, under which HTS may fall. In 4 cities of these 73 cities (5.5%), comprehensive anti-cigarette legislation exempts HTS by name. However, the 4 remaining cities have comprehensive anti-cigarette legislation and no clear exemption under which HTS seems to fall.

Table 6. Categorization of Cities by Clean Air Policy Type

Policy Environ-ment Label	Description of Policy	n of Cities	Specific Cities*
Smoking Legal	No comprehensive clear air legislation related to any type of tobacco use in bars	27	Birmingham, AL; Hialeah, FL; Miami, FL; Orlando, FL; St. Petersburg, FL; Tampa, FL; Jacksonville, FL; Atlanta, GA; Indianapolis, IN; Baton Rouge, LA; New Orleans, LA; Henderson, NV; Las Vegas, NV; North Las Vegas, NV; Reno, NV; Oklahoma City, OK; Tulsa, OK; Pittsburgh, PA; Memphis, TN; Nashville, TN; Arlington, TX; Fort Worth, TX; Garland, TX; Irving, TX; Lubbock, TX; Chesapeake, VA
HTS Exempt	Comprehensive legislation disallowing cigarette smoking in bars; however, HTS specifically exempted by name	4	Long Beach, CA; Chicago, IL; Boston, MA; Albuquerque, NM
TRE Exempt	Comprehensive legislation disallowing cigarette smoking in bars; however, HTS exempted via a generic exemption for “tobacco retail establishments” or “cigar bars”	65	Chandler, AZ; Glendale, AZ; Mesa, AZ; Phoenix, AZ; Scottsdale, AZ; Tucson, AZ; Anaheim, CA; Bakersfield, CA; Chula Vista, CA; Fremont, CA; Fresno, CA; Irvine, CA; Los Angeles, CA; Oakland, CA; Riverside, CA; Sacramento, CA; San Bernadino, CA; San Diego, CA; San Francisco, CA; San Jose, CA; Santa Ana, CA; Stockton, CA; Aurora, CO; Colorado Springs, CO; Denver, CO; Washington, DC; Honolulu, HI; Fort Wayne, IN; Wichita, KS; Lexington, KY; Baltimore, MD; Detroit, MI; Minneapolis, MN; St. Paul, MN; Kansas City, MO; St. Louis, MO; Charlotte, NC; Durham, NC; Greensboro, NC; Raleigh, NC; Winston-Salem, NC; Lincoln, NE; Omaha, NE; Jersey City, NJ; Newark, NJ; Buffalo, NY; Rochester, NY; New York, NY; Cincinnati, OH; Cleveland, OH; Columbus, OH; Toledo, OH; Portland, OR; Philadelphia, PA; Austin, TX; Corpus Christi, TX; El Paso, TX; Houston, TX; Laredo, TX; Plano, TX; San Antonio, TX; Dallas, TX; Norfolk, VA; Spokane, WA; Madison, WI
Strict	Comprehensive legislation disallowing cigarette smoking in bars; HTS does not seem to be exempt from this legislation	4	Anchorage, AK; Louisville, KY; Seattle, WA; Milwaukee, WI

* Cities are listed in alphabetical order by state and then city.

Table 7. Socio-Demographic Characteristics of Cities According to Policy Type

	All* N = 100	**Smoking Legal n = 27**	**HTS Exempt n = 4**	**TRE Exempt n = 65**	**Strict n = 4**
Population	598,499 (921,037)	390,358 (197,042)	1,080,325 (1,078,718)	659,943 (1,097,187)	523,164 (154,343)
Population Density, persons per square mile	4603 (3977)	3116 (2482)	**9184 (4453)†**	**4986 (4250)†**	3861 (3396)
Median Income, U.S. dollars per year	48,196 (12,710)	45,758 (10,342)	48,683 (3151)	49,144 (13,616)	48,768 (19,106)
Median Age, years	33 (3)	34 (3)	33 (1)	33 (3)	34 (3)
Percent Caucasian	60 (16)	62 (15)	53 (12)	60 (17)	63 (10)
Percent Black	21 (18)	26 (19)	16 (10)	19 (18)	21 (17)
Percent Asian	7 (9)	4 (3)	7 (4)	8 (11)	6 (5)
Percent Hispanic	23 (21)	21 (22)	35 (13)	25 (21)	8 (6)
Percent Liberal	58 (16)	53 (15)	69 (13)	**60 (16)†**	61 (19)

*Numbers in table cells represent mean (SD). Please see **Table 1** for definitions of column heading categories.

†*P*<.05 for multinomial logistic regression analyses respectively comparing each of policy types 2, 3, and 4 (HTS exempt, TRE exempt, and Strict) with policy type 1 (Smoking Legal).

Summaries of community socio-demographic characteristics across policy variables are shown in **Table 7**. Compared with cities with no comprehensive clean air laws, the four cities in which HTS was specifically exempted by name were denser (OR=1.46, 95%CI=1.11,1.92, where each unit represents an additional one thousand people per square mile). Compared with cities with no comprehensive clean air laws, the 65 cities with generic retail tobacco store exemptions were denser (OR=1.29, 95%CI=1.02,1.62, where each unit represents an additional one thousand people per square mile), and more concentrated with liberals (OR=1.37,95%CI=1.007, 1.86, where each unit represents an additional 10 percentage points). There was a significant association between geographic region and the summary policy variable (X^2=23.3, P=.006). For example, 53% of cities in the South were in category 1 (no comprehensive clean air legislation), while only 6%, 13%, and 14% of cities in the Midwest, Northeast, and West fell into this category, respectively (**Table 8**).

Table 8. Policy Type by Geographic Region

	Smoking Legal n = 27*	**HTS Exempt n = 4**	**TRE Exempt n = 65**	**Strict n = 4**
Midwest (n = 17)	6	6	82	6
Northeast (n = 8)	13	13	75	0
South (n = 38)	53	0	45	3
West (n = 37)	14	5	76	5

*Cell values are row percentages, which may not sum to 100 because of rounding. For the overall table, P = .006 using Fisher's exact test. Please see **Table 6** for definitions of column heading categories.

4.4 DISCUSSION

I found that, although 73 of the largest 100 cities in the U.S. disallow cigarette smoking in bars, nearly all (n=69) of these cities may allow HTS via exemptions. I also found that, of many socio-demographic variables, only population density, liberality, and geographic location were associated with HTS policy environment.

These findings are consistent with others who have pointed out that many U.S. policies which apply to cigarette smoking do not similarly apply to HTS.[88,89,94] However, this study extends prior findings in three ways. First, this study systematically examined the most populous cities in the U.S. in order to quantify the extent of dissimilarity in policy related to cigarettes and HTS. It also investigated policies on all levels (municipal, county, and state) to determine the specific policy in effect for each location. Finally, this study systematically assessed what socio-demographic community characteristics were associated with overall clean air policy environment.

Compared with cigarette smoking, HTS can be associated with similar or greater exposure to toxins, from both mainstream and second-hand smoke.[8-10,17] Thus, the findings that most policies enacted to reduce cigarette smoking may not apply to HTS highlight the need for improved U.S. health care policy related to HTS. These findings may be valuable to researchers, lawmakers, health policy officials, and advocacy group leaders seeking to improve policy in this area.

Four municipalities specifically exempted HTS from clean air legislation. It would be valuable to investigate reasons for these exemptions with lawmakers, public health officials,

and/or anti-tobacco advocates involved in this legislation. If important knowledge gaps are uncovered regarding HTS toxin exposures among any of these individuals, this may provide valuable opportunity for intervention.

There were four municipalities with comprehensive clean air laws for which there seem to be no specific exemptions that apply to HTS. However, HTS smoking establishments do seem to exist in each of these locations. It is possible that language in these legal codes was missed or misinterpreted. However, it is also possible that HTS establishments are illegal in these communities, but that the law is not being sufficiently enforced. Further investigation specific to each of these locations may clarify the law and assist health department officials and public health advocates with enforcement.

In addition to lawmakers and public health officials, these data will be important to advocates, thought leaders, and the lay public, whose understanding of a potentially harmful loophole in prior legislation may increase pressure to update it. However, the aesthetic appeal of HTS—including the sweet-smelling smoke, the attractive apparatus, exotic associations, the mildness of the experience relative to cigarette smoking, and the belief that the water somehow filters toxins—may make it challenging to persuade lay people of its potential harm and addictiveness.

This study focused on clean air legislation addressing freestanding bars because current concerns related to HTS seem to center on HTS bars/cafés.[17,88,89] However, it may be valuable to examine clean air legislation that relates to other environments such as outdoor locations. Also, it would be valuable to systematically assess how current policies may apply differently to cigarettes and HTS with regard to taxation and labeling. Taxation on cigarettes is now

substantial and increasing in many communities, and the Food and Drug Administration has recently introduced grizzly new warning labels for cigarettes. However, HTS is generally not affected by regulations such as these.

Among the many socio-demographic community factors we assessed, only population density, liberality, and geographic region were significantly associated with policy environment. While the 27 communities without anti-smoking policies had an average of 3116 individuals per square mile, communities in which HTS was exempted by name or may be exempted via a generic clause were denser (9184 and 4986 individuals per square mile, respectively). Although the reason for this difference is unclear, it is possible that denser communities may have more frequent market turnover and more community elements interested in supporting new businesses such as HTS establishments. The relative lack of anti-tobacco legislation in the South may be related to this region's historical and current involvement in growing tobacco. Knowing prior associations such as these may assist future studies linking policy to behavior, as these studies may wish to control for community factors, such as population density and geographic region, which are potentially associated with both policy environment and substance use behavior.

4.4.1 Limitations

This study did not assess the impact of policies on behavior, which is an important area for future work. In particular, it may be valuable to assess whether past changes in policy environment have been associated with changes in HTS rates. If there are unintended

consequences of clean air legislation that result in increased HTS, this will be important information for not only those involved in future legislation but also the lay public. This type of research may be difficult, however, because of how recent the HTS phenomenon is in the U.S.; few systematically collected, national data are currently available on HTS behavior, and much of extant clean air legislation was passed before the proliferation of HTS. This study was also limited in that it only reviewed the top 100 most populous cities. Because historically small cities can be the first to pass strong, innovative clean air laws, it may be valuable to systematically assess smaller jurisdictions. We were also limited by our data source (the ANRF database), which despite strong methodology may have missed certain laws. Additionally, interpretation of legal texts is a complex and often subjective process; thus, although we utilized established data sources and personnel highly familiar with interpretation of these texts, it would be valuable to confirm these findings. Finally, it should be noted that, in our sample, the frequencies of laws in the "HTS exempt" and "Strict" categories were very low, potentially limiting reliability of measurement of this variable.

4.4.2 Conclusion

Despite these limitations, this study systematically assessed clean air policies as they relate to HTS, which is associated with high toxicant exposures via both mainstream and second-hand smoke. It found that about 90% of cities with comprehensive policies disallowing cigarette smoking in freestanding bars may allow hookah tobacco smoking via exemptions. It also found

that community population density is associated with HTS policy environment. These results may be valuable to researchers, lawmakers, health policy officials.

5.0 CONCLUSION

Whereas 30-day rates of HTS among small and/or localized samples as high as 10-20% have been reported,[4-7] the 30-day rate in this large sample was somewhat lower at 8.4%. However, this figure still makes HTS the second most common source of tobacco among college students in this population, suggesting that intervention and surveillance are indicated. For example, HTS use seems to be higher than cigar, little cigar, and smokeless tobacco use among college students. While cigar and smokeless tobacco use are consistently tracked, national assessment instruments such as the Youth Risk Behavior Surveillance Survey do not currently assess HTS.[2,44-46] It is important to acknowledge the limitation that this sample was not necessarily nationally representative, because institutions self-select to participate in the NCHA. However, the size of the sample and the consistency of results among various subgroups suggest that these results are likely to be valid.

Ever use, estimated at 30.5%, was consistent with prior findings. The ratio of ever use to current use was higher for HTS (30.5% vs. 8.4%) than for cigarette smoking (34.6% vs. 16.8%). This may suggest that HTS is not as addictive as cigarette smoking. However, this ratio for HTS was similar to that for cigar and smokeless tobacco use, both of which are known to be addictive (**Figure 1**). Additionally, HTS is a relatively recent phenomenon. It is possible that today's casual users will begin to use with greater frequency in the future. This question will be

important to assess in the future using longitudinal data. These studies should also more carefully assess frequency of use, in order to estimate and compare the total exposure to toxicants associated with the different tobacco consumption behaviors.

I did find independent associations between hookah tobacco smoking and a variety of personal and environmental factors. In particular, HTS was independently associated with certain individual factors (younger age, male gender, white race, lack of a relationship, fraternity/sorority membership and housing, and living off campus) and certain institutional factors (western U.S. location, larger population of campus locale, and nonreligious institutional affiliation). These results may help develop intervention programs targeted at the most appropriate groups. For example, it may be valuable to use social marketing techniques to tailor anti-HTS messages at single males in fraternities. However, it is important to acknowledge that the effect sizes of these differences were relatively small, and that, in fact, use was remarkably consistent across many socio-demographic factors. For example, HTS was significantly associated with male gender such that males had 43% greater odds than females (OR = 1.43, 95% CI = 1.39-1.48); however, a relatively large 28.1% of females were ever users. Similarly, although HTS was significantly associated with the western U.S., >27% of individuals in the Midwest and South were ever users. Thus, if interventions are too specifically tailored, they may fail to reach large proportions of individuals at risk.

Because these studies used large national data sets, they were not able to assess a comprehensive set of potential mediators for HTS. Thus, it will be valuable for future studies to assess factors such as attitudes, knowledge, and normative beliefs related to HTS. Similarly, it may be valuable to triangulate these quantitative findings with qualitative ones. For example,

although we found that over half of current HT users do not smoke cigarettes, it is unclear why this is the case. Although I would hypothesize that it may be because physical and social cues suggest to college-aged students that the two forms of tobacco use are perceived as very different, this question will be important to assess using qualitative data. Additionally, it should be emphasized that the current study focused on college students, and thus it will be important for additional work to assess other populations, including adolescents and young adults who do not attend universities.

Cluster analysis showed that there was a specific group of individuals (between 5 and 6% of the population) who were particularly drawn to HTS. This may be valuable information for the purposes of targeting interventions. However, this group ("drawn to hookah") was not substantially different from other groups. For example, no institutional factors were associated with cluster membership. Thus, further research will be necessary to determine how best to reach this group of individuals.

Although multiple individual and institutional factors were assessed in these models, it is possible that unmeasured variables would help distinguish HT users from non-users. For example, we did not assess policy variables in these multivariable models, and prior work suggests that policy is an important factor with regard to cigarette smoking. However, the policy analysis described above suggests that there is not great variation with regard to HTS policy in the U.S. In particular, the vast majority of cities I assessed either explicitly or incidentally provided exemptions to any extant clean air laws under which HTS may fall. However, the permissive nature of these laws may become important when accounting for differences in policy related to cigarette smoking. For example, in cities where cigarette

smoking is disallowed but HTS is allowed, HTS may provide a market for individuals who wish to use tobacco indoors but are not allowed to use cigarettes. Also, individuals may perceive HTS as less dangerous than cigarette smoking when it is allowed and cigarette smoking is not. This study was not able to test these hypotheses, however. Future work will be necessary to determine whether there are independent associations between policy measures and HTS behaviors. The findings reported here may be valuable in designing these assessments.

It may be valuable for other studies to help inform future efforts at policy change. Although the current findings may be valuable to researchers, lawmakers, health policy officials, and advocacy group leaders, for example, additional assessment of knowledge gaps, attitudes, and intentions among these groups may additionally assist with intervention.

It should also be emphasized that this policy assessment focused solely on clean air regulations. Because current policies may also apply differently to cigarettes and HTS with regard to taxation and labeling, these are also valuable directions for future research.

In conclusion, despite a relative lack of attention from public health officials and researchers, HTS has become an important threat among college aged students. Although certain individual and institutional factors are associated with HTS, it is common across multiple socio-demographic, personal, and environmental characteristics. Thus, comprehensive intervention at the individual and societal levels will likely be necessary to curb this potential threat to U.S. public health.

BIBLIOGRAPHY

1. Centers for Disease Control and Prevention. Cigarette use among high school students--United States, 1991-2005. *MMWR Morb Mortal Wkly Rep.* Jul 7 2006;55(26):724-726.

2. Kilmer G, Roberts H, Hughes E, et al. Surveillance of certain health behaviors and conditions among states and selected local areas--Behavioral Risk Factor Surveillance System (BRFSS), United States, 2006. *MMWR Surveill Summ.* Aug 15 2008;57(7):1-188.

3. National Assocation of Attorneys General. *Cigarette sales in US reach historic 55-year low.* Washington, DC: National Association of Attorneys General; March 8 2006.

4. World Health Organization. *TobReg Advisory Note: Waterpipe tobacco smoking: health effects, research needs and recommended actions by regulators.* Geneva, Switzerland: World Health Organization;2005.

5. Primack BA, Sidani J, Agarwal AA, Shadel WG, Donny EC, Eissenberg TE. Prevalence of and associations with waterpipe tobacco smoking among U.S. university students. *Ann Behav Med.* 2008;36(1):81-86.

6. Maziak W, Ward KD, Afifi Soweid RA, Eissenberg T. Tobacco smoking using a waterpipe: a re-emerging strain in a global epidemic. *Tob Control.* Dec 2004;13(4):327-333.

7. Primack BA, Aronson JD, Agarwal AA. An old custom, a new threat to tobacco control. *Am J Public Health.* Aug 2006;96(8):1339.

8. Katurji M, Daher N, Sheheitli H, Saleh R, Shihadeh A. Direct measurement of toxicants inhaled by water pipe users in the natural environment using a real-time *in situ* sampling technique. *Inhalation Toxicology.* 2010;22(13):1101-1109.

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

10. Sepetdjian E, Shihadeh A, Saliba NA. Measurement of 16 polycyclic aromatic hydrocarbons in narghile waterpipe tobacco smoke. *Food and Chemical Toxicology.* 2008;46:1582-1590.

11. Cobb CO, Shihadeh A, Weaver MF, Eissenberg T. Waterpipe tobacco smoking and cigarette smoking: A direct comparison of toxican exposure and subjective effects. *Nicotine & Tobacco Research.* 2010.

12. El-Nachef WN, Hammond SK. Exhaled carbon monoxide with waterpipe use in US students. *JAMA.* Jan 2 2008;299(1):36-38.

13. Neergaard J, Singh P, Job J, Montgomery S. Waterpipe smoking and nicotine exposure: a review of the current evidence. *Nicotine Tob Res.* Oct 2007;9(10):987-994.

14. Eissenberg T, Shihadeh A. Waterpipe tobacco and cigarette smoking: direct comparison of toxicant exposure. *Am J Prev Med.* 2009;37(6):518-523.
15. Maziak W, Rastam S, Ibrahim I, Ward KD, Shihadeh A, Eissenberg T. CO exposure, puff topography, and subjective effects in waterpipe tobacco smokers. *Nicotine & Tobacco Research.* 2009;11(7):806-811.
16. Maziak W, Rastam S, Shihadeh AL, et al. Nicotine exposure in daily waterpipe smokers and its relation to puff topography. *Addictive Behaviors.* 2011;36:397-399.
17. Barnett TE, Curbow BA, Soule EK, Jr., Tomar SL, Thombs DL. Carbon monoxide levels among patrons of hookah cafes. *Am J Prev Med.* Mar 2011;40(3):324-328.
18. Gentilviso R. Hookah Tradition Clashes With City No-Smoking Law. *The Queens Gazette*2005.
19. Koch W. Hookah trend is puffing along. *USA Today.* December 28, 2005.
20. Eissenberg T, Ward KD, Smith-Simone S, Maziak W. Waterpipe tobacco smoking on a U.S. college campus: prevalence and correlates. *Journal of Adolescent Health* 2008;42:526–529.
21. Akl EA, Gunukula SK, Aleem S, et al. The prevalence of waterpipe tobacco smoking among the general and specific populations: a systematic review. *BMC Public Health.* 2011;11:244.
22. Smith SY, Curbow B, Stillman FA. Harm perception of nicotine products in college freshmen. *Nicotine Tob Res.* Sep 2007;9(9):977-982.
23. Smith-Simone S, Maziak W, Ward KD, Eissenberg T. Waterpipe tobacco smoking: Knowledge, attitudes, beliefs, and behavior in two U.S. samples. *Nicotine Tob Res.* Feb 2008;10(2):393-398.
24. Primack BA, Fertman CI, Rice KR, Adachi-Mejia AM, Fine MJ. Waterpipe and cigarette smoking among college athletes in the United States. *J Adolesc Health.* Jan 2010;46(1):45-51.
25. Primack BA, Walsh M, Bryce C, Eissenberg T. Water-pipe tobacco smoking among middle and high school students in Arizona. *Pediatrics.* Feb 2009;123(2):e282-288.
26. Barnett TE, Curbow BA, Weitz JR, Johnson TM, Smith-Simone SY. Water pipe tobacco smoking among middle and high school students. *Am J Public Health.* Nov 2009;99(11):2014-2019.
27. Lewin T. Collegians smoking hookahs ... filled with tobacco. *The New York Times.* April 19, 2006.
28. Osborne M. Puff the magic hooka. *The University Daily Kansan.* May 4, 2006.
29. Sallis JF, Owen N. Ecological Models. In: Glanz K, Lewis FM, Rimer BK, eds. *Health Behavior and Health Education*. 2 ed. San Francisco, CA: Jossey-Bass Publishers; 1997:403-424.
30. Maziak W, Ward WD, Eissenberg T. Factors related to frequency of narghile (waterpipe) use: the first insights on tobacco dependence in narghile users. *Drug and Alcohol Dependence.* 2004;76:101-106.
31. Ward KD, Eissenberg T, Rastam S, et al. The tobacco epidemic in Syria. *Tobacco control.* 2006;15:24-29.
32. Jabbour S, El-Roueiheb Z, Sibai AM. Narghile (water-pipe) smoking and incident coronary heart disease: a case-control study. *Ann Epidemiol.* 2003;13:570.

33. Akl EA, Gaddam S, Gunukula SK, Honeine R, Jaoude PA, Irani J. The effects of waterpipe tobacco smoking on health outcomes: a systematic review. *Int J Epidemiol.* 2010;39(3):834-857

34. Raad D, Gaddam S, Schunemann H, et al. Effects of waterpipe tobacco smoking on lung function: a systematic review and meta-analysis. *Chest.* 2010.

35. Primack BA, Sidani JE, Agarwal AA, Donny EC, Shadel WG, Eissenberg TE. Prevalence of and associations with waterpipe smoking among US university students. *Annals of Behavioral Medicine.* 2008;36:81-86.

36. Eissenberg T, Ward KD, Smith-Simone S, Maziak W. Waterpipe tobacco smoking on a U.S. college campus: prevalence and correlates. *Journal of Adolescent Health.* 2008;10:526-529.

37. American College Health Association. Sample Survey: ACHA-NCHA II. 2011; http://www.acha-ncha.org/sample_survey.html. Accessed March 2, 2011.

38. Dillman DA, Smyth JD, Christian LM. *Mail, internet, and mixed method surveys: the tailored design method*. 3rd ed. Hoboken, NJ: Wiley & Sons, Inc.; 2008.

39. Bombard JM, Rock VJ, Pederson LL, Asman KJ. Monitoring polytobacco use among adolescents: do cigarette smokers use other forms of tobacco? *Nicotine Tob Res.* Nov 2008;10(11):1581-1589.

40. Chow S, Rodgers P. Constructing Area-Proportional Venn and Euler Diagrams with Three Circles. Paper presented at: Euler Diagrams Workshop; August, 2005; Paris, France.

41. Cramér H. *Mathematical Methods of Statistics*. Princeton, NJ: Princeton University Press; 1999.

42. Leino EV. *National College Health Assessment Web and Scan Form Survey Techniques: An Evaluation of Systematic Differences from Spring 2003 Reference Group Data Base.* Baltimore, MD: American College Health Association;2004.

43. Primack BA, Fertman CI, Rice KR, Adachi-Mejia AM, Fine MJ. Waterpipe and cigarette smoking among college athletes in the United States. *J Adolesc Health.* 2010;46:45-51.

44. Johnston LD, O'Malley PM, Bachman JG, Schulenberg JE. *Monitoring the Future national results on adolescent drug use: Overview of key findings, 2009 (NIH Publication No. 10-7583).* Bethesda, MD: National Institute on Drug Abuse;2010.

45. Centers for Disease Control and Prevention. Youth Risk Behavior Surveillance—United States, 2009. *MMWR Morb Mortal Wkly Rep.* 2010;59(SS-5):1-142.

46. Arizona Department of Education. *Arizona Student Health Survey 2005 Methodology/Technical Report* Phoenix, AZ: Arizona Department of Education; July 2005.

47. Tobacco Control Legal Consortium. *Regulating Hookah and Waterpipe Smoking.* Saint Paul, MN: Tobacco Control Legal Consortium;2011.

48. Morrell HER, Cohen LM, Bacchi D, West J. Predictors of smoking and smokeless tobacco use in college students: A preliminary study using Web-based survey methodology. *Journal of American College Health.* 2005;54(2):108-115.

49. Sax LJ, Gilmartin SK, Bryant AN. Assessing response rates and nonresponse bias in web and paper surveys. *Research in Higher Education.* 2003;44(4):409-431.

50. White AM, Jamieson-Drake DW, Swartzwelder HS. Prevalence and correlates of alcohol-induced blackouts among college students: Results of an E-mail survey. *Journal of American College Health.* 2002;51(3):117-131.

51. Nichter M, Carkoglu A, Lloyd-Richardson E. Smoking and drinking among college students: "it's a package deal". *Drug Alcohol Depend.* Jan 1 2010;106(1):16-20.

52. Mohler-Kuo M, Lee JE, Wechsler H. Trends in marijuana and other illicit drug use among college students: results from 4 Harvard School of Public Health College Alcohol Study surveys: 1993-2001. *J Am Coll Health.* Jul-Aug 2003;52(1):17-24.

53. Wechsler H, Davenport AE, Dowdall GW, Grossman SJ, Zanakos SI. Binge drinking, tobacco, and illicit drug use and involvement in college athletics. A survey of students at 140 American colleges. *J Am Coll Health.* Mar 1997;45(5):195-200.

54. Fiestas F, Radovanovic M, Martins SS, Medina-Mora ME, Posada-Villa J, Anthony JC. Cross-national differences in clinically significant cannabis problems: epidemiologic evidence from 'cannabis-only' smokers in the United States, Mexico, and Colombia. *BMC Public Health.* 2010;10:152.

55. Hingson RW, Zha W, Weitzman ER. Magnitude of and trends in alcohol-related mortality and morbidity among U.S. college students ages 18-24, 1998-2005. *J Stud Alcohol Drugs Suppl.* Jul 2009(16):12-20.

56. Tiffany ST, Agnew CR, Maylath NK, et al. Smoking in college freshmen: University Project of the Tobacco Etiology Research Network (U pTERN). *Nicotine Tob Res.* Nov 2007;9 Suppl 4:S611-625.

57. Rimsza ME, Moses KS. Substance abuse on the college campus. *Pediatr Clin North Am.* Feb 2005;52(1):307-319, xii.

58. McCambridge J, Hunt C, Jenkins RJ, Strang J. Cluster randomised trial of the effectiveness of Motivational Interviewing for universal prevention. *Drug Alcohol Depend.* Apr 1 2011;114(2-3):177-184.

59. Logan DE, Marlatt GA. Harm reduction therapy: a practice-friendly review of research. *J Clin Psychol.* Feb 2010;66(2):201-214.

60. Sloboda Z, Stephens RC, Stephens PC, et al. The Adolescent Substance Abuse Prevention Study: A randomized field trial of a universal substance abuse prevention program. *Drug Alcohol Depend.* Jun 1 2009;102(1-3):1-10.

61. Carter CA, Kahnweiler WM. The efficacy of the social norms approach to substance abuse prevention applied to fraternity men. *J Am Coll Health.* Sep 2000;49(2):66-71.

62. Park A, Sher KJ, Krull JL. Risky drinking in college changes as fraternity/sorority affiliation changes: a person-environment perspective. *Psychol Addict Behav.* Jun 2008;22(2):219-229.

63. Barry AE. Using theory-based constructs to explore the impact of Greek membership on alcohol-related beliefs and behaviors: a systematic literature review. *J Am Coll Health.* Nov-Dec 2007;56(3):307-315.

64. Baldwin JN, Scott DM, DeSimone EM, 2nd, Forrester JH, Fankhauser MP. Substance use attitudes and behaviors at three pharmacy colleges. *Subst Abus.* Jan 2011;32(1):27-35.

65. Dierker L, Stolar M, Lloyd-Richardson E, et al. Tobacco, alcohol, and marijuana use among first-year U.S. college students: a time series analysis. *Subst Use Misuse.* 2008;43(5):680-699.

66. Dierker L, Lloyd-Richardson E, Stolar M, et al. The proximal association between smoking and alcohol use among first year college students. *Drug Alcohol Depend.* Jan 4 2006;81(1):1-9.
67. O'Malley PM, Johnston LD. Epidemiology of alcohol and other drug use among American college students. *J Stud Alcohol Suppl.* Mar 2002(14):23-39.
68. Martin CS, Clifford PR, Clapper RL. Patterns and predictors of simultaneous and concurrent use of alcohol, tobacco, marijuana, and hallucinogens in first-year college students. *J Subst Abuse.* 1992;4(3):319-326.
69. Smith-Simone SY, Curbow BA, Stillman FA. Differing psychosocial risk profiles of college freshmen waterpipe, cigar, and cigarette smokers. *Addict Behav.* Dec 2008;33(12):1619-1624.
70. Streppel MT, Boshuizen HC, Ocke MC, Kok FJ, Kromhout D. Mortality and life expectancy in relation to long-term cigarette, cigar and pipe smoking: the Zutphen Study. *Tobacco control.* Apr 2007;16(2):107-113.
71. Quinn GP, Ellery J, Thomas KB, Marshall R. Developing a common language for using social marketing: an analysis of Public Health literature. *Health Mark Q.* Oct 2010;27(4):334-353.
72. Morris ZS, Clarkson PJ. Does social marketing provide a framework for changing healthcare practice? *Health Policy.* Jul 2009;91(2):135-141.
73. Griffiths J, Blair-Stevens C, Parish R. The integration of health promotion and social marketing. *Perspect Public Health.* Nov 2009;129(6):268-271.
74. Evans WD. Social marketing campaigns and children's media use. *Future Child.* Spring 2008;18(1):181-203.
75. Hafez N, Ling PM. How Philip Morris built Marlboro into a global brand for young adults: implications for international tobacco control. *Tobacco control.* Aug 2005;14(4):262-271.
76. Ling PM, Glantz SA. Using tobacco-industry marketing research to design more effective tobacco-control campaigns. *JAMA.* Jun 12 2002;287(22):2983-2989.
77. Rust L. Tobacco prevention advertising: lessons from the commercial world. *Nicotine Tob Res.* 1999;1 Suppl 1:S81-89.
78. Frades I, Matthiesen R. Overview on techniques in cluster analysis. *Methods Mol Biol.* 2010;593:81-107.
79. Spencer L, Roberts G, Irvine F, Jones P, Baker C. Using cluster analysis to explore survey data. *Nurse Res.* 2007;15(1):37-54.
80. Clatworthy J, Buick D, Hankins M, Weinman J, Horne R. The use and reporting of cluster analysis in health psychology: a review. *Br J Health Psychol.* Sep 2005;10(Pt 3):329-358.
81. Seo DC, Li K. Effects of college climate on students' binge drinking: hierarchical generalized linear model. *Ann Behav Med.* Dec 2009;38(3):262-268.
82. Eaton DK, Kann L, Kinchen S, et al. Youth risk behavior surveillance - United States, 2009. *MMWR Surveill Summ.* Jun 4 2010;59(5):1-142.
83. Beets MW, Flay BR, Vuchinich S, Li KK, Acock A, Snyder FJ. Longitudinal patterns of binge drinking among first year college students with a history of tobacco use. *Drug Alcohol Depend.* Jul 1 2009;103(1-2):1-8.
84. Courtney KE, Polich J. Binge drinking in young adults: Data, definitions, and determinants. *Psychol Bull.* Jan 2009;135(1):142-156.

85. Norušis M. Cluster Analysis. *IBM SPSS Statistics 19 Statistical Procedures Companion*. Old Tappan, NJ: Pearson; 2011:375-404.
86. Bacher J, Wenzig K, Vogler M. *SPSS TwoStep Cluster: A First Evaluation.* Belmont, MA: Statistical Innovations;2004.
87. Tullis LM, Dupont R, Frost-Pineda K, Gold MS. Marijuana and tobacco: a major connection? *J Addict Dis.* 2003;22(3):51-62.
88. Tobacco Public Policy Center. *Hookah Bars and Clean Indoor Air Laws.* Columbus, OH: Capital University Law School;2006.
89. Martinasek MP, McDermott RJ, Martini L. Waterpipe (Hookah) Tobacco Smoking Among Youth. *Curr Probl Pediatr Adolesc Health Care.* 2011;41:34-57.
90. Eriksen M, Chaloupka F. The economic impact of clean indoor air laws. *CA Cancer J Clin.* 2007;57:367-378.
91. Eriksen MP, Cerak RL. The diffusion and impact of clean indoor air laws. *Annu Rev Public Health.* 2008;29:171-185.
92. Mayer JA, Woodruff SI, Slymen DJ, et al. Adolescents' use of indoor tanning: a large-scale evaluation of psychosocial, environmental, and policy-level correlates. *Am J Public Health.* May 2011;101(5):930-938.
93. Bay Area Center for Voting Research. *The most conservative and liberal cities in the United States.* San Francisco, CA. 2005.
94. Quenqua D. Putting a crimp in the hookah. *The New York Times.* May 20, 2011.