

# Hookah Use Among US High School Seniors

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## KEY WORDS

hookah, adolescents, tobacco, socioeconomic status

## ABBREVIATIONS

AOR—adjusted odds ratio

CI—confidence interval

MTF—Monitoring the Future

Dr Palamar conceptualized and designed the study, conducted the statistical analyses, and drafted the initial manuscript; Drs Zhou, Sherman, and Weitzman helped draft the initial manuscript, helped interpret results, critically reviewed the manuscript, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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**WHAT'S KNOWN ON THIS SUBJECT:** Hookah use is increasing dramatically among US adolescents. Many consider it a safer alternative to cigarettes. Existing studies often use nonrepresentative local populations to assess prevalence and correlates of hookah use.



**WHAT THIS STUDY ADDS:** This study used a nationally representative sample of US high school seniors. It confirmed some previously found correlates and determined that adolescents of higher socioeconomic status were at high risk for hookah use.

## abstract

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**OBJECTIVES:** Prevalence of hookah use is increasing significantly among adolescents. This study aimed to delineate demographic and socioeconomic correlates of hookah use among high school seniors in the United States. We hypothesized that more impoverished adolescents and those who smoked cigarettes would be more likely to use hookahs.

**METHODS:** Data were examined for 5540 high school seniors in Monitoring the Future (years 2010–2012), an annual nationally representative survey of high school students in the United States. Using data weights provided by Monitoring the Future, we used multivariable binary logistic regression to delineate correlates of hookah use in the last 12 months.

**RESULTS:** Eighteen percent of students reported hookah use in the past year. Compared with white students, black students were at lower odds for use (adjusted odds ratio [AOR] = 0.27,  $P < .0001$ ). High parent education increased the odds for use (AOR = 1.58,  $P < .001$ ), and student weekly income from a job of  $> \$50/\text{week}$  (AOR = 1.26,  $P < .05$ ) or \$11 to \$50 per week from other sources (AOR = 1.35,  $P < .01$ ) also increased odds for use. Males and urban students were also at higher odds for use, as were users of alcohol, marijuana, and other illicit substances. Former cigarette smokers were at higher risk, and current smokers were at highest risk for use.

**CONCLUSIONS:** Adolescents of higher socioeconomic status appear to be at particularly high risk for hookah use in the United States. Prevention efforts must target this group as prevalence continues to increase. *Pediatrics* 2014;134:227–234

Although cigarette use is declining precipitously among youth,<sup>1–4</sup> evidence indicates that American adolescents are turning to ethnically linked alternative tobacco products, such as hookahs, cigars, and various smokeless tobacco products.<sup>5,6</sup> A recent report from the Centers for Disease Control and Prevention warns that the drop in cigarette consumption is being “offset by increases in other forms of tobacco.”<sup>7</sup> Although alternative tobacco use may have originated among immigrants from South Asia and the Middle East, use of hookah has clearly moved into the mainstream US population.<sup>8</sup>

Hookah, an ancient form of smoking in which shisha (an herbal material that can be tobacco- or non-tobacco-based) smoke is passed through water before inhalation, is 1 such alternative tobacco product. Hookah smoking is rapidly gaining popularity among adolescents in the United States and worldwide. Existing data based on the 2011 US National Youth Tobacco Survey indicated that ~8% of adolescents reported ever trying hookah, and 3% reported using hookah within the past month.<sup>9</sup> The most recent data published in the *Morbidity and Mortality Weekly Review* showed an increase of hookah use from 4.1% in 2011 to 5.4% in 2012 among high school students,<sup>1</sup> and recent work by our group found that nearly 1 in 5 adolescents in the United States reported having tried hookah before high school graduation.<sup>9</sup> The most alarming statistic was recently reported from the Monitoring the Future (MTF) study, which found that 12-month hookah use significantly increased among US high school seniors from 18.3% in 2012 to 21.4% in 2013.<sup>5</sup>

Although the literature on health effects of hookah smoking and exposure to secondhand smoke from hookahs is limited, existing data are consistent and suggest significant adverse health

outcomes. Research has shown that hookahs deliver tar, nicotine, and carbon monoxide in even higher doses than cigarettes.<sup>10–12</sup> Moreover, recent meta-analyses have linked hookah use to lung cancer, respiratory illness, periodontal diseases, and low birth weights.<sup>13</sup> Individual studies have linked use to esophageal cancer,<sup>14,15</sup> chromosomal aberrations,<sup>16</sup> decreased pulmonary and cardiovascular functions,<sup>17,18</sup> infertility,<sup>19</sup> dental problems,<sup>20</sup> and infectious diseases.<sup>21</sup> Surveys of university students in multiple countries, including the United States, suggest that people are unaware of these dangers<sup>22–35</sup> and believe that hookah is less harmful and less addictive than cigarettes.<sup>22,23,25–35</sup>

A number of studies have examined the prevalence and correlates of hookah use among local and national populations,<sup>9,36</sup> including US adolescents. The current study complements and expands on previous findings by investigating a number of previously unexplored but potentially important predictors of adolescent hookah use in a nationally representative sample of high school students in the United States. This study delineates specific demographic, socioeconomic, and substance use factors related to hookah use among US high school seniors. It was hypothesized that more impoverished adolescents with more poorly educated parents would be more likely to use hookahs, as is true of adolescent cigarette use. Similarly, it was hypothesized that hookah use would be independently associated with use of cigarettes, alcohol, and illicit drugs.

## METHODS

### Procedure

MTF is an annual cross-sectional survey of high school seniors in ~130 public and private schools throughout 48 states in the United States. Schools are selected through a multistage random sampling procedure: geographic areas

are selected, then schools within areas are selected, and then students within schools are selected.<sup>37,38</sup> Approximately 15 000 seniors are assessed every year. MTF assesses content through 6 different survey forms, which are distributed randomly. All forms assess demographics, socioeconomic variables, and use of various licit and illicit substances; however, only survey Form 3 assesses (last 12-month) hookah use. Therefore, hookah use was assessed in only about one-sixth of the sample. MTF began assessing hookah use in 2010, so this analysis focuses on aggregated (and weighted) Form 3 data collected from the 3 most recent cohorts with available data (2010–2012). MTF protocols were reviewed and approved by the University of Michigan Institutional Review Board.

### Measures

Students were asked to indicate their gender, age (<18, ≥18 years), and race or ethnicity (ie, black, white, Hispanic). MTF classified population density of students' residences as in terms of metropolitan statistical areas (MSAs). Small MSAs are defined as counties or groups of counties with ≥1 city of ≥50 000 inhabitants, and the 24 largest MSAs are defined as large MSAs.<sup>37</sup> Non-MSAs are the remaining areas. To assess family composition, students were asked which parents they lived with. Answers were coded as 0 parents, 1 parent, or 2 parents. Level of religiosity was determined by 2 ordinal items that asked about level of religious attendance and importance. These items were computed into a composite (range 1–4) and divided into tertiles indicating low (1.0–2.0), moderate (2.5–3.0), and high (3.5–4.0) religiosity. Parent level of educational attainment (ie, grade school, some high school, high school graduate, some college, college graduate, or graduate school) was assessed for each parent, and a mean score for both parents (or raw score if only 1 parent)

was coded into 3 groups: low (1.0–3.0), medium (3.5–4.0), and high (4.5–6.0) education. Students were also asked how much they earn during the average week from a job or other work and how much money they earned from other sources. Responses for each of these 2 income items were coded into  $\leq$ \$10 or less, \$11–50, or  $\geq$ \$51. Coding of sociodemographic variables was based on previous MTF analyses.<sup>39,40</sup>

MTF assessed annual hookah use through the following item: “During the last 12 months, on how many occasions (if any) have you smoked tobacco using a hookah (water pipe)?” Answer options were 0 occasions, 1 or 2 occasions, 3 to 5 occasions, 6 to 9 occasions, 10 to 19 occasions, 20 to 39 occasions, and  $\geq$ 40. Using the same answer options, MTF also assessed lifetime use of alcohol, marijuana (pot, weed, hashish), and other illicit substances including cocaine, crack, LSD, hallucinogens other than LSD, heroin, and nonmedical use of narcotics (other than heroin), tranquilizers (eg, benzodiazepines), sedatives (eg, barbiturates), and amphetamine. We dichotomized hookah use into ever used versus never used, and use of all other illicit substances aforementioned was also dichotomized into lifetime use (yes versus no) for each. A new indicator was created for any illicit substance use other than marijuana; specifically, students were coded as whether they indicated use of any of these substances. This variable was computed if the student provided data for  $\geq$ 4 of these substances (other than marijuana). Therefore, students who did not provide (yes/no) responses for  $\geq$ 4 substances were removed from the analytic sample. Finally, lifetime cigarette use was assessed, and answer options were never, once or twice, occasionally but not regularly, regularly in the past, and regularly now.

### Statistical Analyses

Analyses focused on students with complete substance use and sociodemographic data ( $N = 5540$ ), although we allowed race or ethnicity and religiosity to be missing. All analyses used the survey sample weights provided by MTF. This was done to adjust for differential probability of selection of schools and students. All percentages reported are also weighted. Hookah use in the analytic sample did not significantly differ across cohorts (2010, 17.4%; 2011, 18.4%; 2012, 18.2%;  $P = .76$ ), giving us confidence in combining datasets into a single cross-section for analysis. We examined descriptive statistics for each covariate and compared sample characteristics according to hookah use (ie, no use versus use). This was done using Rao–Scott  $\chi^2$  tests for homogeneity, which correct for the complex study design.<sup>41</sup> All variables were then fit into a multivariable binary logistic regression model with hookah use (yes or no) as the outcome to determine conditional associations (controlling for all other covariates). Specifically, covariates were modeled to explain hookah use compared with no use. This model produces an adjusted odds ratio (AOR) and 95% confidence interval (CI) for each covariate. Indicators for cohort (with 2010 as the comparison) were included in the model to adjust for potential cohort effects or secular trends, and because large percentages of students were missing race (14.8%) or religiosity (25.0%) data, we entered missing data indicators into the model for these 2 variables instead of deleting these cases.<sup>39,42</sup> All analyses were design-based for survey data (PROC SURVEYFREQ and PROC SURVEYLOGISTIC),<sup>43</sup> conducted using SAS 9.3 software (SAS Institute, Inc, Cary, NC).

### RESULTS

The annual prevalence of hookah use was 18.0% (the mean prevalence of 2010–2012 data). Table 1 presents the

descriptive statistics of the sample and the comparisons of demographic, socioeconomic, and substance use variables by hookah use. Bivariable ( $\chi^2$  test) results suggest that identifying as male, nonblack, or nonreligious was associated with use. Likewise, students residing in small or large MSAs and students reporting higher (eg,  $\geq$ \$50) weekly income or income from “other sources” were more likely to report use. In addition, students who smoked cigarettes (at any level other than never) or reported lifetime use of alcohol, marijuana, or other illicit substances were all more likely to report hookah use. Hookah use did not significantly differ by age, family structure, or level of parental education.

After examining bivariable associations, we then fit all covariates simultaneously into a binary logistic regression model (Table 2). The model had good fit (Nagelkerke  $R^2 = 40\%$ , Correct Classification Rate = 85%). Compared with males, females were at lower odds for using hookah (AOR = 0.81; 95% CI, 0.67–0.98), and students identifying as black (compared with white) had lower odds of use (AOR = 0.27; 95% CI, 0.17–0.41). Compared with residing in a non-metropolitan statistical area, students in both small (AOR = 2.67; 95% CI, 2.04–3.49) and large MSAs (AOR = 2.64; 95% CI, 1.95–3.56) were at higher odds of use. Although religiosity was a protective factor in the bivariable model, religiosity was not significant in explaining hookah use in the multivariable model. In contrast, although parent educational attainment was not significant in the bivariable model, moderate (AOR = 1.33; 95% CI, 1.03–1.73) and high parent education (AOR = 1.58; 95% CI, 1.24–2.02) were risk factors for use in the multivariable model. With regard to student income, earning  $\geq$ \$50 per week from a job was a risk factor for use (AOR = 1.26; 95% CI, 1.02–1.56), and earning \$11 to \$50 per

**TABLE 1** Sample Characteristics and Comparison of Characteristics by Frequency of Hookah Use in Last 12 Months

	Full Sample, N = 5540, Weighted %	No Hookah Use, n = 4502, Weighted %	Hookah Use, n = 1038, Weighted %	P
Gender				<.001
Male	48.6	79.8	20.2	
Female	51.4	84.0	16.0	
Age, y				.09
<18	45.6	83.1	16.9	
≥18	54.4	81.1	18.9	
Race <sup>a</sup>				<.0001
White	62.6	79.9	20.1	
Black	9.5	95.2	4.8	
Hispanic	13.1	82.0	18.0	
Population density				<.0001
Non-MSA	20.6	89.6	10.4	
Small MSA	50.7	80.3	19.7	
Large MSA	28.7	79.6	20.4	
Religiosity <sup>a</sup>				<.0001
Low	31.2	79.8	20.2	
Moderate	20.0	82.3	17.7	
High	24.4	90.2	9.8	
Family structure				.39
0 parents	5.1	80.2	19.8	
1 parent	27.0	81.0	19.0	
2 parents	67.9	82.5	17.5	
Parent education				.22
Low	29.6	83.6	16.4	
Moderate	28.8	81.7	18.3	
High	41.6	81.1	18.9	
Weekly income from job				<.0001
≤\$10	47.6	85.9	14.1	
\$11–\$50	11.9	82.5	17.5	
≥\$51	40.5	77.2	22.8	
Weekly income from other source				<.001
≤\$10	56.7	84.2	15.8	
\$11–\$50	33.9	79.1	20.9	
≥\$51	9.4	79.2	20.8	
Cigarette smoking				<.0001
Never smoked	59.8	93.7	6.3	
Smoked once or twice	19.1	74.8	25.2	
Smoked regularly in the past	4.7	63.9	36.1	
Smoke occasionally	9.6	57.1	42.9	
Smoke regularly	6.8	47.2	52.8	
Lifetime alcohol use				<.0001
No	29.2	97.8	2.2	
Yes	70.8	75.5	24.5	
Lifetime marijuana use				<.0001
No	54.8	96.1	3.9	
Yes	45.2	64.9	35.1	
Lifetime use of other illicit substances				<.0001
No	76.3	89.0	11.0	
Yes	23.7	59.5	40.5	

$\chi^2$ s are design-based to account for the complex sampling design. MSA, metropolitan statistical area.

<sup>a</sup> Valid percentages are presented for race and religiosity because we allowed data to be missing for these variables in our analyses (missing data indicators were included in models). Data are weighted, so percentages may not add up to exactly 100%.

week from “other sources” was also a risk factor for use (AOR = 1.35; 95% CI, 1.10–1.67).

With respect to substance use, cigarette smoking was 1 of the most robust and consistent risk factors for hookah use.

Current smokers (those who smoke occasionally or regularly) were at higher odds for hookah use than past smokers (those who reported smoking once or twice, or regularly in the past). Regular smokers in particular were at highest odds for use (AOR = 5.12; 95% CI, 3.61–7.26). With regard to other lifetime substance use, alcohol and marijuana use both increased the odds for hookah use. Use of other illicit substances was also significantly associated with hookah use but to a weaker degree than cigarette smoking, alcohol use, and marijuana use.

## DISCUSSION

The emergence of widespread hookah use among US adolescents has resulted in a growing body of epidemiologic studies on its use. However, most studies have relied on small, non-representative samples. In contrast, the current study uses data from a large, nationally representative sample of 5540 US high school seniors. While confirming previously identified risk factors, this study also uncovered a number of formerly unrecognized correlates of use by adolescents, such as urban residence and high parental education. Moreover, higher weekly income, cigarette smoking, and use of alcohol, marijuana, or other illicit substances were also found to be associated with more frequent hookah use.

Many demographic predictors of hookah use uncovered in this study, such as male gender and nonblack race, were consistent with findings of previous studies.<sup>22,25,28,35,44–48</sup> However, although another study<sup>49</sup> found religiosity to be a protective factor against use, in this study this association lost significance after we controlled for other demographic, socioeconomic, and substance use variables. Although still rudimentary, the socioeconomic dynamics of hookah use are gradually

**TABLE 2** Binary Logistic Regression Explaining Hookah Use in the Last 12 Months

	Recent Use ( <i>n</i> = 1038) (No Recent Use = Comparison)	
	AOR	95% CI
Gender		
Male	1.00	—
Female	0.81	0.67–0.98
Age, y		
<18	1.00	—
≥18	1.09	0.90–1.32
Race		
White	1.00	—
Black	0.27	0.17–0.41
Hispanic	0.81	0.58–1.12
Population density		
Non-MSA	1.00	—
Small MSA	2.67	2.04–3.49
Large MSA	2.64	1.95–3.56
Religiosity		
Low	1.00	—
Moderate	1.12	0.84–1.49
High	0.94	0.70–1.27
Family structure		
0 parents	1.00	—
1 parent	1.07	0.72–1.60
2 parents	1.29	0.87–1.90
Parent education		
Low	1.00	—
Moderate	1.33	1.03–1.73
High	1.58	1.24–2.02
Weekly income from job		
≤\$10	1.00	—
\$11–\$50	1.22	0.90–1.64
≥\$51	1.26	1.02–1.56
Weekly income from other source		
≤\$10	1.00	—
\$11–\$50	1.35	1.10–1.67
≥\$51	1.10	0.81–1.49
Cigarette smoking		
Never smoked	1.00	—
Smoked once or twice	2.22	1.69–2.91
Smoked regularly in the past	2.45	1.66–3.61
Smoke occasionally	4.19	3.03–5.78
Smoke regularly	5.12	3.61–7.26
Lifetime alcohol use		
No	1.00	—
Yes	3.34	2.12–5.25
Lifetime marijuana use		
No	1.00	—
Yes	4.48	3.38–5.94
Lifetime use of other illicit substances		
No	1.00	—
Yes	1.53	1.22–1.92

The reference group consists of non-hookah users (*n* = 4502). AORs are adjusted odds ratios because all other variables were controlled in the multivariable model. The model included a cohort indicator and missing data indicators for race and religiosity. MSA, metropolitan statistical area.

being elucidated. Given the cost of frequenting hookah bars, it is not surprising that wealthier students, as indicated by higher weekly income, are more regular visitors, although it

remains unknown what proportion of hookah use occurs in hookah bars versus in homes or other non-commercial settings.<sup>46,50</sup> Our finding that students with higher parental ed-

ucation are more likely to be hookah users also supports the hypothesis that hookah smoking, unlike cigarette smoking, is a social activity often occurring among those of higher socioeconomic status. In fact, hookahs and cigarettes, though both tobacco products, have several differences in terms of their predictors and distribution of use among US adolescents. Well-known risk factors for cigarette use among adolescents, such as lower socioeconomic status and lower parental education, unexpectedly were associated with lower rates of hookah use.<sup>51,52</sup>

Similar to the findings of this study, Sutfin et al<sup>35</sup> reported concurrent use of hookah with alcohol, marijuana, and other illicit substances. Among current hookah users in the Sutfin study, 22% reported never trying a cigarette, suggesting that hookah use may be their first encounter with tobacco products. In this study, only 6.3% reported never smoking a cigarette. Given the addictive nature of the nicotine in tobacco, these data raise concern that hookah use may serve as a gateway to cigarette smoking. However, it may be more likely that cigarette use occurs before hookah use. To better understand the temporal sequence of hookah use relative to that of cigarette and marijuana use, Fielder et al<sup>53</sup> followed 424 first-year college women until graduation and found that precollege hookah use predicted cigarette initiation or relapse, thereby supporting the aforementioned gateway theory. Interestingly, although precollege marijuana use predicted hookah initiation, precollege cigarette use predicted neither hookah nor marijuana initiation, suggesting a complex interplay between these potentially addictive substances. Clearly, more longitudinal studies using more representative samples are needed to investigate temporal associations.

A common belief among adolescents and young adults is that hookah use is



less harmful and addictive than cigarettes.<sup>22,23,25–35</sup> This misconception probably leads to the social normalization of hookah use as a trendy and acceptable way to have fun with friends.<sup>24,27,31,33,34,48,54–56</sup> Several studies have demonstrated that more accurate knowledge about hookahs is directly related to less frequent hookah use. In fact, those with more accurate information about the health effects of hookah use were more likely both to report greater perceived risk and to voice an intention to quit.<sup>57,58</sup> Unfortunately, the data available from MTF did not enable us to investigate this critical issue, but clearer understanding of the association between accurate knowledge and hookah-related attitudes and behaviors might have clinical and public health policy implications.

Despite the important findings in this study, a number of limitations exist. Hookah use was assessed only in high school seniors; use was not assessed among younger adolescents (eg, in the 8th- or 10th-grade MTF samples) or

young adults, and these data do not provide information on the many adolescents who drop out of school before their senior year of high school. In addition, MTF began assessing hookah use only in 2010 and assessed use through only 1 of 6 survey forms, so the amount of data available was limited. We combined the 3 cohorts of available data, and annual prevalence did not differ significantly across cohorts, so we did not examine trends over time. Although there were no statistical differences in prevalence by cohort, we still included cohort indicators in analyses. Missing data, particularly the 14.8% missing race or ethnicity and the 25.0% missing religiosity, were problematic; however, to maintain power we included missing data indicators for these 2 variables in multivariable analyses. Lastly, as is true of much of the literature on adolescent use of alternative tobacco products, the racial and ethnic information is quite sparse given the increasing diversity of the US population.

This is one of the few studies in the research literature to use a large, na-

tionally representative sample of high school senior students in the United States to assess the prevalence and predictors of hookah use. As an increasingly popular social activity among adolescents, hookah smoking seems to appeal to those of higher socioeconomic status and interplays with cigarette smoking, alcohol, and illicit substance use on many complex levels. Given the rudimentary understanding of hookah use, it is crucial for educators, health professionals, researchers, and policy makers to collaborate to fill in gaps in public understanding of its harm and guide public interventions to diminish problematic hookah smoking.

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**SCENT OF A FUNGUS:** *Last week I was having dinner with friends at a lovely restaurant. While I do not usually order risotto at restaurants, as I can make many very good versions myself at home, this particular dish caught my eye because it was made with truffles and garlic. I rarely cook with truffles as they are expensive and hard to find in the Burlington area. I opted to order the risotto dish and was rewarded with a spectacular dinner bursting with flavor.*

*As reported in The Wall Street Journal (Food: April 3, 2014), truffles are the small knobby fruit of an underground fungus. In contrast to other mushrooms, this particular fungus matures entirely underground. Initially, they are scentless but as they mature they acquire a distinctive odor easily detected by animals such as pigs or dogs. Truffles are highly prized in a variety of cuisines. The most famous truffle is the French black Périgord truffle which may cost \$2,000 a pound. Other well-known (and very expensive) varieties include the Italian Alba white truffle which has a scent reminiscent of garlic.*

*Until recently, few truffles were produced or harvested in the US. However, culinary enthusiasts hope to change that. Truffles are now cultivated in Tennessee and throughout Oregon. Oregon, in particular, has become the home of the American truffle industry, and Périgord and white truffles have been cultivated there quite successfully. While the flavors are not identical to their European brethren, they perform well in blind tasting competitions and are much, much less expensive. Unfortunately, they are hard to find outside Oregon. I have no idea which truffle was used in my risotto dish or even the country of origin, but it was delicious and made me want to have more.*

*Noted by WVR, MD*



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