

Sustained Waterpipe Tobacco Smoking and Trends Over Time

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Introduction: Use of waterpipe tobacco smoking (WTS) is now prevalent among U.S. adolescents. However, the more clinically relevant questions are whether users exhibit sustained patterns of use and whether use is increasing over time relative to other tobacco products. We aimed to examine factors associated with sustained WTS among U.S. adolescents and to compare prevalence trends between WTS and other tobacco products.

Methods: The Monitoring the Future project began assessing WTS among 12th-grade students in 2010. In 2014, we conducted multivariable regression analyses to examine correlates of sustained WTS, which we defined as use at least six times in the past 12 months. We used trend analysis to compare use of WTS and other types of tobacco.

Results: Of the 8,737 participants queried from 2010 to 2013, 18.8% (1,639) reported past-year WTS, whereas 7.2% (627) reported sustained use. Sustained WTS was inversely associated with female sex (versus male, OR=0.78, 95% CI=0.63, 0.96); African American race (versus Caucasian, OR=0.26, 95% CI=0.14, 0.48); and increased number of parents in the home ($p < 0.001$). Sustained WTS was positively associated with increased school-level parental education ($p = 0.002$); lower grades ($p = 0.005$); truancy ($p < 0.001$); lower religiosity ($p < 0.001$); more evenings out per week ($p < 0.001$); and dating ($p = 0.03$). Visual inspection and non-overlapping CIs suggest that both past-year and sustained WTS are significantly increasing relative to cigarette use but not small cigar use.

Conclusions: Given the prevalence of sustained WTS and indications of its increase over time, it should be included in efforts related to tobacco surveillance and intervention.

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Introduction

Smoking tobacco with a waterpipe (also known as a hookah or narghile) is an emerging trend.¹⁻³ Many smokers perceive the potential harm from

waterpipe tobacco smoking (WTS) to be low.⁴⁻⁶ Compared with a single cigarette, however, one waterpipe session—typically occurring over approximately 45–60 minutes^{7,8}—can expose the user to substantially greater amounts of key toxicants, including tar, nicotine, carbon monoxide, and polycyclic aromatic hydrocarbons.^{7,9-12} These findings are consistent with preliminary reports that associate WTS with cancer, cardiovascular disease, decreased pulmonary function, and nicotine dependence.^{13,14}

Past research suggests that among U.S. college students, the prevalence of WTS is about 20%–40% ever and 5%–15% in the past 30 days.^{1,15-18} Studies of high school students report lifetime WTS prevalence rates as high as 15%–17% by the senior year of high school.^{15,17,19,20} A recent study of high school seniors found an 18% WTS

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prevalence rate and identified certain key sociodemographic and lifestyle correlates associated with past-year WTS, including sex, race, parental education level, and use of other substances.²¹

However, sustained WTS has been less frequently examined. Concern about adverse health effects and addiction have often been minimized given the assumption that use is generally intermittent or experimental.²² Although some users report more frequent use, suggesting an extension beyond experimentation,^{23,24} it is not clear to what extent sustained use is exhibited in nationally representative samples. Heavier users are potentially exposed to a greater volume of toxicants and are more likely to report being dependent on WTS and more resistant to quitting.^{25,26}

Another important unanswered question is whether use over time is changing relative to other forms of tobacco use. Though some indications are that use may be increasing,^{3,20} many organizations are resistant to invest in long-term surveillance. For example, the 2015 Youth Risk Behavior Surveillance Survey for U.S. high school students asks about smokeless tobacco, cigars, and electronic cigarettes, but does not assess WTS.²⁷

Monitoring the Future (MTF), which uses a weighted multistage random sampling procedure to ensure that results are nationally representative, began assessing WTS among 12th-grade students in 2010.²⁸ Data are currently available through 2013. We first aimed to leverage this data source to assess sustained WTS, including determination of independent associations between various sociodemographic and lifestyle factors and sustained WTS. Second, we aimed to compare prevalence trends for WTS with prevalence trends for other tobacco products during the study period.

Methods

Participants and Procedures

A detailed description of the University of Michigan's MTF study is available elsewhere.²⁹ Briefly, MTF uses a multistage sampling procedure to obtain nationally representative samples of students attending public and private schools in the 48 contiguous states. Sample weights are assigned to each student to account for differential selection probabilities. The present study examined data from 12th-graders only, because WTS was not asked of eighth- and tenth-graders. We combined 2010–2013 data to include all available data (N=8,737). Students completed self-administered, machine-readable questionnaires during a normal class period. Response rates averaged 83%.³⁰ Absence on data collection day was the primary reason that students were missed; it is estimated that <1% of students declined to complete the questionnaire.³⁰ The study received approval from the University of Michigan IRB (HUM00063656).

Measures

The WTS question in the MTF survey read: *During the last 12 months, on how many occasions (if any) have you smoked tobacco using a hookah (water pipe)?* with response categories 0, 1–2, 3–5, 6–9, 10–19, 20–39, and 40+. For this study, the main outcome variable of sustained use was defined as use on at least six occasions in the last 12 months. This cut off was selected a priori for two reasons. First, use at least every other month seems to indicate a sustained pattern beyond isolated or experimental use, which might be because of a particular event such as Spring Break or a holiday party.^{1,16,31} Second, because available data indicate that a single WTS session delivers the tar of about 40 cigarettes,^{32–34} use on six occasions over the past year would indicate tar inhalation approximating 12 packs of cigarettes—at least one per month on average—which represents concerning and sustained exposure. We assessed cigarette use with the item: *How frequently have you smoked cigarettes during the past 30 days?* with responses ranging from *not at all* to *two packs or more per day*. Current (past 30-day) cigarette use was defined as no if *not at all* was selected and as yes if any other choice was selected. Small cigar use was assessed with an item similar to WTS (past-year use) and was categorized the same as cigarette use (*not in the past year* versus all others).

Sociodemographic variables of interest included sex, race/ethnicity, number of parents in the home, parental education level, school SES, population density, and region of the U.S.

Race and ethnicity were assessed per MTF protocol. The item asked: *How do you describe yourself?* and allowed participants to choose as many as they wished from nine different options. These responses were subsequently collapsed into four mutually exclusive categories: Caucasian, African American, Hispanic, or Other. Details on categories and coding are provided in Table 1. Those who did not select any check-boxes were considered missing. Parental education, also assessed using MTF protocol, was based on an 11-point scale created from an average of the mother and father's data and divided into quintiles. To determine school SES, the average parental education level for each school was collapsed into quartiles. Population density was based on U.S. Census Metropolitan Statistical Areas (MSAs).

Assessed lifestyle characteristics included students' educational behaviors and aspirations, employment, religiosity, and social activity, all of which have been shown to have preliminary associations with WTS.^{17,18,21,35} For grade point average, students responded to the item: *Which of the following best describes your average grade so far in high school?* We collapsed data into three categories: A (90–100); B (80–89); or C or below. We assessed truancy with the item: *During the LAST 4 WEEKS, how many whole days of school have you missed because you skipped or "cut"?* To assess educational plans, we used the item: *How likely is it that you will graduate from college (4-year program) after high school?* followed by a 4-point Likert-type scale. Students also self-reported the number of hours per week in a job and their average weekly income from paid work. We assessed religiosity with the item: *How important is religion in your life?* followed by a 4-point Likert-type scale. Students were also asked, *During a typical week, on how many evenings do you go out for fun and recreation?* and *On the average, how often do you go out with a date (or your spouse, if you are married)?* Response choices for all measures are noted in the tables.

Table 1. Associations Between Participant Characteristics and Waterpipe Tobacco Smoking

Characteristics	All	Any WTS ^a		Sustained WTS ^a		AOR (95% CI) ^c	p ^d
	N=8,737	1,639/8,737=18.8%	627/8,737=7.2%	Column %	Row %		
Sociodemographic characteristics							
Sex							
Male	49.6	20.1		8.5		1	
Female	50.4	17.4		5.8		0.78 (0.63, 0.96)	
Race/ethnicity ^e							
Caucasian	59.3	20.4		7.6		1	
African-American	11.7	7.1		2.4		0.26 (0.14, 0.48)	
Hispanic	16.1	20.3		8.2		1.00 (0.66, 1.49)	
Other	13.0	19.3		7.9		1.06 (0.78, 1.44)	
Number of parents							
0	6.2	18.3		10.0		1	
1	28.2	19.3		8.3		0.69 (0.42, 1.14)	
2	65.6	18.5		6.4		0.46 (0.30, 0.73)	
Parents education level index ^f							
1 (Low)	10.1	18.5		5.8		1	
2	21.6	17.7		7.5		1.25 (0.72, 2.18)	
3	28.9	19.9		7.6		1.41 (0.80, 2.47)	
4	26.2	18.5		6.8		1.32 (0.74, 2.36)	
5 (high)	13.2	19.9		7.2		1.44 (0.79, 2.64)	
School SES (rank)							
1 (low)	28.3	15.2		5.6		1	
2	23.2	16.2		5.9		1.30 (0.83, 2.04)	
3	24.4	21.8		9.0		1.69 (1.08, 2.65)	
4 (high)	24.2	22.0		8.2		1.60 (1.06, 2.42)	
Population density							
Large MSA	30.9	21.4		7.6		1	
Non-MSA	49.1	20.5		8.4		1.06 (0.78, 1.45)	
Other MSA	20.0	10.6		3.7		0.48 (0.32, 0.72)	
U.S. region							
Northeast	17.8	17.9		5.3		1	
North Central	23.6	19.2		7.6		0.68 (0.42, 1.11)	
South	35.6	14.6		4.9		1.39 (0.92, 2.08)	
West	23.1	25.1		11.5		2.28 (1.41, 3.70)	

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Table 1. Associations Between Participant Characteristics and Waterpipe Tobacco Smoking (continued)

Characteristics	All	Any WTS ^a		Sustained WTS ^a		AOR (95% CI) ^c	p ^d
	N=8,737	1,639/8,737=18.8%			627/8,737=7.2%		
	Column %	Row %	p ^b	Row %	p ^b		
Educational characteristics							
Grades			< 0.001		< 0.001		0.005
A	36.2	15.3		5.3		1	
B	47.9	19.4		7.2		1.20 (0.91, 1.57)	
C or below	16.0	24.4		11.1		1.54 (1.10, 2.15)	
Days cut school in the past month			< 0.001		< 0.001		< 0.001
Not at all	69.0	13.9		4.9		1	
1 or 2 times	20.8	26.9		9.7		1.76 (1.37, 2.26)	
3 or more times	10.3	37.1		17.6		2.48 (1.79, 3.43)	
Plans to graduate from college			0.046		0.006		0.66
Definitely won't	7.8	17.8		8.7		1	
Probably won't	9.3	21.1		9.1		1.04 (0.62, 1.72)	
Probably will	23.5	20.8		8.0		0.97 (0.65, 1.46)	
Definitely will	59.5	17.7		6.2		0.94 (0.64, 1.38)	
Employment characteristics							
Hours per week in a job			< 0.001		0.001		0.63
None	38.6	14.4		5.7		1	
1-15	32.5	20.1		7.2		0.93 (0.62, 1.40)	
16-≥ 30	28.9	23.4		9.1		1.04 (0.67, 1.63)	
Weekly income from paid work (\$)			< 0.001		< 0.001		0.09
None	43.8	14.8		5.4		1	
1-75	22.8	20.1		7.2		1.20 (0.82, 1.77)	
≥ 75	33.4	23.4		9.6		1.46 (0.93, 2.27)	
Other characteristics							
Religiosity			< 0.001		< 0.001		< 0.001
Not important	19.3	23.9		9.6		1	
A little important	20.6	20.6		6.7		0.70 (0.52, 0.95)	
Pretty important	22.4	18.1		6.9		0.83 (0.61, 1.13)	
Very important	24.5	10.8		3.7		0.50 (0.35, 0.71)	
Excluded ^e	13.2	24.8		11.3		0.70 (0.43, 1.13)	
Evenings out per week			< 0.001		< 0.001		< 0.001
Fewer than one	12.2	7.8		2.0		1	
One	15.2	11.4		4.0		1.88 (0.98, 3.62)	
Two	26.0	15.8		5.0		2.18 (1.14, 4.19)	

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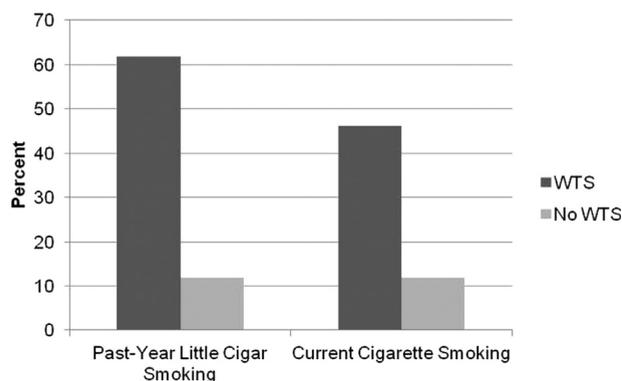
Table 2. Frequency of Waterpipe Tobacco Smoking by Study Year

Year	No. of times smoked waterpipe tobacco in the past year						
	0	1-2	3-5	6-9	10-19	20-39	≥40
2010	82.9	6.5	4.1	2.3	1.8	1.2	1.2
2011	81.5	8.2	4.4	1.4	2.1	0.8	1.7
2012	81.7	6.9	4.0	2.7	1.8	0.8	2.2
2013	78.6	7.3	5.0	2.8	2.5	2.1	1.7

Note: Values are percentages.

Sustained WTS was higher among male than female students (8.5% vs 5.8%, $p < 0.001$). Additionally, though between 7.6% and 8.2% of Caucasians, Hispanics, and those who identified as “Other” race/ethnicity reported sustained WTS, only 2.4% of African Americans reported this behavior ($p < 0.001$). Sustained WTS was highest in the West (11.5%), followed by the North Central, Northeast, and South (7.6%, 5.3%, and 4.9%, respectively). Other bivariable associations are presented in Table 1.

In the multivariable model controlling for all covariates (Table 1), compared with male students, female students had a reduced odds of sustained WTS (OR=0.78, 95% CI=0.63, 0.96). Compared with Caucasian students, African American students had lower odds of sustained WTS (OR=0.26, 95% CI=0.14, 0.48). Although participants’ parents’ educational level was not significantly associated with sustained WTS ($p=0.44$) at the individual level,

**Figure 1.** Prevalence of little cigar and cigarette smoking among those who had and had not smoked tobacco from a waterpipe.

Note: Dark vertical bars indicate the percentage of WTS users who also engaged in past-year little cigar smoking and past 30-day cigarette smoking, respectively. Light vertical bars indicate the percentage of non-WTS users who engaged in past-year little cigar smoking and past 30-day cigarette smoking. Monitoring the Future does not assess use of cigarettes in the past 12 months. Both comparisons were significant at the $p < 0.001$ level using χ^2 analyses.

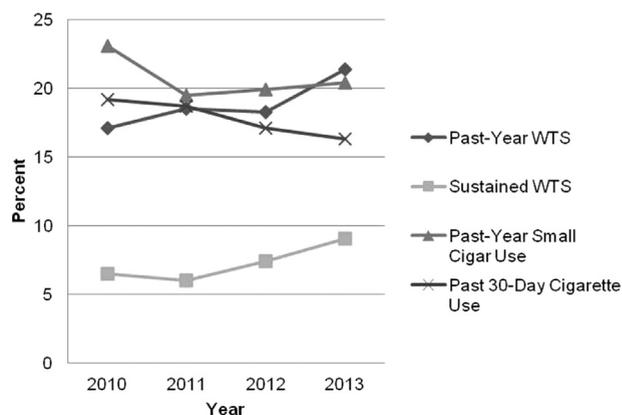
WTS, waterpipe tobacco smoking.

school-level parent education was positively associated with sustained WTS ($p=0.002$). Students with more parents in the house had reduced odds of sustained WTS ($p < 0.001$). Compared with those who lived in a large MSA, those in other MSAs (the most rural areas) had lower odds of sustained WTS (OR=0.48, 95% CI=0.32, 0.72). Finally, compared with those in the Northeastern U.S., those in the Western U.S. had higher odds of sustained WTS (OR=2.28, 95% CI=1.41, 3.70). Multiple lifestyle factors, including lower grades ($p=0.005$); increased truancy ($p < 0.001$); lower religiosity ($p < 0.001$); more evenings out per week ($p < 0.001$); and more dating ($p=0.03$) were also independently associated with sustained WTS.

Visual inspection of point estimates over time suggests that sustained and past-year WTS are increasing whereas past-year small cigar use and past 30-days cigarette use are decreasing (Figure 2). Linear regression coefficients over the 2010–2013 period were 0.08 for any past-year WTS (95% CI= -0.01, 0.17); 0.14 for sustained past-year WTS (95% CI= -0.0003, 0.27); -0.048 for past-year small cigar use (95% CI= -0.12, 0.03); and -0.070 for past 30-day cigarette smoking (95% CI= -0.12, -0.02). Therefore, CIs did not overlap between past-year WTS (-0.01, 0.17) and cigarette smoking (-0.12, -0.02). Additionally, CIs did not overlap between sustained WTS (-0.0003, 0.27) and cigarette smoking (-0.12, -0.02). However, both WTS outcomes did overlap with the small cigar outcome.

Discussion

From 2010 to 2013, nearly one of five (18.8%) U.S. 12th-graders used a waterpipe to smoke tobacco in the past year, and 38% of those did so at least six times in the past year. These findings are consistent with other studies of U.S. adolescents but lower than studies of adolescents from the Eastern Mediterranean Region, where WTS is

**Figure 2.** Trends in tobacco use from 2010-2013.

Note: Sustained WTS indicates use 6 or more times in the past 12 months.

WTS, waterpipe tobacco smoking.

more endemic.^{3,17} One common theme of prior WTS data is that ever use tends to be substantially higher than frequent use, suggesting a high level of experimentation but a lower level of sustained use.^{18,40,41} However, these findings suggest that more than a third of past-year users exhibit a more sustained pattern equating to a high toxicant load. For example, because one WTS session, which can last up to 45–60 minutes,^{7,8} is associated with about 40 times the tar inhaled from a single cigarette,^{32–34} current findings suggest that more than 7% of U.S. high school seniors have inhaled the tar of 240 cigarettes, or 12 packs of cigarettes, in the past year from waterpipes. Therefore, WTS is common enough among U.S. youth to be included in future surveillance and prevention efforts. These findings also raise concern regarding dependence, because heavier users may be more likely to be dependent.²⁶

There is substantial overlap between WTS and other forms of inhaled tobacco use in this population (Figure 1). However, the amount of disjunction between the behaviors is also noteworthy. For example, of past-year WTS users, more than half were not current users of cigarettes. This suggests that there is a large population of WTS-only smokers who represent an important target for prevention programming.

Although parental educational level was not significantly associated with WTS at the individual level, the average school-level educational attainment was significantly associated with sustained WTS, which was more prevalent in schools with higher proportions of more highly educated parents. Although there are possible explanations for this phenomenon—such as possible increased availability of these products in wealthier neighborhoods—it deserves future study.

This study also found that sustained WTS was less prevalent among African Americans but roughly comparable among other racial and ethnic groups. Because African Americans have higher prevalence of cigar and small cigar use,⁴² it is possible that their lower rate of WTS is due to a substitution effect. However, this issue may be valuable to explore in future qualitative work. Another issue worth considering is the meaning of the term *Caucasian*, which generally includes those of Middle Eastern ethnicity, who may be particularly at risk.⁴³ Thus, it is possible that this subgroup may at least somewhat influence the association between Caucasian race and WTS.

Sustained WTS was generally associated with the western U.S. in fully adjusted models (OR=2.28, 95% CI=1.41, 3.70). However, there was also relative consistency of prevalence throughout the U.S.—sustained use was 11.5% in the West, but was still between 4.9% and 7.6% in the other regions. Thus, though ultimately there may be some benefit to focusing on the Western region, sustained use prevalence rates are relatively consistent across geography.

Sustained WTS was associated with poorer academic achievement, including lower grades and truancy. Other risk-taking behaviors—including other forms of tobacco use—are associated with these factors.^{44–46} However, this is interesting in juxtaposition with the finding that use was more prevalent in higher-SES areas, which is not often the case for cigarette smoking. Therefore, WTS may represent a hybrid behavior for which some traditional associations apply whereas others do not. This may make intervention challenging.

Sustained WTS was more common among those with more-active social and occupational lives, such as spending more evenings out per week and dating. This is consistent with the perception of WTS as a highly social behavior, which has been described in both quantitative and qualitative studies.^{6,47–50}

From 2010 to 2013, both past-year and sustained WTS prevalence seem to be trending upward (Figure 2). Because the WTS CIs do not overlap with the CIs for cigarette smoking, these data suggest that both WTS outcomes may be increasing relative to cigarette smoking. Additionally, visual inspection of these trends suggests that the rise in sustained WTS seems to be larger than that in overall WTS prevalence. Although this is concerning because it may indicate transitions from occasional users to more frequent users over time, longitudinal analyses assessing the same individuals over time will be needed to confirm possible trends such as these.

Policy changes have driven much of the decrease in cigarette smoking over the past two decades.^{51,52} However, it has been noted that most extant policies do not adequately address WTS.^{8,53} Thus, one interpretation of possible increases in WTS compared with cigarette smoking is that policy measures aimed at reducing cigarette prevalence may have unintended consequences of a subsequent migration to WTS.⁵⁴ Policymakers should consider these findings while modifying existing clean indoor legislation and other tobacco regulations. For example, although the newly implemented Affordable Care Act allows insurers to charge cigarette smokers up to 50% higher premiums,⁵⁵ this may not affect WT users.

Limitations

The MTF survey relied on self-report of waterpipe use without biochemical verification. Additionally, it is a necessary limitation of the data that at present MTF does not assess 30-day or lifetime WTS. It should also be noted that the definition of “sustained” used in this study was based on report of WTS six times in the preceding year, and not on lack of interruption of WTS. Finer-grained data will be needed for more detailed pattern analysis. Additionally,

our time trend analyses sought to compare linear trends and did not model changes using higher-order (i.e., quadratic or cubic) terms. When more data points are available, more-complex modeling approaches may be useful. Finally, because of the breadth of the MTF instrument, it was not able to accommodate in-depth assessments specific to WTS such as attitudes, normative beliefs, and expectancies.

Conclusions

This 4-year study of a nationally representative sample of U.S. 12th-graders demonstrates a substantial prevalence of WTS in terms of use at least six times in the past year, and that both past-12-month and sustained WTS seem to be increasing in comparison with cigarette smoking. These findings suggest that WTS should be included with other forms of tobacco in efforts related to surveillance and intervention. This study was also valuable in that it revealed important bivariable and multivariable relationships between sustained WTS and important sociodemographic and lifestyle factors, which may help target interventions. However, analyses also revealed a relative consistency of WTS across multiple demographic factors. Thus, optimal intervention is likely to be challenging, because it will need to reach a large cohort of varied individuals.

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