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.


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 minutes7,8—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
prevalence rate and identified certain key sociodemo-
graphic 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 assump-
tion that use is generally intermittent or experimental.22
Although some users report more frequent use, suggest-
ing an extension beyond experimentation,23,24 it is not
clear to what extent sustained use is exhibited in nation-
ally 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,3,26 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 cigarette 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/
etnicity, 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 exclu-
sive 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

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All</th>
<th>Any WTS&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Sustained WTS&lt;sup&gt;a&lt;/sup&gt;</th>
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<tbody>
<tr>
<td></td>
<td>N=8,737</td>
<td>1,639/8,737=18.8%</td>
<td>627/8,737=7.2%</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Column %</td>
<td>Row %</td>
<td>p&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sociodemographic traits</td>
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<td></td>
<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
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<td>20.1</td>
<td>8.5</td>
</tr>
<tr>
<td>Female</td>
<td>50.4</td>
<td>17.4</td>
<td>5.8</td>
</tr>
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<td>Race/ethnicity</td>
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<td>Caucasian</td>
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</tr>
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<td></td>
</tr>
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<td>18.3</td>
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<td>2</td>
<td>65.6</td>
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<td>5 (high)</td>
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<td>19.9</td>
<td>7.2</td>
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<td>School SES (rank)</td>
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<tr>
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<td>5.9</td>
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<tr>
<td>3</td>
<td>24.4</td>
<td>21.8</td>
<td>9.0</td>
</tr>
<tr>
<td>4 (high)</td>
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<td>22.0</td>
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<td>Population density</td>
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<td>Non-MSA</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
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<td>17.9</td>
<td>5.3</td>
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<tr>
<td>North Central</td>
<td>23.6</td>
<td>19.2</td>
<td>7.6</td>
</tr>
<tr>
<td>South</td>
<td>35.6</td>
<td>14.6</td>
<td>4.9</td>
</tr>
<tr>
<td>West</td>
<td>23.1</td>
<td>25.1</td>
<td>11.5</td>
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Table 1. Associations Between Participant Characteristics and Waterpipe Tobacco Smoking (continued)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All (N=8,737)</th>
<th>Any WTSa (1,639/8,737=18.8%)</th>
<th>Sustained WTSa (627/8,737=7.2%)</th>
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<tbody>
<tr>
<td></td>
<td>Column %</td>
<td>Row %</td>
<td>p</td>
</tr>
<tr>
<td>Grades</td>
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<tr>
<td>A</td>
<td>36.2</td>
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<tr>
<td>B</td>
<td>47.9</td>
<td>19.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>C or below</td>
<td>16.0</td>
<td>24.4</td>
<td>&lt;0.001</td>
</tr>
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<td>Days cut school in the past month</td>
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<tr>
<td>Not at all</td>
<td>69.0</td>
<td>13.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1 or 2 times</td>
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<td>26.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3 or more times</td>
<td>10.3</td>
<td>37.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Plans to graduate from college</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definitely won't</td>
<td>7.8</td>
<td>17.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Probably won't</td>
<td>9.3</td>
<td>21.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Probably will</td>
<td>23.5</td>
<td>20.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Definitely will</td>
<td>59.5</td>
<td>17.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Employment characteristics</td>
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<tr>
<td>Hours per week in a job</td>
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<td></td>
<td>&lt;0.001</td>
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<tr>
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<td>38.6</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>1–15</td>
<td>32.5</td>
<td>20.1</td>
<td></td>
</tr>
<tr>
<td>16–≥30</td>
<td>28.9</td>
<td>23.4</td>
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</tr>
<tr>
<td>Weekly income from paid work ($)</td>
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<td></td>
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</tr>
<tr>
<td>None</td>
<td>43.8</td>
<td>14.8</td>
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</tr>
<tr>
<td>1–75</td>
<td>22.8</td>
<td>20.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≥75</td>
<td>33.4</td>
<td>23.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other characteristics</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Religiosity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not important</td>
<td>19.3</td>
<td>23.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>A little important</td>
<td>20.6</td>
<td>20.6</td>
<td></td>
</tr>
<tr>
<td>Pretty important</td>
<td>22.4</td>
<td>18.1</td>
<td></td>
</tr>
<tr>
<td>Very important</td>
<td>24.5</td>
<td>10.8</td>
<td></td>
</tr>
<tr>
<td>Excludedf</td>
<td>13.2</td>
<td>24.8</td>
<td></td>
</tr>
<tr>
<td>Evenings out per week</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fewer than one</td>
<td>12.2</td>
<td>7.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>One</td>
<td>15.2</td>
<td>11.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Two</td>
<td>26.0</td>
<td>15.8</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All</th>
<th>Any WTS (b)</th>
<th>Sustained WTS (a)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>N=8,737</td>
<td>1,639/8,737=18.8%</td>
<td>627/8,737=7.2%</td>
</tr>
<tr>
<td></td>
<td>Column %</td>
<td>Row %</td>
<td>p(^b)</td>
</tr>
<tr>
<td>Three</td>
<td>23.0</td>
<td>22.0</td>
<td>8.3</td>
</tr>
<tr>
<td>Four or five</td>
<td>15.4</td>
<td>26.8</td>
<td>10.9</td>
</tr>
<tr>
<td>Six or seven</td>
<td>8.2</td>
<td>34.7</td>
<td>17.6</td>
</tr>
<tr>
<td>Dating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>32.0</td>
<td>11.7</td>
<td>4.5</td>
</tr>
<tr>
<td>Once a month or fewer</td>
<td>17.8</td>
<td>19.8</td>
<td>7.3</td>
</tr>
<tr>
<td>2 or 3 times a month</td>
<td>15.7</td>
<td>20.6</td>
<td>7.1</td>
</tr>
<tr>
<td>Once a week</td>
<td>14.7</td>
<td>20.6</td>
<td>7.7</td>
</tr>
<tr>
<td>2 or 3 times a week</td>
<td>13.7</td>
<td>25.4</td>
<td>10.2</td>
</tr>
<tr>
<td>&gt; 3 times a week</td>
<td>6.1</td>
<td>29.3</td>
<td>13.3</td>
</tr>
</tbody>
</table>

Note: Boldface indicates statistical significance (p<0.05).
\(a\)Sustained WTS was defined as use \(\geq\) 6 times in the past 12 months.
\(b\)Rao-Scott chi-square test adjusts for complex survey design.
\(c\)AOR are for sustained WTS and were computed using logistic regression.
\(d\)Test for trend was computed only for ordered categorical variables.34

Items assessing race and ethnicity asked How do you describe yourself? and allowed participants to choose more than one from the following options: (1) Black or African American; (2) Mexican American or Chicano; (3) Cuban American; (4) Puerto Rican; (5) Other Hispanic or Latino; (6) Asian American; (7) White (Caucasian); (8) American Indian or Alaska Native; and (9) Native Hawaiian or Other Pacific Islander. These responses were subsequently collapsed into four mutually exclusive categories. Participants marking only (7) were classified as Caucasian; those selecting only (2), (3), (4), or (5) or any combination of these were categorized as Hispanic; and those who selected other categories or multiple categories were defined as Other. Those who did not select check-boxes were considered missing.

Based on an 11-point scale created from an average of the mother and father’s data, divided into quintiles. Those with missing data were excluded from analysis.

\(f\)California respondents excluded.

WTS, waterpipe tobacco smoking.

Statistical Analysis

We used descriptive statistics to examine respondent characteristics and determine the prevalence of past-year and sustained WTS. Because all covariates were categorical, we used two-way chi-square tests to assess bivariant associations between covariates and WTS outcomes. To assess multivariable associations, we used logistic regression analyses for the primary outcome variable of sustained WTS. We used an established method for assessing overall linear trend for ordered categorical independent variables.36 All analyses were adjusted to account for the complex sample design, including clustering of individuals within schools and integrating survey weights. Because only 2.9% of those in the sample had any missing covariate data, we used listwise deletion instead of imputation for multivariable analyses. Because there was no effect of year in diagnostic bivariant and multivariable logistic regression analyses, we grouped all years together for all primary analyses.

We compared trends over time (2010–2013) by visual inspection. However, we also used linear regression to calculate slope estimates and 95% CIs for each tobacco type over the 4 years. We then examined overlap between the 95% CIs of these slope estimates for each WTS trend (any 12-month use and 12-month sustained use) and each other tobacco use trend (30-day cigarette use and 12-month cigar or small cigar use).37–38 We performed statistical analyses with SAS, version 9.3, and two-tailed p-values < 0.05 were considered significant.

Results

The 8,737 respondents were 50.4% female, 59.3% Caucasian, 11.7% African American, and 16.1% Hispanic. About two thirds (65.6%) of the sample reported smoking cigarettes in the past 30 days. Both small cigar smoking and alternative tobacco use (notably hookah) were significantly associated with WTS use in the past 12 months (Figure 1). However, among past-year WTS users, 53.8% were not current users of cigarettes and about 38.1% had not used little cigars in the past year (Figure 1).
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 decreased 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, 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 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
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,28 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 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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