

Waterpipe Tobacco Smoking: An Emerging Health Crisis in the United States

Caroline Cobb, MS; Kenneth D. Ward, PhD; Wasim Maziak, MD, PhD;
Alan L. Shihadeh, ScD; Thomas Eissenberg, PhD

Objective: To examine the prevalence and potential health risks of waterpipe tobacco smoking. **Methods:** A literature review was performed to compile information relating to waterpipe tobacco smoking. **Results:** Waterpipe tobacco smoking is increasing in prevalence worldwide; in the United States, 10-20% of some young adult populations are current waterpipe users. Depending on the toxicant measured, a single

waterpipe session produces the equivalent of at least 1 and as many as 50 cigarettes. Misconceptions about waterpipe smoke content may lead users to underestimate health risks. **Conclusion:** Inclusion of waterpipe tobacco smoking in tobacco control activities may help reduce its spread.

Key words: waterpipe tobacco smoking, prevention, adolescent behavior

Am J Health Behav. 2010;34(3):275-285

Tobacco use causes many of the world's leading lethal ailments, including cardiovascular disease, chronic obstructive pulmonary disease, and lung cancer.¹ In the United States, tobacco smoking remains the leading preventable cause of death, even as considerable success has been achieved in curb-

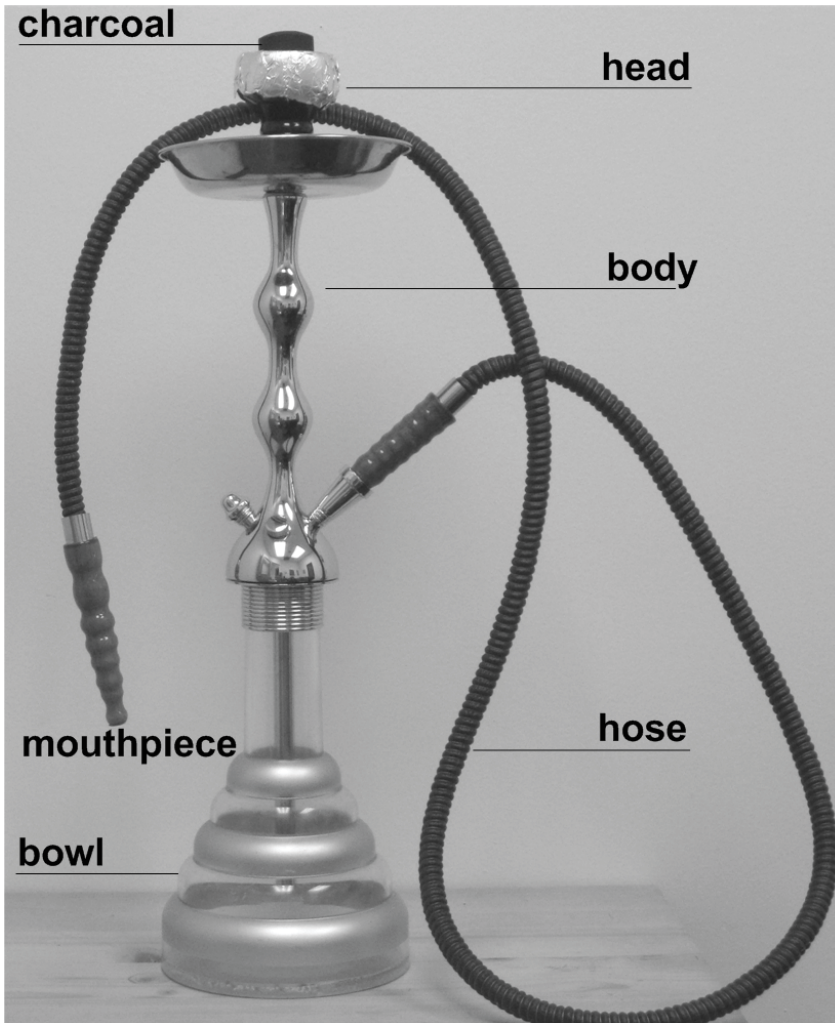
ing the tobacco epidemic over the past 20 years.² This success is threatened by alternative methods of tobacco use, including waterpipe tobacco smoking.^{3,4}

Waterpipe tobacco smoking is a centuries-old tobacco use method with an ambiguous origin⁵ and links to the countries of southwest Asia and north Africa. Although known by many different names (eg, hookah, narghile, shisha), the term *waterpipe* has been used for the last 2 decades in the English language scientific literature⁶⁻¹⁰ to refer to any of a variety of instruments that involve passing tobacco smoke through water before inhalation. Contrary to popular belief that waterpipe tobacco smoking is less lethal than cigarette smoking,^{9,11} emerging research indicates that both involve comparable health risks^{3,4,12} including nicotine/tobacco dependence.^{13,14} In addition, waterpipe tobacco smoking may be, for some individuals, a precursor to cigarette smoking.¹⁵⁻¹⁷ All of these issues are relevant to the United States, where waterpipe tobacco smoking appears to be increasing in popularity. Thus, this review addresses this emerging tobacco

Caroline Cobb, Graduate Student, Department of Psychology, Virginia Commonwealth University, Richmond, VA. Kenneth D. Ward and Wasim Maziak, Associate Professors, Department of Health and Sport Sciences and Center for Community Health The University of Memphis, Syrian Center for Tobacco Studies, Aleppo, Syria, Memphis, TN. Alan L. Shihadeh, Associate Professor, Department of Mechanical Engineering, American University of Beirut, Lebanon. Thomas Eissenberg, Professor, Department of Psychology and Institute for Drug and Alcohol Studies, Virginia Commonwealth University, Syrian Center for Tobacco Studies, Aleppo, Syria, Richmond, VA.

Address correspondence to Dr Eissenberg, Department of Psychology and Institute for Drug and Alcohol Studies, Virginia Commonwealth University, Box 980205, Richmond, VA 23298. E-mail: teissenb@vcu.edu

Figure 1
A Waterpipe Prepared for Tobacco Smoking, Including Perforated Foil Separating the Charcoal from the Tobacco That Has Been Placed in the Head



use method in the United States by highlighting current data regarding its prevalence and potential health effects, as well as the knowledge, beliefs, and attitudes associated with, and potentially fueling, the spread of this tobacco use method. Our goals include increasing awareness, stimulating research, influencing policy, and developing effective prevention and treatment interventions.

What Are Waterpipes and How Are They Used to Smoke Tobacco?

Although composition details may differ by culture, tobacco waterpipes most often seen in the United States have a fired-clay head, metal body, glass or acrylic water bowl, and leather or plastic hose (Figure 1). The bowl is partially filled with water and the head is filled with moistened tobacco upon which a lit piece of

Table 1
Mean Puff Topography for Waterpipe Users and Cigarette Smokers

Topography variable	Waterpipe		Cigarette	
	N = 20 ²⁴	N = 52 ²²	N = 30 ²⁵	N = 56 ²⁶
Puff number	178	171	10.0	12.7
Puff volume (ml)	590	530	51.0	48.6
Puff duration (s)	2.8	2.6	1.4	1.5
Interpuff interval (s)	15.2	15.5	30.7	21.3

charcoal is placed (tobacco and charcoal are often separated by perforated aluminum foil). The smoker inhales through the hose, thus drawing air over the burning charcoal, heating the tobacco, and producing smoke that travels through the body of the waterpipe, the water, and the hose to the user.¹⁸ The most popular type of waterpipe tobacco is called *maassel* (also known as *shisha* tobacco), a wet mixture of tobacco, sweetener, and flavorings. *Maassel* comes in many flavors, including fruit and candy, and it produces an aromatic smoke that may be particularly appealing to youth.¹⁹ Waterpipe charcoal products range from traditional earthen kiln charcoal to quick-lighting products that are particularly common in the United States.²⁰

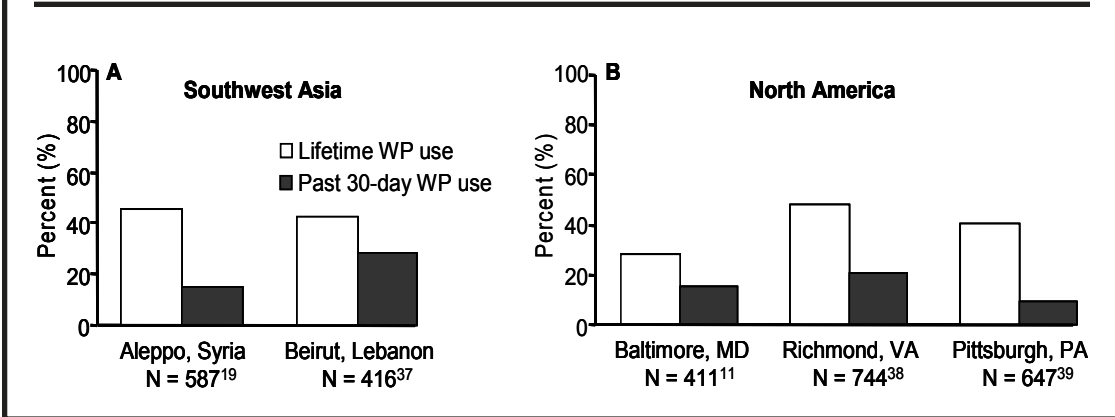
Relative to a single cigarette, completed in about 5 minutes,²¹ a single waterpipe use episode typically lasts for about 1 hour.¹⁸ Recent technical innovations²²⁻²⁴ confirm this duration and also provide a more detailed analysis of waterpipe tobacco smoking episodes. As seen in Table 1, data collected from actual waterpipe tobacco smokers in natural settings show that a waterpipe use episode typically involves almost 200 puffs, with an average puff volume exceeding 500 ml.^{22,24} Thus, compared to a cigarette, which involves inhalation of approximately 500-600 ml of smoke (ie, 10-13 puffs of about 50 ml, on average^{25,26}), a single waterpipe use episode involves inhalation of approximately 90,000 ml of smoke.^{22,24} Although these detailed puff topography data are based on waterpipe tobacco smokers in Lebanon, the duration of waterpipe use episodes has been explored (via self-report) in surveys of US waterpipe tobacco smokers, with as many as 44% reporting episodes of 60 minutes or longer.²⁰

Waterpipe Tobacco Smoking in the United States

Waterpipe tobacco smoking is often associated with southwest Asia and north Africa but, in recent years, has spread across the globe and to the United States. In this country, several lines of evidence suggest that waterpipe tobacco smoking is becoming more common, especially on college campuses. First, in April 2004, *Smokeshop* magazine (a 30-year-old trade journal serving the tobacco industry) reported that 200-300 new waterpipe cafés had opened in the United States since 1999 and that these cafés were “often near college campuses.”²⁷ Second, recent press reports support the idea that the United States is in the early stages of a waterpipe epidemic among its college-age population: waterpipe use has been reported in at least 33 states, with most reports coming from cities with a large university.²⁸⁻³⁵ As one recent letter in the *American Journal of Public Health* noted: “In Pittsburgh, 4 hookah bars have opened since 2003, each no more than 5 miles from the campuses of Carnegie Mellon University and the University of Pittsburgh. Hookahs have become commonplace at fraternity parties at these universities. . . .”³⁶

These anecdotal reports are beginning to be corroborated by survey data from individual universities across the country (Figure 2, Panel B). For example, in a convenience sample survey of 411 Johns Hopkins University freshmen (100% <age 23, 48% women, 58% white, 93% US citizen), 15.3% reported past 30-day waterpipe tobacco smoking.¹¹ In another convenience sample survey of 744 Virginia Commonwealth University students (93% <age 23, 65% women, 43% nonwhite, 92% US citizen), 20.3% reported past 30-day waterpipe use.³⁸ In the only study of a US college population to use random sam-

Figure 2
Percent of Respondents from Locations in Southwest Asia^{19,37}
and North America^{11,38,39} Reporting Lifetime and Past 30-day
Waterpipe (WP) Tobacco Smoking



pling procedures, 40.5% of 647 students who responded to an e-mail survey reported ever using a waterpipe to smoke tobacco, with 9.5% reporting waterpipe tobacco smoking in the past 30 days.^{39,40} Thus, especially among university students, waterpipe tobacco smoking has become remarkably common in the United States. The spread of waterpipe tobacco smoking may be attributable, at least in part, to the ready commercial availability of flavored tobacco and quick-lighting charcoal.⁹ In the United States, these and other waterpipe-related products commonly are purchased via the Internet.²⁰

Recent work in Southwest Asia and the United States suggests that some individuals begin smoking tobacco using a waterpipe at a young age. For example, in a survey of 2443 Lebanese students (11 to 17+ years old; M=15) from public and private secondary schools in greater Beirut, 64.9% reported that they had tried waterpipe at some point in their life, and 25.6% reported past 30-day use.⁴¹ Also, among 388 Israeli schoolchildren aged 12-18, 41% reported current waterpipe tobacco smoking, and 22% reported that they used a waterpipe to smoke tobacco every weekend.⁴² In the United States, a survey of 1671 Arab American adolescents found that 26.6% reported ever use of a waterpipe, and by the age of 14, more adolescents had tried waterpipe than ciga-

rettes (23% vs 15%, respectively).⁴³ Many waterpipe users in this survey reported that they first used the waterpipe before the age of 10.⁴³ In a study of a convenience sample of 1872 14- to 18-year-olds in the US Midwest, 16.7% Arab American youth, and 11.3% non-Arab youth reported past-month waterpipe use.⁴⁴ Clearly, cultural factors may be important in understanding waterpipe use among these Arab American populations, and more work addressing this issue is necessary. Waterpipe tobacco smoking is also surprisingly common in more diverse populations: among 6594 Arizona students (grades 6 thru 12) who responded to the Youth Tobacco Survey, 7.3% of 12th graders and 3.5% of all students reported past 30-day waterpipe use.⁴⁵ All of these data addressing youth are important because, at least for cigarette smoking, earlier initiation is associated with longer duration of smoking and increased risk of nicotine dependence and deleterious health effects.⁴⁶ Moreover, waterpipe tobacco smoking in the United States may be introducing tobacco to an otherwise tobacco-naïve group of adolescents and young adults. In Pittsburgh, 35.4% of university students who use a waterpipe had never smoked a cigarette.³⁹

The fact that many waterpipe tobacco smokers are otherwise tobacco naïve is worrisome, in part because waterpipe tobacco smoking may become a gateway to

initiation of cigarette smoking.¹⁵ Such a prospect is plausible given that waterpipe tobacco smoking is time-consuming and largely sedentary: active individuals who enjoy the effects of smoking tobacco with a waterpipe may turn to cigarettes for a more convenient and mobile smoking method. Evidence from cross-sectional study of Arab American adolescents shows that the odds of experimenting with cigarettes were 8 times greater for those who have ever smoked tobacco using a waterpipe.⁴³ In a population-based study of young adult US military recruits, waterpipe users were more likely than nonusers to plan to initiate cigarette smoking in the next year.¹⁶ Thus, preliminary data suggest that the waterpipe can become a vector to highly lethal and addictive cigarette smoking. There is less evidence that waterpipe tobacco smoking is associated with marijuana use: in a survey of 201 US waterpipe tobacco smokers, 64.2% reported not having used marijuana in the past 30 days, and only 10.4% reported that they smoked marijuana and tobacco in the same waterpipe.²⁰

To What Toxicants Are Waterpipe Users Exposed?

For some tobacco smoke toxicants (eg, nicotine, carbon monoxide, or CO), the smoke content and user toxicant exposure associated with waterpipes is at least comparable to that of cigarettes.^{10,47,48} In terms of smoke toxicant content, when waterpipe tobacco smoke is generated by a machine that is programmed to imitate the puff parameters of actual waterpipe users, substantial amounts of nicotine, CO, and tar (nicotine-free dry particulate matter) can be measured in the smoke.^{18,23} As Table 2 shows, the levels of CO and tar produced by a single waterpipe use episode are substantially greater than those found in the smoke generated by a machine programmed to smoke a single cigarette using puffing parameters observed in cigarette smokers. In fact, these data suggest that, relative to a single cigarette (about 500 ml of smoke, see Table 1), a single waterpipe use episode (about 90,000 ml of smoke, see Table 1) is associated with 1.7 times the nicotine, 6.5 times the CO, and 46.4 times the tar. Although extrapolating this type of smoke content analysis to actual cigarette or waterpipe smokers has important limitations (see ^{23,49}), these data suggest that

Table 2
Machine-generated Smoke Content Using Realistic Puff Parameters for a Single Waterpipe Episode and a Single Cigarette

Toxicant (mg)	Waterpipe ²³	Cigarette ²⁶	Ratio
Nicotine	2.94	1.74	1.7
CO	145	22.3	6.5
Tar	802	17.3	46.36

waterpipe tobacco smoking is likely associated with substantial toxicant exposure.

Although more research is needed, preliminary evidence supports the notion that waterpipe tobacco smokers are exposed to a variety of smoke toxicants. For example, a meta-analysis of studies looking at waterpipe users' exposure to the psychoactive and dependence-producing drug nicotine shows that daily waterpipe use produces a urinary cotinine level that corresponds to a nicotine absorption rate equal to smoking 10 cigarettes per day.⁴⁸ CO, a smoke toxicant that reduces the blood's ability to carry oxygen, can also be found in waterpipe users,⁵⁰ and waterpipe-induced increases in expired air CO may far exceed those produced by a cigarette.^{51,52} Indeed, in a recently published study of waterpipe users in California, waterpipe tobacco smoking led to a mean increase in expired air CO of over 30 ppm,¹⁰ about 5 times that which would be expected from a single cigarette.^{eg,25} Thus far, there has been little empirical attention paid to users' exposure to other toxicants in waterpipe smoke, including lung carcinogens^{23,53} and heavy metals.^{18,54}

Recent research has shown that waterpipe smoke may contain a variety of specific toxicants found in cigarettes. For example, machine-generated waterpipe smoke contains alarming levels of volatile aldehydes such as formaldehyde, acetaldehyde, and acrolein, all compounds present in cigarette smoke.⁵⁵ Another toxicant of interest is the isotope ²¹⁰Po, which is a member of the uranium decay series and present in tobacco and tobacco smoke.⁵⁶ Entering smokers' bodies via inhaled smoke ²¹⁰Po is capable of delivering powerful radiation doses and thus

radiotoxic effects to humans.^{56,57} Although the activity concentrations of ²¹⁰Po in 2 forms of waterpipe tobacco may be lower than those in cigarette tobacco, the percentage of ²¹⁰Po released in the smoke stream is still high (>39%, see^{58,59}). Taken together, all of the data concerning waterpipe tobacco toxicant content raise important concerns, as decades of research on cigarette smokers demonstrate that prolonged exposure to these toxicants leads to significant adverse health effects.⁶⁰

However, based on existing data, there is little evidence to support the perception that passing the smoke through water reduces toxicant exposure.¹⁸ There may be more reason to believe that the lower temperatures attained by waterpipe tobacco (approximately 450°C for waterpipe vs 900°C degrees for cigarette¹⁸) reduce mutagenicity of the smoke components originating in the tobacco⁶¹ though the same is not true for the components originating in the charcoal. In any case, discussions of whether the water or the tobacco temperature reduces smoke toxicant content from some maximal level may be made moot by the fact that, in a single use episode with water in the waterpipe and a relatively low tobacco temperature, a waterpipe produces an average of 90,000 ml of smoke that, relative to a single cigarette, contains about 6 times the CO (Table 2), 46 times the tar (see Table 2), and more than 50 times the quantity of some carcinogenic polycyclic aromatic hydrocarbons,⁵³ as well as heavy metals such as lead and arsenic.¹⁸

Exposure to waterpipe-associated toxicants is not restricted to users; nearby nonsmokers may also be exposed. Recent studies show that mainstream smoke from a waterpipe contains high levels of fine particulate matter,^{62,63} which can be an important cardio-respiratory hazard.^{64,65} A considerable proportion of these particles (eg, PM_{2.5}) are emitted by waterpipe tobacco smokers to the surrounding air, reaching levels compared to those associated with cigarette smoking.⁶⁶ These data justify inclusion of waterpipe cafés and lounges in current clean indoor air policies aimed at protecting customers and workers of these establishments.

What Are the Health Effects of Waterpipe Tobacco Smoking?

Despite the long history of the

waterpipe, the health effects of this method of tobacco smoking have not been as clearly documented as for cigarettes, perhaps due to a lack of adequate resources in the world regions where waterpipe tobacco smoking traditionally has occurred. The available evidence, although scant, suggests that waterpipe tobacco smokers, like cigarette smokers, are at risk for nicotine/tobacco dependence, cardiovascular disease, and cancer.

Dependence is thought to represent cellular adaptation to chronic drug exposure.^{eg,67,68} The potential for waterpipe use to support dependence is based on the fact that waterpipe smoke delivers the dependence-producing drug nicotine.⁴⁸ Because cellular adaptations are difficult to observe in humans, drug dependence is characterized behaviorally by repeated drug self-administration despite known health risks, financial costs, and quit attempts.⁶⁹ Abstinence effects that are suppressed by drug administration are also dependence indicators.⁷⁰ Although more systematic study is required, at least some users perceive waterpipe tobacco smoking to be detrimental to their health and may not be able to quit easily: in one study, 28.4% of waterpipe users indicated an interest in quitting, with over half of these reporting a past-year unsuccessful quit attempt.⁷¹ Also, in a recent survey of US waterpipe users, 12.9% (24/186) said that they were "hooked on a waterpipe."²⁰ Still, emerging evidence suggests higher quit rates among waterpipe users compared to cigarette smokers.^{16,72}

One way to assess drug dependence is to terminate drug administration: dependence is revealed by abstinence-induced effects that are suppressed by subsequent drug administration.⁷³⁻⁷⁵ Importantly, abstinent daily waterpipe users report withdrawal symptoms that are suppressed by waterpipe use.¹⁷ Thus, although more study is clearly needed, available evidence from surveys and clinical laboratory studies support the idea that tobacco smoking using a waterpipe supports tobacco/nicotine dependence.

Waterpipe-induced tobacco/nicotine dependence is likely to share features with cigarette smoking (ie, those mediated by nicotine), but may also have distinct features attributable to waterpipe-specific characteristics such as setting

and time of use, accessibility, taste and smell of flavored waterpipe smoke.¹³ To the extent that empirical study reveals these distinct features of waterpipe-induced dependence, they will need to be accounted for as smoking cessation interventions for waterpipe users are developed.⁹

More research is also needed to clarify waterpipe-induced risk of other tobacco-caused diseases, such as cardiovascular disease and cancer. The existing literature has been reviewed elsewhere^{3,4} and demonstrates that waterpipe use may be associated with coronary heart disease,⁷⁶ a variety of negative pulmonary outcomes,^{77,78} and bronchogenic carcinoma.^{79,80} A recent study demonstrated that, relative to nonsmokers, both daily waterpipe tobacco smokers and daily cigarette smokers had higher levels of carcinoembryonic antigen (CEA), a protein associated with tumor formation.⁸¹ In addition, an epidemiological study suggests that heavy waterpipe users have significantly higher levels of CEA in comparison to nonsmoking healthy controls.⁸² Waterpipe tobacco smoking also increases micronucleus (MN) frequency, a marker for early identification of carcinogenesis.^{12,83} Waterpipe smoking is also a risk to dental^{84,85} and fetal health.⁸⁶⁻⁸⁸ Finally, because waterpipe tobacco smoking is often a social behavior that involves sharing the same waterpipe, it may increase the risk of infectious disease transmission.⁸⁹ Disposable mouthpieces are available to address this concern, though their acceptability, actual use, and ultimate effectiveness are unknown. Importantly, causal links between waterpipe tobacco smoking and these various health risks are uncertain, due to small sample sizes used in the few existing studies, concurrent or prior cigarette use among the studied individuals, and other potentially confounding factors.^{3,4} As waterpipe tobacco smoking spreads across the globe, rigorous study and clear communication regarding its potential effects on health will be required.

What Do People Believe About Waterpipes?

One of the defining features of the global resurgence in waterpipe use is the widespread perception that, relative to tobacco cigarette smoking, tobacco smoking using a waterpipe is likely to be less

lethal due to the presumed but unsubstantiated “filtering” effects of the water.⁹ Indeed, several recent US college-based studies show that the majority of waterpipe tobacco smokers perceive this tobacco use method as being less harmful and addictive than cigarettes.^{17,20}

Another component of the “reduced” harm/addictiveness perception among waterpipe users may be related to the predominantly intermittent use pattern of this tobacco use method.¹³ However, intermittent waterpipe tobacco smoking does not preclude dependence development – in cigarette smokers, symptoms of nicotine dependence and withdrawal can appear with intermittent smoking.^{90,91} Also, the fact that a single episode of waterpipe smoking can involve volumes of tobacco smoke that are orders of magnitude greater than a single cigarette suggests that intermittent waterpipe tobacco smoking may involve substantial levels of smoke toxicant exposure.

Aside from perceptions regarding health risks and addiction, many young waterpipe users are attracted to the aromatic smell of waterpipe smoke and the opportunity it provides for social interaction.^{3,9,92} In particular, the social dimension has emerged in several studies from countries in southwest Asia (reviewed in reference 3). In qualitative studies among Arab American adolescents, waterpipe use has been viewed as being “cool” and a way to socialize with friends.⁹² Socializing is a common theme in the few studies conducted in the United States: in one, 79% of 201 waterpipe tobacco smokers surveyed reported that they smoked tobacco in a waterpipe at least in part because it is a good way to socialize with friends.²⁰ Indeed, a series of recent studies among US college students suggests that the majority of waterpipe users view the practice as socially acceptable.^{20,38,39} Perhaps more than with cigarette smoking, effective waterpipe prevention interventions will need to deal with the misconceptions related to health risks associated with waterpipe use and address some specific features of this tobacco use method, including its value and stimulus for social behavior.

CONCLUSIONS AND IMPLICATIONS

Waterpipe tobacco smoking is a growing health concern globally and especially among young adults in the United States.

Many waterpipe tobacco smokers perceive this behavior to be less lethal and addicting than cigarettes.²⁰ Converging lines of evidence, including waterpipe smoke analysis, user toxicant exposure, and health effects research contradict this perception, though more study is required.⁸³ As more detailed study continues, physicians, policy makers, and tobacco control advocates can play an important role in addressing perceptions and minimizing the spread of waterpipe tobacco smoking.

One important step that can be taken immediately is that health care providers can include waterpipe tobacco smoking when evaluating patients, especially adolescents and young adults. This inclusion could come in the form of explicit mention of waterpipe when implementing standardized assessments⁹³ and clear statements that waterpipe tobacco smoke contains many of the same toxicants as cigarette smoke. On an individual level, the addition of waterpipe in assessments of tobacco use may help counteract the perception that this form of tobacco use is benign.

To date, waterpipe tobacco smoking has received little attention in systematic surveillance, large-scale social marketing campaigns, prevention interventions, and other tobacco control activities. For example, most national surveys of tobacco use do not explicitly assess waterpipe tobacco smoking, making prevalence estimates difficult. Similarly, clean indoor air legislation in many states has been unclear concerning whether waterpipe smoking establishments (eg, "hookah cafés") fall under criteria that prohibit or limit their operation.⁹⁴ Also, more must be done to limit minors' access to waterpipe products, enforce clear warning labels on waterpipe tobacco, and ensure that common but misleading descriptors such as "0% tar" are removed from packaging. Until waterpipe tobacco smoking is included in these and other interventions, many young adults are likely to maintain their belief that it is less lethal than cigarette smoking. Indeed, some may already interpret the absence of waterpipe tobacco smoking from these activities as implied endorsement of this perception. By including waterpipe tobacco smoking in all levels of tobacco control – from individual providers to large-scale public information cam-

paigns – we may be able to halt and eventually reverse its spread among American youth.

Acknowledgments

Sources of support include National Institute on Drug Abuse grant R01DA024876, National Cancer Institute grants R01CA103827 and R01CA120142, and Fogarty International Center grant R01TW05962. ■

REFERENCES

1. World Health Organization. Factsheet No. 310: The top 10 causes of death. 2007. Available at <http://www.who.int/mediacentre/factsheets/fs310/en/print.html>. Accessed August, 1, 2007.
2. Centers for Disease Control and Prevention. Cigarette smoking among adults — United States, 2006. *MMWR Morb Mortal Wkly Rep*. 2007;56(44):1157-1161.
3. Maziak W, Ward KD, Soweid RA, Eissenberg T. Tobacco smoking using a waterpipe: a re-emerging strain in a global epidemic. *Tob Control*. 2004;13:327-333.
4. Knishknowy B, Amitai Y. Water-pipe (Narghile) smoking: an emerging health risk behavior. *Pediatrics*. 2005;116(1):e113-e119.
5. Chattopadhyay A. Emperor Akbar as a healer and his eminent physicians. *Bull Indian Inst Hist Med Hyderabad*. 2000;30:151-157.
6. Lubin JH, Li JY, Xuan XZ, et al. Risk of lung cancer among cigarette and pipe smokers in southern China. *Int J Cancer*. 1992;51(3):390-395.
7. Inhorn MC, Buss KA. Ethnography, epidemiology and infertility in Egypt. *Soc Sci Med*. 1994;39(5):671-686.
8. Bedwani R, el-Khwsy F, Renganathan E, et al. Epidemiology of bladder cancer in Alexandria, Egypt: tobacco smoking. *Int J Cancer*. 1997;73(1):64-7.
9. Maziak W, Ward KD, Eissenberg T. Interventions for waterpipe smoking cessation. *Cochrane Database Syst Rev*. 2007;(4):CD005549.
10. El-Nachef WN, Hammond SK. Exhaled carbon monoxide with waterpipe use in US students. *JAMA*. 2008;299(1):36-38.
11. Smith SY, Curbow B, Stillman FA. Harm perception of nicotine products in college freshmen. *Nicotine Tob Res*. 2007;9(9):977-982.
12. El-Setouhy M, Loffredo CA, Rawan G, et al. Genotoxic effects of waterpipe smoking on the buccal mucosa cells. *Mutation Res*. 2008;655:36-40.
13. Maziak W, Eissenberg T, Ward KD. Patterns of waterpipe use and dependence: implications for intervention development. *Pharmacol Biochem Behav*. 2005;80:173-179.
14. Al Mutairi SS, Shihab-Eldeen AA, Mojiminiyi OA, Anwar AA. Comparative analysis of the

- effects of hubble-bubble (sheesha) and cigarette smoking on respiratory and metabolic parameters in hubble-bubble and cigarette smokers. *Respirology*. 2006;11(4):449-455.
15. Hammal F, Mock J, Ward KD, et al. A pleasure among friends: how narghile (waterpipe) smoking differs from cigarette smoking in Syria. *Tob Control*. 2008;17(12):e3.
 16. Ward KD, Vander Weg MW, Relyea G, et al. Waterpipe smoking among American military recruits. *Prev Med*. 2006;43:92-97.
 17. Ward KD, Eissenberg T, Gray JN, et al. Characteristics of U.S. waterpipe users: a preliminary report. *Nicotine Tob Res*. 2007;9(12):1339-1346.
 18. Shihadeh A. Investigation of mainstream smoke aerosol of the argileh waterpipe. *Food Chem Toxicol*. 2003;4:143-152.
 19. Maziak W, Eissenberg T, Rastam S, et al. Beliefs and attitudes related to narghile (waterpipe) smoking among university students in Syria. *Ann Epidemiol*. 2004;14(9):646-654.
 20. Smith-Simone S, Maziak W, Ward KD, Eissenberg T. Waterpipe tobacco smoking: knowledge, attitudes, beliefs, and behaviors in two U.S. samples. *Nic Tob Research*. 2008;10(2):393-398.
 21. Eissenberg T, Adams C, Riggins III EC, Likeness M. Smokers' sex and the effects of tobacco cigarettes: subject-rated and physiological measures. *Nicotine Tob Research*. 1999;1:317-324.
 22. Shihadeh A, Azar S, Antonios C, Haddad A. Towards a topographical model of narghile water-pipe cafe smoking: a pilot study in a high socioeconomic status neighborhood of Beirut, Lebanon. *Pharmacol Biochem Behav*. 2004;79(1):75-82.
 23. Shihadeh A, Saleh R. Polycyclic aromatic hydrocarbons, carbon monoxide, "tar", and nicotine in the mainstream smoke aerosol of the narghile waterpipe. *Food Chem Toxicol*. 2005;43(5):655-661.
 24. Katurji M. A portable closed-loop control isokinetic particle sampling system for narghile waterpipe field studies. Master's Thesis, American University of Beirut, Department of Mechanical Engineering. 2006. Available at: http://olib.aub.edu.lb/cgi-bin/jl_w207.sh. Accessed December 11, 2008.
 25. Breland AB, Kleykamp BA, Eissenberg T. Clinical laboratory evaluation of potential reduced exposure products for smokers. *Nicotine Tob Res*. 2006;8(6):727-738.
 26. Djordjevic MV, Stellman SD, Zang E. Doses of nicotine and lung carcinogens delivered to cigarette smokers. *J Natl Cancer Inst*. 2000;92(2):106-111.
 27. Hookah cafes on the rise (online). *Smokeshop*. 2004. Available at: <http://www.smoke-shop.com/0404/retail.htm>. Accessed July 31, 2007.
 28. D'Andrea N. Up in smoke: looking for a place to puff. *Phoenix New Times*. July 19, 2007. Available at: <http://www.phoenixnewtimes.com/2007-07-19/music/up-in-smoke/>. Accessed July 31, 2007.
 29. Hillary L. Up in Smoke. *Arizona Daily Wildcat*. February 22, 2005. Available at: http://wc.arizona.edu/papers/98/103/04_1.html. Accessed August 20, 2007.
 30. Horn C. Is smoking hookah worse than smoking cigarettes. *University Daily Kansan*. September 6, 2007. Available at: http://www.kansan.com/stories/2007/sep/06/good_youbad_you/. Accessed July 31, 2007.
 31. Coleman W. Off the hookah. *The Oklahoma Daily*. October 22, 2006. Available at: http://hub.ou.edu/articles/article.php?article_id=1788148691. Accessed July 31, 2007.
 32. Enenmoh I. Hookah bar business is good, expansion planned. *Iowa State Daily*. August 22, 2005. Available at: http://www.iowastatedaily.com/home/index.cfm?event=displayArticlePrinterFriendly&uStory_id=b5e97c4f-a346-1028-a55e-75b0145261f1. Accessed July 31, 2007.
 33. Rosacker C. Popular hookah bar reopening soon. *Daily Nebraskan*. September 20, 2006. Available at: <http://media.www.dailynebraskan.com/media/storage/paper857/news/2006/09/20/News/Popular.Hookah.Bar.Reopening.Soon-2286735.shtml>. Accessed July 31, 2007.
 34. Circosta C, Carlon B. Hookah smoking can have health effects similar to cigarettes. *Kentnews.net*. November 14, 2006. Available at: <http://media.www.kentnewsnet.com/media/storage/paper867/news/2006/11/14/Features/Hookah.Smoking.Can.Have.Health.Effects.Similar.To.Cigarettes-2457182.shtml>. Accessed July 31, 2007.
 35. Kasper A. Hookah Joe is on the grow: Utah clean air act prohibits. *The Signpost*. October 5, 2005. Available at: <http://media.www.wsusignpost.com/media/storage/paper985/news/2005/10/05/Features/Hookah.Joe.Is.On.The.Grow-2110423.shtml>. Accessed July 31, 2007.
 36. Primack BA. An old custom, a new threat to tobacco control. *Am J Public Health*. 2006;96(8):1339.
 37. Chaaya M, El-Roueiheb Z, Chemaitelly H, et al. Argileh smoking among university students: a new tobacco epidemic. *Nicotine Tob Res*. 2004;6(3):457-463.
 38. Eissenberg T, Ward KD, Smith-Simone S, Maziak W. Waterpipe tobacco smoking on a U.S. college campus: prevalence and predictors. *J Adolesc Health*. 2008;42(5):526-529.
 39. Primack BA, Sidani J, Agarwal A, et al. Prevalence of an association with waterpipe tobacco smoking among college students. *Ann Behav Med*. 2008;36(1):81-86.
 40. Grekin ER, Ayna D. Argileh use among college students in the united states: an emerging trend. *J Stud Alcohol Drugs*. 2008;69:472-475.

41. Tamim H, Al-Sahab B, Akkary G, et al. Cigarette and nargileh smoking practices among school students in Beirut, Lebanon. *Am J Health Behav.* 2007;31(1):56-63.
42. Varsano S, Ganz I, Eldor N, Garenkin M. [Water-pipe tobacco smoking among school children in Israel: frequencies, habits, and attitudes]. *Harefuah.* 2003;142(11). Hebrew.
43. Rice VH, Weglicki LS, Templin T, et al. Predictors of Arab American adolescent tobacco use. *Merrill Plamer Q.* 2006;52(2):327-342.
44. Weglicki LS, Templin T, Hammad A, et al. Health issues in the Arab American community. Tobacco use patterns among high school students: do Arab American youth differ? *Ethn Dis.* 2007;17(2 Suppl 3):S3-22-S3-24.
45. Primack BA, Walsh M, Bryce C, Eissenberg T. Waterpipe tobacco smoking among middle and high school students. *Pediatrics.* 2009;123(2):e282-e288.
46. Breslau N, Peterson EL. Smoking cessation in young adults: age of initiation of cigarette smoking and other suspected influences. *Am J Public Health.* 1996;86(2):214-220.
47. World Health Organization. Waterpipe Tobacco Smoking: Health Effects, Research Needs and Recommended Actions by Regulators. Geneva, Switzerland: World Health Organization, 2005.
48. Neergaard J, Singh P, Job J, Montgomery S. Waterpipe smoking and nicotine exposure: a review of the current evidence. *Nicotine Tob Res.* 2007;9(10):987-994.
49. Shihadeh A, Azar A. A closed-loop control "playback" smoking machine for generating mainstream smoke aerosols. *J Aerosol Med.* 2006;19(2):137-147.
50. Shafagoj YA, Mohammed FI. Levels of maximum end-expiratory carbon monoxide and certain cardiovascular parameters following hubble-bubble smoking. *Saudi Med J.* 2002;23(8):953-958.
51. Bacha ZA, Salameh P, Waked M. Saliva cotinine and exhaled carbon monoxide levels in natural environment waterpipe smokers. *Inhal Toxicol.* 2007;19:771-777.
52. Ward KD, Eissenberg T, Rastam S, et al. The tobacco epidemic in Syria. *Tob Control.* 2006;15 Suppl 1:i24-29.
53. Sepetdjian E, Shihadeh A, Saliba N. Measurement of 16 polycyclic aromatic hydrocarbons in narghile waterpipe tobacco smoke. *Food Chem Toxicol.* 2008;46(5):1582-1590.
54. Sukumar A, Subramanian R. Elements in hair and nails of residents from a village adjacent to New Delhi: influence of place of occupation and smoking habits. *Biol Trace Elem Res.* 1992;34:99-105.
55. Al Rashidi M, Shihadeh A, Saliba NA. Volatile aldehydes in the mainstream smoke of the narghile waterpipe. *Food Chem Toxicol.* 2008;46(11):3546-3549.
56. Martell EA. Radioactivity of tobacco trichomes and insoluble cigarette smoke particles. *Nature.* 1974;;249(454):215-217.
57. Kiltzau GF. Cancer risk in relation to radioactivity in tobacco. *Radiol Technol.* 1996;67(3):217-222.
58. Al-Arifi MN. Estimation of the amount of ²¹⁰Po Released with the smoke stream into smoker's lungs from cigarette tobacco and some smoking-pastes in Saudi Arabia. *J Med Sci.* 2005;5(2):83-88.
59. Khater AEM, Abd El-Aziz N, Al-Sewaidan HA, Chaouachi K. Radiological hazards of narghile (hookah, shisha, goza) smoking: activity concentrations and dose assessment. *J Environ Radioact.* 2008;99(12):1808-1814.
60. U.S. Department of Health and Human Services. The Health Consequences of Smoking: a Report of the Surgeon General. Atlanta, Georgia: U.S. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2004.
61. White JL, Conner BT, Perfetti TA, et al. Effect of pyrolysis temperature on the mutagenicity of tobacco smoke condensate. *Food Chem Toxicol.* 2001;39:499-505.
62. Monn Ch, Kindler P, Meile A, Brändli O. Ultrafine particle emissions from waterpipes. *Tob Control.* 2007;16(6):390-393.
63. Khalil M. Aerosol dynamics in the narghile waterpipe. Master's Thesis, American University of Beirut, Department of Mechanical Engineering. 2006. Available at: http://olib.aub.edu.lb/cgi-bin/jl_w207.sh. Accessed December 11, 2008.
64. Pope CA III, Burnett RT, Thun MJ, et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA.* 2002;287(9):1132-41.
65. International Agency for Research on Cancer (IARC). The IARC Monograph 83 on involuntary smoking. *IARC Monographs.* 2004.
66. Maziak W, Rastam S, Ibrahim I, et al. Waterpipe associated particulate matter emissions. *Nicotine Tob Res.* 2008;10(3):519-523.
67. Hildebrand BE, Nomikos GG, Hertel P, et al. Reduced dopamine output in the nucleus accumbens but not in the medial prefrontal cortex in rats displaying a mecamylamine-precipitated nicotine withdrawal syndrome. *Brain Res.* 1998;779(1-2):214-225.
68. Watkins SS, Koob GF, Markou A. Neural mechanisms underlying nicotine addiction: acute positive reinforcement and withdrawal. *Nicotine Tob Res.* 2000;2(1):19-37.
69. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision. Washington, DC: American Psychiatric Association; 2000.
70. Eissenberg T. Measuring the emergence of tobacco dependence: the contribution of negative reinforcement models. *Addiction.* 2004;99 Suppl 1:5-29.

71. Ward KD, Hammal F, VanderWeg MW, et al. Are waterpipe users interested in quitting? *Nicotine Tob Res.* 2005;7(1):149-56.
72. Yunis K, Beydoun H, Nakad P, et al. Patterns and predictors of tobacco smoking cessation: a hospital-based study of pregnant women in Lebanon. *Int J Public Health.* 2007;52(4):223-232.
73. Kolb L, Himmelsbach C K. Clinical studies of drug addiction. III. A critical review of the withdrawal treatments with method of evaluating abstinence syndromes. *Am J Psychiat.* 1938;94(4):759-797.
74. Hughes JR, Hatsukami D. Signs and symptoms of tobacco withdrawal. *Arch Gen Psychiatry.* 1986;43(3):289-294.
75. Martin WR, Sloan JW. Neuropharmacology and neurochemistry of subjective effects, analgesia, tolerance, and dependence produced by narcotic analgesics. In: W.R. Martin, H.T. Conrad and E. Ånggård, Eds, *Drug Addiction I: Morphine, Sedative/Hypnotic and Alcohol Dependence.* Handbook of Experimental Pharmacology, Springer-Verlag, Berlin, 1977:43-158.
76. Jabbour S, El-Roueiheb, Z, Sibai AM. Narghile (water-pipe) smoking and incident coronary heart disease: a case-control study [abstract]. *Ann Epidemiol.* 2003;13:570.
77. Al-Fayez SF, Salleh M, Ardawi M, Zahran FM. Effects of sheesha and cigarette smoking on pulmonary function of Saudi males and females. *Trop Geogr Med.* 1988;40:115-123.
78. Köseoglu N, Aydin A, Uçan ES, et al. [The effects of water-pipe, cigarette and passive smoking on mucociliary clearance]. *Tuberk Toraks.* 2006;54(3):222-8. Turkish.
79. Nafae A, Misra SP, Dhar SN, Shah SN. Bronchogenic carcinoma in Kashmir Valley. *Indian J Chest Dis.* 1973;15(4):285-295.
80. Nasrollahzadeh D, Kamangar F, Aghcheli K, et al. Opium, tobacco, and alcohol use in relation to oesophageal squamous cell carcinoma in a high-risk area of Iran. *Br J Cancer.* 2008;98(11):1857-1863.
81. Sajid KM, Parveen R, Durr-e-Sabih, et al. Carcinoembryonic antigen (CEA) levels in hookah smokers, cigarette smokers and non-smokers. *J Pak Med Assoc.* 2007;57:595-599.
82. Sajid KM, Chaouachi K, Mahmood R. Hookah smoking and cancer: carinoembryonic antigen (CEA) levels in exclusive/ever hookah smokers. *Harm Reduct J.* 2008;5:19.
83. World Health Organization: Regional Office for the Eastern Mediterranean. *The Health Hazards of Smoking Shisha.* Publication number WHO-EM/TFI/026-E-05-06. Cairo, Egypt: WHO EMRO, 2006.
84. Natto S, Baljoon M, Bergström J. Tobacco Smoking and Periodontal Health in a Saudi Arabian Population. *J Periodontol.* 2005;76(11):1919-1926.
85. Al-Belasy FA. The relationship of "shisha" (waterpipe) smoking to postextraction dry socket. *J Oral Maxillofac Surg.* 2004;62(1):10-14.
86. Nuwayhid IA, Yamout B, Azar G, Kambris MA. Narghile (hubble-bubble) smoking, low birth weight, and other pregnancy outcomes. *Am J Epidemiol.* 1998;148(4):375-383.
87. Bachir R, Chaaya M. Maternal smoking: Determinants and associated morbidity in two areas in Lebanon. *Matern Child Health J.* 2008;12(3):298-307.
88. Tamim H, Yunis KA, Chemaitelly H, Alameh M, Nassar AH; National Collaborative Perinatal Neonatal Network Beirut, Lebanon. Effect of narghile and cigarette smoking on newborn birthweight. *BJOG.* 2008;115(1):91-97.
89. Steentoft J, Wittendorf J, Andersen JR. [Tuberculosis and waterpipes as source of infection]. *Ugeskr Laeger.* 2006;168(9):904-7. Danish.
90. DiFranza JR, Savageau JA, Rigotti NA, et al. Development of symptoms of tobacco dependence in youths: 30 month follow up data from the DANDY study. *Tob Control.* 2002;11:228-235.
91. DiFranza JR, Savageau JA, Fletcher K, et al. Symptoms of tobacco dependence after brief intermittent use: the development and assessment of nicotine dependence in youth-2 study. *Arch Pediatr Adolesc Med.* 2007;161(7):704-10.
92. Rice VH, Templin T, Kulwicki A. Arab-american adolescent tobacco use: four pilot studies. *Prev Med.* 2003;37:492-498.
93. Schroeder SA. What to do with a patient who smokes. *JAMA.* 2005;294(4):482-487.
94. American Lung Association. Tobacco Policy Trend Alert, an Emerging Deadly Trend: Waterpipe Tobacco Use. 2007. Available at: http://slati.lungusa.org/alerts/Trend%20Alert_Waterpipes.pdf. Accessed January 8, 2008.