

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

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**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

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Tobacco use causes many of the world's leading lethal ailments, including cardiovascular disease, chronic obstructive pulmonary disease, and lung cancer.<sup>1</sup> 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.<sup>2</sup> This success is threatened by alternative methods of tobacco use, including waterpipe tobacco smoking.<sup>3,4</sup>

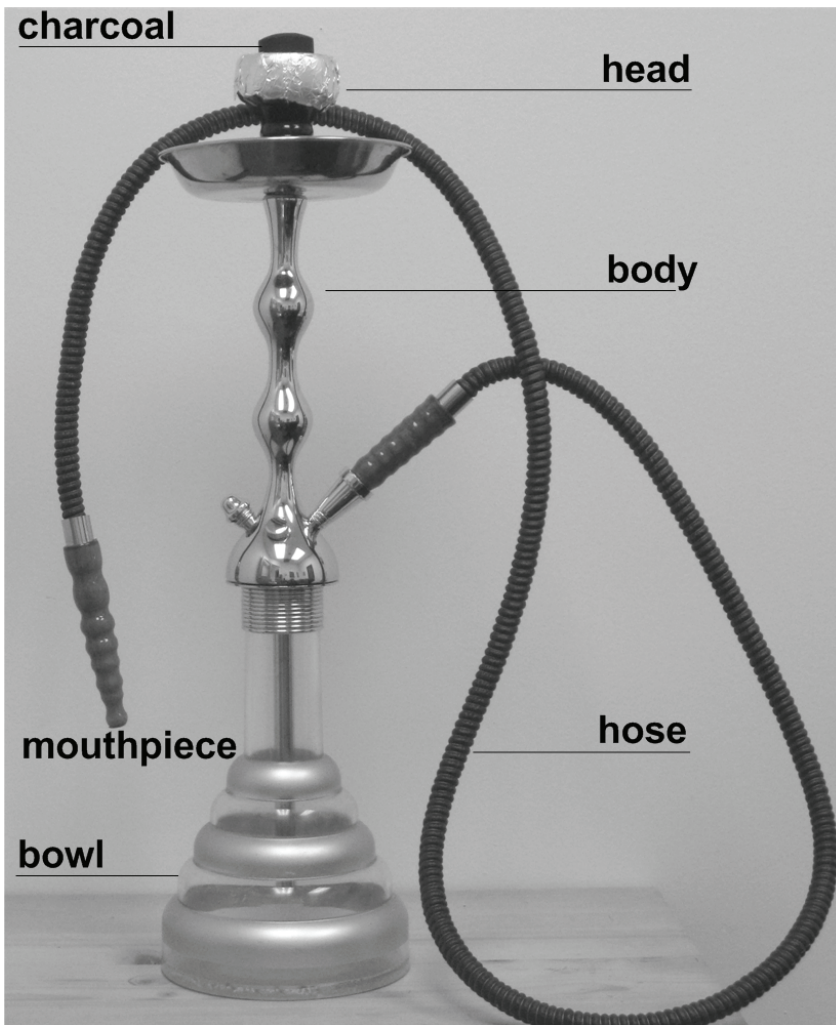
Waterpipe tobacco smoking is a centuries-old tobacco use method with an ambiguous origin<sup>5</sup> and links to the countries of southwest Asia and north Africa. Although known by many different names (eg, hookah, narghile, shisha), the term *waterpipe* has been used for the last 2 decades in the English language scientific literature<sup>6-10</sup> 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,<sup>9,11</sup> emerging research indicates that both involve comparable health risks<sup>3,4,12</sup> including nicotine/tobacco dependence.<sup>13,14</sup> In addition, waterpipe tobacco smoking may be, for some individuals, a precursor to cigarette smoking.<sup>15-17</sup> 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

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**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 <sup>24</sup>	N = 52 <sup>22</sup>	N = 30 <sup>25</sup>	N = 56 <sup>26</sup>
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.<sup>18</sup> 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.<sup>19</sup> Waterpipe charcoal products range from traditional earthen kiln charcoal to quick-lighting products that are particularly common in the United States.<sup>20</sup>

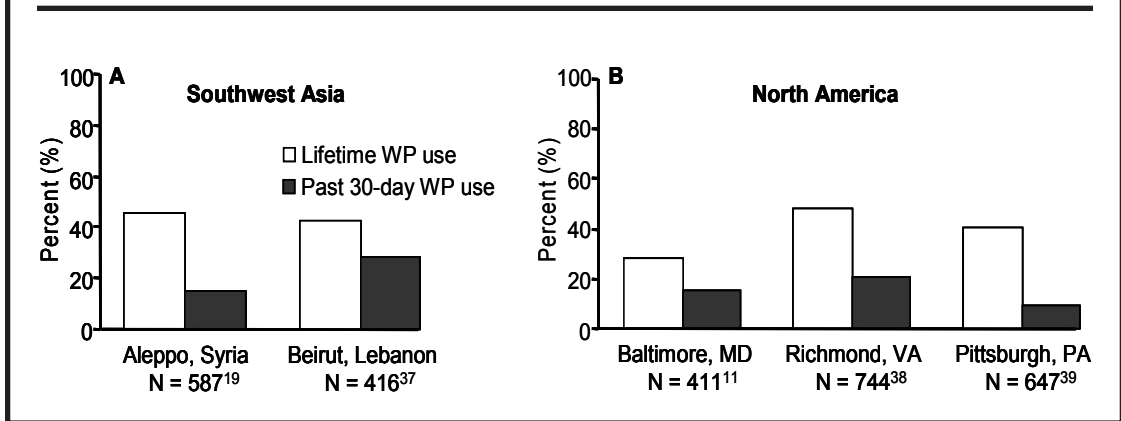
Relative to a single cigarette, completed in about 5 minutes,<sup>21</sup> a single waterpipe use episode typically lasts for about 1 hour.<sup>18</sup> Recent technical innovations<sup>22-24</sup> confirm this duration and also provide a more detailed analysis of waterpipe tobacco smoking episodes. 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.<sup>22,24</sup> 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<sup>25,26</sup>), a single waterpipe use episode involves inhalation of approximately 90,000 ml of smoke.<sup>22,24</sup> 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.<sup>20</sup>

### 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.”<sup>27</sup> 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.<sup>28-35</sup> 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. . . .”<sup>36</sup>

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.<sup>11</sup> 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.<sup>38</sup> In the only study of a US college population to use random sam-

**Figure 2**  
**Percent of Respondents from Locations in Southwest Asia<sup>19,37</sup>**  
**and North America<sup>11,38,39</sup> 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.<sup>39,40</sup> 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.<sup>9</sup> In the United States, these and other waterpipe-related products commonly are purchased via the Internet.<sup>20</sup>

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.<sup>41</sup> 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.<sup>42</sup> 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).<sup>43</sup> Many waterpipe users in this survey reported that they first used the waterpipe before the age of 10.<sup>43</sup> 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.<sup>44</sup> 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 12<sup>th</sup> graders and 3.5% of all students reported past 30-day waterpipe use.<sup>45</sup> 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.<sup>46</sup> 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.<sup>39</sup>

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.<sup>15</sup> 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.<sup>43</sup> 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.<sup>16</sup> 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.<sup>20</sup>

### 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.<sup>10,47,48</sup> 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.<sup>18,23</sup> 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<sup>23,49</sup>), 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 <sup>23</sup>	Cigarette <sup>26</sup>	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.<sup>48</sup> CO, a smoke toxicant that reduces the blood's ability to carry oxygen, can also be found in waterpipe users,<sup>50</sup> and waterpipe-induced increases in expired air CO may far exceed those produced by a cigarette.<sup>51,52</sup> 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,<sup>10</sup> about 5 times that which would be expected from a single cigarette.<sup>eg,25</sup> Thus far, there has been little empirical attention paid to users' exposure to other toxicants in waterpipe smoke, including lung carcinogens<sup>23,53</sup> and heavy metals.<sup>18,54</sup>

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.<sup>55</sup> Another toxicant of interest is the isotope <sup>210</sup>Po, which is a member of the uranium decay series and present in tobacco and tobacco smoke.<sup>56</sup> Entering smokers' bodies via inhaled smoke <sup>210</sup>Po is capable of delivering powerful radiation doses and thus

radiotoxic effects to humans.<sup>56,57</sup> Although the activity concentrations of <sup>210</sup>Po in 2 forms of waterpipe tobacco may be lower than those in cigarette tobacco, the percentage of <sup>210</sup>Po released in the smoke stream is still high (>39%, see<sup>58,59</sup>). 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.<sup>60</sup>

However, based on existing data, there is little evidence to support the perception that passing the smoke through water reduces toxicant exposure.<sup>18</sup> 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 cigarette<sup>18</sup>) reduce mutagenicity of the smoke components originating in the tobacco<sup>61</sup> 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,<sup>53</sup> as well as heavy metals such as lead and arsenic.<sup>18</sup>

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,<sup>62,63</sup> which can be an important cardio-respiratory hazard.<sup>64,65</sup> A considerable proportion of these particles (eg, PM<sub>2.5</sub>) are emitted by waterpipe tobacco smokers to the surrounding air, reaching levels compared to those associated with cigarette smoking.<sup>66</sup> 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.<sup>eg,67,68</sup> The potential for waterpipe use to support dependence is based on the fact that waterpipe smoke delivers the dependence-producing drug nicotine.<sup>48</sup> 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.<sup>69</sup> Abstinence effects that are suppressed by drug administration are also dependence indicators.<sup>70</sup> 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.<sup>71</sup> Also, in a recent survey of US waterpipe users, 12.9% (24/186) said that they were "hooked on a waterpipe."<sup>20</sup> Still, emerging evidence suggests higher quit rates among waterpipe users compared to cigarette smokers.<sup>16,72</sup>

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.<sup>73-75</sup> Importantly, abstinent daily waterpipe users report withdrawal symptoms that are suppressed by waterpipe use.<sup>17</sup> 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.<sup>13</sup> 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.<sup>9</sup>

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<sup>3,4</sup> and demonstrates that waterpipe use may be associated with coronary heart disease,<sup>76</sup> a variety of negative pulmonary outcomes,<sup>77,78</sup> and bronchogenic carcinoma.<sup>79,80</sup> 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.<sup>81</sup> In addition, an epidemiological study suggests that heavy waterpipe users have significantly higher levels of CEA in comparison to nonsmoking healthy controls.<sup>82</sup> Waterpipe tobacco smoking also increases micronucleus (MN) frequency, a marker for early identification of carcinogenesis.<sup>12,83</sup> Waterpipe smoking is also a risk to dental<sup>84,85</sup> and fetal health.<sup>86-88</sup> 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.<sup>89</sup> 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.<sup>3,4</sup> 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.<sup>9</sup> 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.<sup>17,20</sup>

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.<sup>13</sup> However, intermittent waterpipe tobacco smoking does not preclude dependence development – in cigarette smokers, symptoms of nicotine dependence and withdrawal can appear with intermittent smoking.<sup>90,91</sup> 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.<sup>3,9,92</sup> 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.<sup>92</sup> 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.<sup>20</sup> Indeed, a series of recent studies among US college students suggests that the majority of waterpipe users view the practice as socially acceptable.<sup>20,38,39</sup> 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.<sup>20</sup> Converging lines of evidence, including waterpipe smoke analysis, user toxicant exposure, and health effects research contradict this perception, though more study is required.<sup>83</sup> 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 assessments<sup>93</sup> 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.<sup>94</sup> 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.

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