

Waterpipe tobacco-smoking: a new smoking epidemic among the young?

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Abstract Waterpipe (hookah, narghile) tobacco smoking (WTS) is becoming prevalent worldwide and is one of the most popular forms of tobacco use among youth. WTS prevalence has increased dramatically among youth in the USA within the past decade. Misperceived as less harmful than cigarette smoking, WTS is associated with many of the same chronic health effects such as lung cancer, chronic obstructive pulmonary disease, cardiovascular disease, bronchitis, and asthma. Much of this risk is due to the fact that a single WTS session exposes users to large volumes of smoke that contain toxic chemicals such as carbon monoxide, cancer-causing polycyclic aromatic hydrocarbons, and volatile aldehydes. Unlike cigarette smoking, WTS poses unique risks of acute negative health outcomes including carbon monoxide poisoning and the spread of communicable diseases such as herpes and tuberculosis. Because waterpipe tobacco smoke contains the addictive chemical nicotine, youth who smoke tobacco from a waterpipe may be at risk for dependence. As a result, many youth may initiate WTS and continue to use despite negative health effects. Considering many of the

potential negative health effects associated with WTS affect the pulmonary system, pulmonologists and primary care providers may treat patients who are waterpipe tobacco smokers and should be aware of the risk associated with WTS. The purpose of this review is to describe a waterpipe, the prevalence and correlates of WTS, the toxicants found in waterpipe tobacco smoke, the health effects of WTS, and implications for pulmonologists and other clinicians.

Keywords Waterpipe tobacco smoking · Youth · Prevalence and correlates · Smoke toxicants · Health effects

Introduction

Nearly all health practitioners in the USA are aware of the dangers associated with tobacco use, with almost half a million deaths each year in the USA attributed to cigarette smoking [1]. Most of these deaths are caused by diseases of the lung or cardiovascular system [1]. However, many clinicians may be unaware of a growing tobacco-use trend that poses similar risks: tobacco smoking using a waterpipe (also known as hookah, narghile, or shisha). Waterpipe tobacco smoking (WTS) is increasing in prevalence, especially among adolescents and young adults. Health practitioners should be aware of the potential dangers associated with WTS so that they can help to prevent morbidity and mortality associated with it, just as they do with cigarette smoking. The purpose of this review is to provide a basic overview of WTS, describe current youth trends and why youth are attracted to WTS, describe the toxicants found in waterpipe tobacco smoke, and discuss the acute and chronic health effects associated with WTS, including implications for pulmonologists.

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Waterpipe tobacco-smoking overview

A waterpipe has four main components: the head, body, bowl, and hose/mouthpiece assembly (Fig. 1). A waterpipe is prepared for tobacco smoking by filling the head with 10–20 g of a moist, sweetened, and flavored tobacco mixture (called ma'assel or shisha). Virtually any flavor is available, and fruit (e.g., apple, peach, strawberry, watermelon), drink (e.g., margarita, piña colada), or candy flavors (e.g., chocolate, vanilla, white gummi bear) are common. The tobacco-filled head is covered with perforated aluminum foil onto which a lit piece of charcoal is placed. Charcoal is used in WTS because the moistness of the tobacco mixture in the head does not allow for self-sustained combustion. Rather, when the waterpipe smoker inhales on the hose/mouthpiece assembly, charcoal-heated air is drawn across the tobacco, thus producing the mainstream aerosol. This aerosol then passes through the body of the pipe, bubbles through the water in the bowl, travels the length of the hose, and the user inhales the resulting smoke.

Prevalence of WTS

While tobacco smoking using a waterpipe commonly is associated with the Eastern Mediterranean Region (EMR), it is now a common practice globally, though few countries regularly conduct surveillance on WTS [2]. As a result, determining up-to-date WTS prevalence rates in many countries can be challenging. With respect to the EMR, current adult WTS rates of 15 % have been reported in Lebanon [3], 8.6 % in Jordan [4], 44.6 % exclusive WTS (no other tobacco product

used) in Kuwait [5], and 3.3–6 % in Egypt [6, 7]. Adolescent WTS is also common in the EMR. A study examining data on WTS among 13–15-year-old adolescents from the Global Tobacco Survey reported current other tobacco-use (primarily WTS in the EMR region) rates of 15 % in Bahrain, 16 % in Kuwait, 9 % in Oman, 14 % in Qatar, 15 % in the United Arab Emirates, and 15 % in Yemen [8]. Current WTS rates among university students in the EMR include 28 % in Lebanon [9], 8–14.6 % in Saudi Arabia [10, 11], 6 % in the United Arab Emirates [12], and 33 % in Pakistan [13]. With respect to the rest of the world, ever WTS rates include 7.8 % in Scotland and 12.0 % in England [14], and current WTS has been reported among 8 % college students in the UK [15], 10 % among adolescents in Germany [16], 6.4 % of adults aged 15 and older in Vietnam [17], and 30 % of university students in Malaysia [18]. This global trend of increasing popularity of WTS has also made its way to North America.

Though WTS in the USA is a relatively recent trend, it has increased in popularity rapidly, particularly among adolescents and young adults. Young adults in the USA report current (past 30 day) WTS rates ranging from 7.2 to 20.3 % [19–25], past-year WTS rates of 12.1 to 43.4 % [19, 20, 23, 26, 27] and lifetime use rates ranging from 10 to 48.4 % [19, 20, 23, 25, 26]. In one study [19], more participants reported past-year WTS than past-year cigarette smoking (46.4 vs. 42.1 %) and in another study [23], lifetime WTS smoking was more common than lifetime cigarette smoking (41.0 vs. 39.6 %).

WTS smoking is not only becoming increasingly common among college students and young adults, but younger populations as well. Despite being illegal for individuals under the age of 18 in the USA, many studies report WTS among middle and high school students with rates increasing over time. For instance, two studies [28, 29] examining lifetime WTS among high school students in Florida reported that in 2007 11 % of high school students had tried WTS [28]. In 2012, this number had increased to 16.7 % [29]. Studies from other states and nationally representative samples report consistent findings. A survey of New Jersey high school students in 2008 found that 9.7 % of high school students were current waterpipe tobacco smokers [30]. A study of 5540 high school seniors from across the USA found that 18 % of the sample reported WTS in the past year [31]. Additionally, while some of these numbers may represent experimentation or infrequent WTS, some adolescents progress to continued use. A study examining WTS using 2011 data from the National Youth Tobacco Survey reported adolescent ever WTS at 7.3 % and current WTS at 2.6 % [32]. Using data from the same survey 1 year later, 1.3 % of middle school students and 5.4 % of high school students reported current WTS [33] which represented significant increases from WTS current use rates in 2011. These rates continued to increase and in 2014, current WTS was reported by 2.5 % of middle school students and 9.4 % of high school students [34] (See Fig. 2). In fact, in 2014 the only

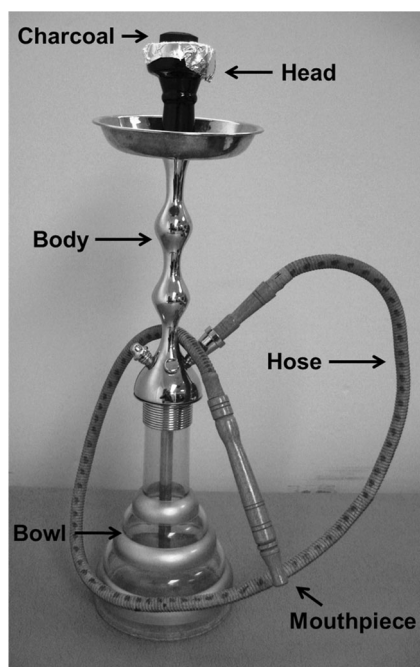


Fig. 1 Waterpipe tobacco-smoking assembly

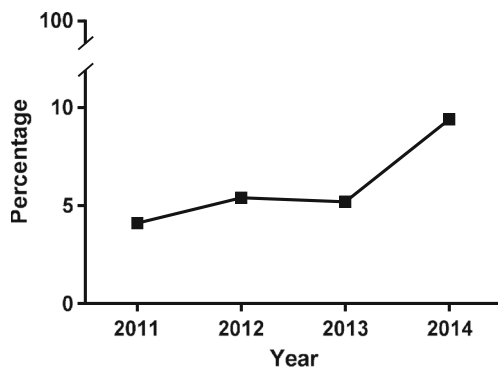


Fig. 2 Trends in past 30 day (current) waterpipe tobacco smoking among US high school students from 2011 to 2014. Data from [33, 34]

tobacco product more popular among adolescents than WTS was electronic cigarettes [34]. The current evidence from the USA and elsewhere around the world indicates that WTS is more than a passing fad and that many youth are at risk for WTS.

Youth appeal and correlates of WTS

Understanding the correlates of WTS may help us learn about what youth subgroups are most likely to engage in it. One of the most commonly reported and most problematic correlates of youth WTS is the perception that WTS is associated with less harm potential, especially when compared to combustible cigarette smoking [20, 23, 25, 35–40]. Many young adults perceive that WTS is associated with less nicotine, tar, and carcinogen exposure, less harmful secondhand smoke, a lower likelihood of causing addiction, and a lower likelihood of causing both short term and long-term harm including cancer [41]. Some of these perceptions could be a result of the numerous social media outlets that often portray WTS in a positive light [42] or misleading packaging that may cause waterpipe tobacco smokers to believe waterpipe tobacco smoke to be less harmful than cigarette smoke [43]. WTS is also perceived by youth as a more attractive and acceptable behavior compared to other forms of tobacco use [44]. There are many aspects of WTS that may be attractive to youth, especially the highly social dynamic associated with WTS. A qualitative study of 49 young adults reported that social acceptance, peer influence, socializing with friends, and looking “cool” were main reasons for WTS [45]. These results are supported by a larger survey of 438 young adults [46]. Of those respondents who reported hookah use, 29 % reported socializing/partying and 27 % reported peer influence as motivating factors for WTS [46]. Additionally, many youth may be attracted to attending the waterpipe cafés that have increased in number dramatically [47]. These cafés may be appealing to youth and young adults because they provide an attractive social atmosphere [48] especially for those wanting

to attend bars or nightclubs but are not of legal drinking age [49, 50] but are still old enough to gain access (legally or illegally) to venues where WTS occurs and alcohol is not served.

With some variations depending on sample characteristics, common demographic and behavioral correlates of WTS include: sex (males) [15, 22, 25, 28, 31, 36, 51–56], younger age (i.e., young adults) [25, 28, 52, 53], Arab ethnicity [15, 30, 36], non-Hispanic white race [22, 31, 53, 56], higher household income [31, 52, 57], tobacco use including cigarettes and cigar use [15, 21, 22, 25, 28, 30, 31, 36, 41, 46, 52–56], substance use including alcohol use and marijuana use [21, 25, 31, 41, 46, 52–56], binge drinking [46, 52, 55], and sensation-seeking personality characteristics [55]. There are several important points to understand regarding common correlates. First, the extent to which these common WTS correlates can be applied to different populations may differ substantially depending on cultural norms. For example, while WTS may be more common among those who report alcohol use and binge drinking in the USA, in countries and cultures where alcohol use is not as common (e.g., EMR countries), alcohol use is not a strong correlate. Second, while many studies have identified behavioral correlates of WTS, few longitudinal studies have examined behavioral predictors of WTS. That is, much of the current body of evidence does not allow causal inferences to be made regarding WTS initiation. Third, while Arab ethnicity has been identified as a correlate of WTS, the majority of young waterpipe tobacco smokers in the USA are of non-Arab ethnicity. However, the current evidence does indicate that many adolescents and young adults globally are at risk for WTS (for a more detailed discussion of the epidemiology of WTS, see [58•]).

Toxicants in waterpipe tobacco smoke

One especially problematic quality of WTS is the large volume of toxicant-laden smoke inhaled during a WTS session. The large volume is a product of long session durations and the large number of high volume puffs taken during each session. With regard to session length, a typical WTS session may last 45 min or more [59], much longer than the approximately 5 min taken to consume a tobacco cigarette. During this time, waterpipe users will take as many as 78–269 puffs [60, 61], as compared to approximately ten from a tobacco cigarette that is usually smoked in about 5 min (e.g., [62]). Moreover, each puff from a waterpipe involves inhalation of approximately 768–899 ml of smoke, compared to approximately 50 ml for a tobacco cigarette [60, 63]. As a result of each of these factors (time, puff number, puff volume), waterpipe smokers may inhale 31 to 86 l of smoke in a typical WTS session [61, 63–65], and potentially more for extended WTS sessions. Given that cigarette smokers typically inhale

on average 0.5 to 0.8 l of smoke per cigarette [66–68], waterpipe tobacco smokers may inhale anywhere between 39 and 172 times the volume of smoke in a single WTS session compared to smoking a single cigarette (Fig. 3).

There is much evidence demonstrating that waterpipe tobacco smoke contains many of the same lethal smoke toxicants as cigarette smoke that are known to cause disability, disease, and death. These toxicants include carbon monoxide (CO; [63, 69, 70]), polycyclic aromatic hydrocarbons (PAHs; [69, 71–73]), volatile aldehydes [74–76], and nicotine [63, 70]. Exposure to these toxicants is associated with a variety of adverse health consequences including cardiovascular disease, cancer, and pulmonary disease, and nicotine/tobacco dependence.

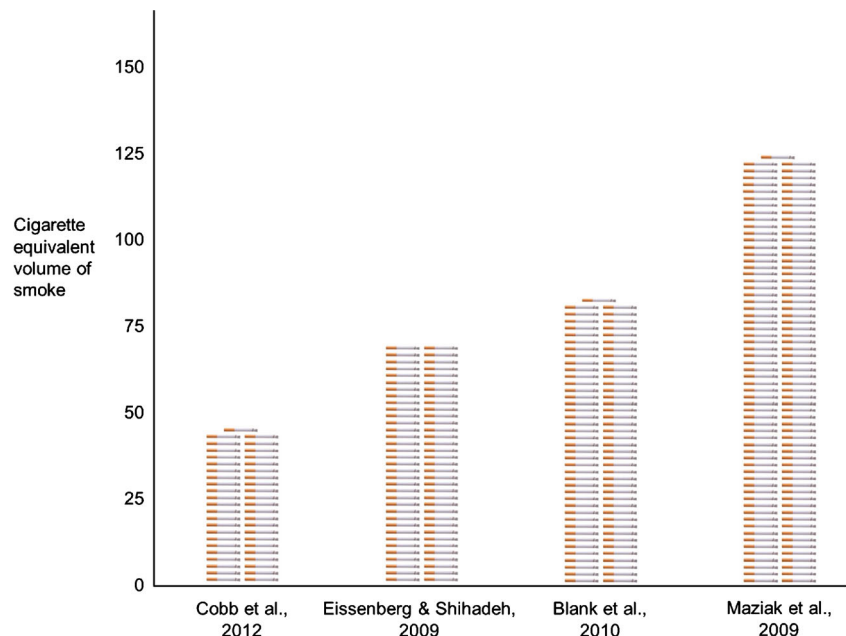
Many of the toxicants found in waterpipe tobacco smoke generated from a single session are found in significantly higher concentrations than in smoke generated from a single cigarette. For example, in one laboratory study examining PAHs in waterpipe tobacco smoke generated using a smoking protocol modeled after smokers observed in waterpipe cafés, a single WTS session produced an average of 2.5 times more phenanthrene, 8.2 times more fluoranthene, and 5.0 times more chrysene compared to the amount of toxins found in the smoke from a single cigarette [70]. Using similar methods, another study found that a single WTS session produced 16.6 times higher formaldehyde in the mainstream smoke than what is produced from smoking a single tobacco cigarette [74]. In no case is the amount of any toxicant contained in the smoke from a single WTS session ever less than the amount of that toxicant contained in the smoke from a single cigarette.

There is ample evidence that these toxicants reach the waterpipe tobacco smokers' lungs and blood. In one study,

carboxyhemoglobin levels among participants who engaged in a WTS session increased from 0.8 to 4.5 % compared to 0.8 to 1.1 % after smoking a single cigarette [60]. Field studies have also reported increased expired air CO after WTS. These studies report mean expired air CO concentration of patrons exiting waterpipe cafés of 34.7–58.2 ppm [15, 77, 78]. Metabolites of carcinogenic tobacco specific nitrosamines (TSNAs) such as NNAL have also been found in waterpipe tobacco smokers. Non-smokers have lower NNAL concentrations (0.7 pg/mL) than exclusive waterpipe daily waterpipe smokers (8.4 pg/mL) and exclusive daily cigarette smokers (10.7 pg/mL) [79] (see also [80]). Several studies have shown increases in plasma nicotine concentrations after WTS. These studies report mean increases in plasma nicotine concentration of 3.1–6.8 ng/ml [61, 64, 65, 81]. Finally, CO and nicotine measured in waterpipe tobacco smoke generated from a smoking machine that is programmed to replicate exactly the individual puffing behavior of actual waterpipe smokers is correlated strongly with those smokers' exposure to CO ($r > 0.78$) and nicotine ($r > 0.76$; [82]). This result means that waterpipe tobacco smokers are likely exposed to other toxicants such as aldehydes and PAHs that are measured in waterpipe tobacco smoke but have not yet been measured in waterpipe tobacco smokers (for a more detailed discussion of waterpipe smoke toxicant content see [83]).

One final note about toxicants in waterpipe smoke and in waterpipe tobacco smokers is in order. Many waterpipe smokers will point to labeling on waterpipe tobacco that indicates “0 % tar”, and “0.05 % nicotine” or “0.5 % nicotine”. This labeling is misleading. “Tar” is a tobacco smoke constituent, legally defined as “nicotine free, dry particulate matter”

Fig. 3 Volume of smoke generated in a single waterpipe tobacco-smoking session compared to a single cigarette



[84]. Because “tar” is a *smoke* constituent, any labeling on a container of non-burning tobacco is technically accurate that there is no “tar” in the tobacco, just as an unlit cigarette also contains no tar. However, once the tobacco is heated to produce smoke, tar is formed and is contained in the smoke. In fact, the smoke from a single waterpipe session produces approximately 802 mg of tar, compared to 11.2 mg from a single cigarette—more than 71 times greater tar produced [70]. While the content of the tar found in waterpipe smoke may differ from that of cigarette smoke, the fact that there is tar in waterpipe smoke is irrefutable. The nicotine labeling is also misleading. In one study, 110 waterpipe tobacco users smoked one of three brands of tobacco from a waterpipe [43]. These tobacco products were contained in packaging that listed nicotine content as 0.5 % (brand 1) or 0.05 % nicotine (brands 2 and 3). Peak plasma nicotine concentrations associated with these tobacco products were 9.8 ng/ml for Brand 1, 11.4 ng/ml for Brand 2 and 5.8 ng/ml for Brand 3 [43]. In other words, product labeling was not predictive of actual nicotine exposure. Not only does WTS deliver high concentrations of dangerous and dependence-causing toxicants to smokers, but waterpipe tobacco packaging may cause smokers to believe they are getting low or even no exposure to these toxicants.

Health effects of waterpipe smoking

A growing body of research identifies the acute and long-term health effects associated with WTS [85, 86•]. In terms of acute effects, WTS can, in some cases, cause CO intoxication. Numerous cases of CO poisoning have been reported in the literature [87–95]. In one of these reports [87], a 21-year-old man presented to the emergency department due to an episode of syncope. The patient reported smoking tobacco from a waterpipe earlier in the day and during the physical examination, the patient had a carboxyhemoglobin (COHb) level of 15.3 %. Cigarette smokers who smoke 40 or more cigarettes per day (≥ 2 packs per day) typically have COHb levels of 8–9 % [87]. CO poisoning is a potential risk of WTS because of the high concentrations of CO found in mainstream and sidestream waterpipe tobacco smoke and greater volumes of smoke inhaled per puff and per session (relative to other combustible tobacco products). Symptoms associated with increased CO concentration in the body include dizziness or feeling lightheaded. Some waterpipe tobacco smokers enjoy physiological effects associated with WTS including dizziness, relaxation, or feeling a head rush [45]. One study used a placebo control to disentangle the differences in effects resulting from exposure to nicotine and other smoke toxicant exposure [64]. In this study, occasional waterpipe tobacco smokers engaged in WTS in two double-blind sessions that differed by the product placed in the waterpipe head: the participants’ preferred flavor/brand of waterpipe tobacco or a

flavor matched, herbal waterpipe product that contained no tobacco and no nicotine (placebo). Participants in both conditions reported feelings of dizziness. Given that there was no nicotine in one condition, some of the dizziness may be attributable to CO inhalation. Ironically, the dizziness which is likely in part due to exposure to harmful CO may be perceived as a positive physiological effect associated with WTS.

In addition to CO intoxication, WTS has been implicated with the spread of certain communicable diseases including herpes and tuberculosis, likely due to sharing of the same hose/mouthpiece assembly during use [96, 97]. WTS has also been shown to cause acute increases in respiratory rate [98–100], decreased forced expiratory flow [98, 99], and decreased peak expiratory flow rate [98, 101].

In terms of the health effects associated with longer-term use, WTS is associated with many of the same chronic health effects as cigarette smoking. One of the most important is likely nicotine dependence, because dependence helps maintain WTS over the long-term. Like dependent cigarette smokers, at least some long-term waterpipe tobacco smokers report cravings for WTS [6, 15, 60, 102]. Also like cigarette smokers, some frequent waterpipe tobacco smokers report WTS within the first hour after waking, smoking a waterpipe even when feeling ill, and finding abstaining from WTS even for less than a day between sessions difficult [6]. These studies support the notion that WTS supports nicotine/tobacco dependence, and that many waterpipe tobacco smokers may continue WTS despite experiencing adverse health consequences (for a detailed review of this literature, see [103•]).

Indeed, a variety of adverse health consequences of WTS have been documented including chronic pulmonary health conditions, though this literature could be more robust [85]. WTS has been linked with lung cancer [104–106]. In a study of Lebanese adult hospital patients, being a former waterpipe tobacco smoker was associated with a 6 times greater risk of lung cancer compared to non-former waterpipe tobacco smokers [104]. Chronic obstructive pulmonary disease (COPD) has also been linked with WTS [107–110]. One study of 2201 adults reported that waterpipe tobacco smokers were 2.5 times as likely as non-waterpipe smokers to have COPD [110]. Additionally, WTS is associated generally with “decreased respiratory quality of life” [111]. More dependent waterpipe tobacco smokers may be at increased risk for certain chronic health conditions. A case-control study of 274 individuals with chronic bronchitis and 559 controls reported that compared to individuals who were not dependent on WTS, dependent waterpipe tobacco smokers were 3.7 times more likely to have chronic bronchitis [112]. Youth waterpipe tobacco smokers have been found to be at greater risk for asthma. In a 2012 study of 36,578 Florida high school students, approximately 20 % had a lifetime diagnoses of asthma. Though the nature of the study does not allow causal inferences, the participants with a lifetime asthma diagnosis were

approximately 1.5 times more likely to report ever WTS [38]. Secondhand waterpipe tobacco smoke may also negatively affect the respiratory system even among non-smokers. More so than secondhand cigarette smoke, exposure to secondhand WTS has been found to be associated with chronic cough [113].

WTS has also been associated with cardiovascular disease. One study reported that participants with 40 years of WTS experience had a three times greater risk of coronary artery disease compared to non-waterpipe smokers [114]. The increased risk of cardiovascular disease among waterpipe tobacco smokers is likely a product of the increased stress placed on the cardiovascular system due to the large amounts of CO to which waterpipe tobacco smokers are exposed [115]. An important point to note is that establishing a causal link between WTS and chronic health conditions presents many challenges including the inability to differentiate between negative health outcomes caused by WTS alone and those that may be influenced by other factors such as exposure to cigarette smoke or environmental toxicants. Despite this limitation, the literature linking WTS and chronic health conditions continues to grow (for a detailed review of this literature, see [86•]).

Implications for pulmonologists and primary care providers

A growing body of research demonstrates that WTS is a dependence-inducing behavior that is linked with severe acute and long-term negative health outcomes. Despite the dangers, WTS has become a highly prevalent behavior, especially among youth and young adults across the globe. As a result, pulmonologists and primary care providers may treat patients presenting with conditions that have resulted from or are exacerbated by WTS. However, standard assessments of tobacco use may not include asking patients about their WTS. Furthermore, when patients are asked if they are “smokers,” some waterpipe tobacco smokers may interpret this question as referring to cigarette smoking only and not WTS and therefore would not reveal their WTS. For this reason, many young waterpipe tobacco smokers who are at risk for significant negative health effects may not receive appropriate counseling and/or treatment. Therefore, when assessing tobacco-use behaviors, especially with younger populations, pulmonologists and primary care providers should ask patients about all forms of tobacco use, including WTS, specifically. Similarly, when providing smoking cessation recommendations or instructions to patients to limit or prevent negative health effects associated with smoking, pulmonologists and primary care providers should extend these recommendations and instructions to their patients who engage in WTS.

Because WTS is more prevalent among young adults and adolescents compared to older individuals, pediatricians need

to ask specifically about WTS as part of their routine prevention of smoking initiation. While cigarette smoking is currently more prevalent among individuals with lower socioeconomic status [116], evidence suggests that in the USA, WTS may be more common among non-Hispanic whites from families with higher household income than non-white individuals with a lower socioeconomic status (with the exception of individuals with Arab ethnicity). This demographic difference between waterpipe tobacco smokers and cigarette smokers suggests that the group most at risk for WTS is not being counseled adequately.

Achieving cigarette smoking cessation in adolescents is an important preventive care goal for pediatric primary care providers because only a minority quit without intervention, despite the fact that the majority of adolescent smokers want to quit [117]. Waterpipe tobacco smokers may not exhibit similar desire to quit because of the perception that WTS is associated with less harm potential than cigarette smoking. This perception may pose more challenges for the clinician when addressing cessation with waterpipe tobacco-smoking patients. The peer influences associated with smoking plus the socializing aspect of hookah bars and cafés, and the more lenient smoking WTS regulations (or lack thereof) in many jurisdictions may support waterpipe smokers to continue smoking.

For adults who have been smoking cigarettes for years, clinicians have a method to assess the amount of cigarettes smoked in a year by multiplying the number of packs smoked per day with the number of days spent smoking. For lifelong waterpipe smokers there is no such method to quantify their lifetime smoke exposure. The absence of such a method is concerning in light of the higher number of puffs per smoking session, and the larger volumes of smoke inhaled with each puff by waterpipe smokers compared to cigarette smokers. Furthermore the pack-year quantification of cigarette smoking is used to guide the starting dose and duration of nicotine replacement pharmacotherapy for smoking cessation. Recently, the U.S. Preventive Services Task Force recommended that individuals aged 55 through 80 years with 30 or more pack-years' exposure to smoking get annual CT screening for lung cancer [118]. At the present time, clinicians are not able to compare WTS to cigarette smoking as it relates to the amount a person smokes over a long period of time. As WTS continues to become more prevalent, such quantification will be important for waterpipe tobacco smokers because their risk of developing lung cancer may be much higher than estimated using a metric developed for cigarette smokers.

Conclusion

Waterpipe tobacco smoking is becoming increasingly popular, particularly among youth and young adults. Evidence suggests that WTS is associated with dependence and acute and

long-term negative health outcomes similar to those of cigarette smoking. Pulmonologists and primary care providers should assess for WTS in addition to other forms of tobacco use and explain to patients that there is no indication that WTS is less risky than cigarette smoking. Based on clinical judgment, patients who report any form of tobacco use, including WTS, should be advised that abstaining from all forms of tobacco will limit their risks of negative health outcomes.

Compliance with ethics guidelines

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Human and animal rights and informed consent This article contains no original research with human or animal research performed by the authors.

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