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Waterpipe smoking and nicotine exposure: A review of the current evidence

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Abstract

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The waterpipe, also known as shisha, hookah, narghile, goza, and hubble bubble, has long been used for tobacco consumption in the Middle East, India, and parts of Asia, and more recently has been introduced into the smokeless tobacco market in western nations. We reviewed the published literature on waterpipe use to estimate daily nicotine exposure among adult waterpipe smokers. We identified six recent studies that measured the nicotine or cotinine levels associated with waterpipe smoking in four countries (Lebanon, Jordan, Kuwait, and India). Four of these studies directly measured nicotine or cotinine levels in human subjects. The remaining two studies used smoking machines to measure the nicotine yield in smoking condensate produced by the waterpipe. Meta-analysis of the human data indicated that daily use of the waterpipe produced a 24-hr urinary cotinine level of 0.785 μg/ml (95% *CI* = 0.578–0.991 μg/ml), a nicotine absorption rate equivalent to smoking 10 cigarettes/day (95% *CI* = 7–13 cigarettes/day). Even among subjects who were not daily waterpipe smokers, a single session of waterpipe use produced a urinary cotinine level that was equivalent to smoking two cigarettes in one day. Estimates of the nicotine produced by waterpipe use can vary because of burn temperature, type of tobacco, waterpipe design, individual smoking pattern, and duration of the waterpipe smoking habit. Our quantitative synthesis of the limited human data from four nations indicates that daily use of waterpipes produces nicotine absorption of a magnitude similar to that produced by daily cigarette use.

Introduction

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According to the World Health Organization (WHO, 2005), tobacco use is responsible for about 5 million deaths per year worldwide. Furthermore, half of the people who smoke today will die prematurely.

In the midst of the present worldwide tobacco epidemic, concern is growing regarding the use of a waterpipe (referred to in various regions as shisha, hookah, narghile, and hubble bubble) to smoke tobacco, a practice dating back at least 400 years. This early form of smoking is experiencing a global revival, particularly in Middle Eastern countries (Maziak, Ward, Soweid, & Eissenberg, 2004). Some of this increase in use has been attributed to the popularity of flavored or sweetened tobaccos for use in the waterpipe (Rastam, Ward, Eissenberg, & Maziak, 2004). Recent reports indicate that waterpipes are commonly used in Egypt, Saudi Arabia, Jordan, Lebanon, Syria, Kuwait, Israel, Africa, India, and certain parts of Asia (Al Mutairi, Shihab-Eldeen, Mojiminiyi, & Anwar, 2006; Maziak, Ward, Soweid, et al., 2004; Singh et al., 2006).

Traditionally, waterpipe smoking has been the habit of older males who, in the Middle East, often gather for waterpipe smoking in street-side cafes where they visit with friends and play table games together. Waterpipe use has recently grown in popularity and present-day waterpipe smokers include trendy youth, university students, and even high-school-aged children (Maziak, Ward, Soweid, et al., 2004). Empirical observations from mainly Middle Eastern countries confirm that new chic cafes for waterpipe smoking are alive with loud music, bright lights, and frequently big screen television sets, and that such establishments are rapidly expanding to shopping malls, expensive hotels, and popular neighborhoods. It is fashionable for young people to socialize around the waterpipe.

Growing evidence indicates that women are increasingly likely to become waterpipe smokers. Some of this trend may be attributable to the introduction of sweetened and flavored waterpipe tobacco during the 1990s (Rastam et al., 2004), which may be attracting female teenagers (Hadidi & Mohammed, 2004). Women in general tend to perceive waterpipe use more positively than cigarette smoking, with women waterpipe users noting its positive attributes of being familiar, looking traditional, and being social (Maziak, Ward, Soweid, et al., 2004). Other studies in the Middle East indicate that women find waterpipe smoking to be attractive (Maziak, Rastam et al., 2004) and an occasion when they can participate with others (Tamim, Terro et al., 2003). Family members' attitudes toward women using the waterpipe appears to be shifting, with female university students thinking that adult family members would offer no particular opinion, either negative or positive, about their smoking waterpipes (Maziak, Eissenberg et al., 2004).

Much of the emerging public health and medical literature on waterpipe use focuses on its impact on health. A widespread perception exists among users, as well as some physicians (Kandela, 2000), that waterpipe smoking is a far less harmful habit than cigarette smoking. This notion is based on the premise that waterpipe smoke contains less tar, nicotine, and other toxins because of the "purification" (Shihadeh, 2003) that occurs when the smoke passes through water before being inhaled by the user. However, this perception may be changing (Maziak, Eissenberg et al., 2004). Some researchers have speculated that the health consequences are not significantly different from those associated with cigarette smoking and have presented evidence linking waterpipe smoking to cancer, abnormal pulmonary functions, elevated heart rate and blood pressure, high carboxyhemoglobin concentrations, low-birth-weight infants, respiratory ailments from environmental tobacco smoke, and decreased fertility (Knishkowy & Amitai, 2005; Shafagoj, Mohammed, & Hadidi, 2002; Tamim, Musharrafieh, El Roueiheb, Yunis, & Almawi, 2003). Further studies of the morbidity and mortality associated with waterpipe smoking are needed.

In light of the current social trends toward increased waterpipe use, a number of additional questions need to be asked. For example, does waterpipe use promote nicotine addiction with the same strength as more common forms of tobacco such as cigarettes? Also relevant is whether nicotine addiction that is developed through waterpipe use leads to other forms of tobacco use (i.e., cigarette smoking). Much more needs to be learned about waterpipe dependence, but preliminary evidence suggests it has an addictive characteristic (Maziak, Eissenberg, & Ward, 2005). Furthermore, it seems likely that waterpipe dependency has some unique characteristics that differ from those of cigarette dependency (Maziak, Ward, & Eissenberg, 2004)

We reviewed the data on nicotine exposure and waterpipe smoking from six studies that used recent, valid methodologies for measurement and collection of biospecimens (Al Mutairi et al., 2006; Behera, Uppal, & Majumdar, 2003; Macaron, Macaron, Maalouf, Macaron, & Moor, 1997; Shafagoj et al., 2002; Shihadeh, 2003; Shihadeh & Saleh, 2005). This review aimed to (a) ascertain nicotine levels associated with waterpipe usage and (b) compare the nicotine delivery data for waterpipes with comparable data from cigarettes. This analysis will be valuable in ascertaining the public health impact of waterpipe use and its capacity to contribute to nicotine addiction in the population.

Method

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The search for articles in this review included computerized databases and references found in published articles. Databases included Medline, EBSCOhost, the Centers for Disease Control and Prevention Office on Smoking and Health, and the WHO's Tobacco Free Initiative, as well as a general search of the Internet using Google. The waterpipe is also known as shisha, hookah, narghile, arghile, hubble bubble, or goza in various countries and parts of the world. Therefore, the search included all of these terms with their possible alternate spellings (such as sheesha or chicha).

The inclusion criterion for this comprehensive search was that the published work provided an estimate of the nicotine level associated with waterpipe use and was published since 1975. We felt that research done prior to this date would be limited by the technology of its time, raising questions about its comparability with more recent studies. Three identified articles dealing with waterpipe use, but not its nicotine delivery, were published in Hebrew and French. The final search was made in August 2006.

Our review of the literature revealed that two approaches were used to measure nicotine levels from waterpipe use. One method involved analyzing mainstream waterpipe smoke generated by machines designed to mimic human smoking patterns. This method mechanically captured the waterpipe smoke and examined it for nicotine content or other components. The second approach was to collect and analyze a waterpipe smoker's plasma, urine, or saliva.

Six articles were identified that described studies measuring nicotine levels associated with waterpipe smoking. Two of these studies involved smoking-machine measurements and four were human studies. These studies were conducted between 1997 and 2006 in Lebanon, Jordan, Kuwait, and India. In all of these countries, waterpipe use has been a traditional form of smoking.

Data analyses

The mean urinary cotinine values from *k* human studies were pooled in a meta-analysis using methods described by Armitage and Berry (1987):

$$\text{Mean}_{\text{Pooled}} = \frac{\sum_{i=1}^{k} weight_i \times mean_i}{\sum_{i=1}^{k} mean_i},$$

where weight is given by 1/variance of the urinary cotinine value. A 95% confidence interval for the pooled mean is given by

$$\text{Mean}_{\text{Pooled}} \pm \left(1.96 \times \sqrt{\frac{1}{\sum_{i=1}^{k} weight}} \right).$$

Computing cigarette equivalency from urinary cotinine values

One of the aims of our review was to determine whether the nicotine exposure from daily use of the waterpipe is comparable with the nicotine exposure from daily use of cigarettes. Therefore, we translated our best estimate of the 24-hr urinary cotinine levels among daily waterpipe users into an equivalent number of cigarettes needed to produce the same urinary cotinine level during a 24-hr period. For this analysis we needed accurate data on the relationship between urinary cotinine and number of cigarettes smoked.

Heinrich et al. (2005), in their study of 5,000 German adults aged 18–69 years, confirmed the data from many previous studies indicating that in the range of 1–30 cigarettes/day the relationship is linear and corresponds to urinary cotinine values of 0.075 μg/ml (≤2 cigarettes/day) to 2.1

μg/ml (21–30 cigarettes per day). In a sample of 190 Japanese males, Yang et al. (2001) found similar results, indicating a significant positive correlation between urinary cotinine and number of cigarettes smoked and a regression line indicating that urinary cotinine ranged from 0.08 μg/ml to 2.0 μg/ml for smoking 1–30 cigarettes/day.

Taken together, the slope coefficients from these studies indicated that, in the range of 1–30 cigarettes/day, each cigarette smoked produced 0.078 μg/ml of cotinine in a 24-hr urine sample. In this report, we used this value to compute the "cigarette equivalency" of waterpipe smoking.

Results

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In Lebanon, Shihadeh (2003) devised a first-generation smoking machine to determine the chemical profile of the waterpipe's mainstream smoke (Table 1). For the smoking of 10 g of waterpipe tobacco (maassel-flavored tobacco) using a standard smoking protocol (100 puffs of 3 s/per puff, 300 ml/puff, and 30 s between each puff), he measured a nicotine yield of 2.25 mg of nicotine from the smoke condensate.

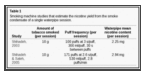

Table 1

Smoking machine studies that estimate the nicotine yield from the smoke condensate of a single waterpipe session.

Shihadeh (2003) noted the limitation that the true smoking patterns (i.e., puff frequency, duration, interval between puffs) of waterpipe smokers were unknown. A two-phase follow-up study (Shihadeh, Azar, Antonios, & Haddad, 2004) addressed this concern by studying the smoking patterns of 52 waterpipe smokers in a Beirut cafe. Specifically, the authors studied 38 men and 14 women smokers in a busy Beirut cafe adjacent to a private university. Most of the participants were university students (M_{age} = 21 years), most likely from higher income strata of Beirut. These volunteers agreed to smoke a waterpipe with an attached smoking topography instrument that measured flow rate against time. The second phase consisted of inconspicuously observing 56 randomly selected waterpipe smokers in the same cafe, recording their smoking patterns. These observations were made without the smoker's knowledge, and no contact was made before or after the smoking session. The findings from this follow-up study indicated that an "average" waterpipe session involved greater intake of smoke (171 puffs at 530 ml/puff, 2.6 s/puff, and 2.8 puffs/min) than was estimated in the previous smoking-machine study.

Using the new data that indicated a higher-intensity smoking pattern for waterpipe smokers, Shihadeh and Saleh (2005) found that the nicotine yield from a smoking session of 10 g of waterpipe tobacco was 2.94 mg (Table 1). By comparison, the sales-weighted (1,294 brands) machine-measured mean nicotine yield from a single cigarette was 0.88 mg using the standard U.S. Federal Trade Commission (FTC) method that assumes taking 2-s, 35-ml puffs from a U.S. cigarette until a 23-mm butt length remained (FTC, 2000). The higher volume and longer duration of a waterpipe session is noteworthy in this regard.

As a point of interest, we note findings from two early studies that used older smoking machines that are not comparable with the recent studies. Hoffmann, Rathkamp, and Wynder (1963) found that smoking 100 g of waterpipe tobacco produced 38 mg of nicotine in the smoke condensate. The results from smoking 800 mg of waterpipe tobacco showed the nicotine level in the smoke condensate to be 0.43 mg (Galal, Youssef, & Salem, 1973).

Human studies

Table 2 presents the data from recent studies of adults in Lebanon, Jordan, India, and Kuwait that have measured urinary cotinine levels among water-pipe users. These studies are briefly described and summarized below, and pertinent results were included in a meta-analysis.

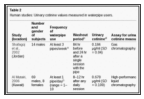

Table 2

Human studies: Urinary cotinine values measured in waterpipe users.

Lebanon Macaron et al. (1997) studied 48 adult Lebanese subjects (aged 20–68 years) to examine their intake of nicotine. The participants consisted of three equal-sized groups of waterpipe smokers (15 men and 1 woman), cigarette smokers (13 men and 3 women), and a control group of nonsmokers (12 men and 4 women). The urinary cotinine levels for the 16 waterpipe smokers (M = 6.080 μg/ml) were not significantly different from the levels for cigarette smokers (M = 5.980 μg/ml) but were significantly higher than those of nonsmokers (M = 0.127 μg/ml).

Jordan Shafagoj et al. (2002) studied 14 males (aged 20–45 years) who had been smoking the waterpipe at least three times per week for more than 1 year. Subjects who used any other form of tobacco were excluded. After a single waterpipe smoking session, their blood plasma, saliva, and urine were tested for both nicotine and cotinine. Because of the washout period in this protocol (no waterpipe use 84 hr before the waterpipe session and 24 hr after the waterpipe session), the urinary cotinine levels represent the effect of a single waterpipe session occurring during a 4.5-day period. Also, because the authors provided only the total measurement of cotinine in the 24-hr urine (249 μg), we estimated the 24-hr urine volume for a healthy 28-year-old male to be an average of 1,350 ml (Snyder et al., 1975) for the purpose of comparison in Table 2.

India Behera et al. (2003) measured urinary levels of nicotine and cotinine in users of various forms of tobacco. The 130 healthy adult subjects from north India ranged in age from 20 to 65 years. The study groups included 30 male cigarette smokers, 30 male bidi smokers, 10 male waterpipe smokers, 20 male tobacco chewers, 20 passive smokers (1 man and 19 women), and 20 nonsmokers (12 men and 8 women). No significant difference was found in mean urinary nicotine or cotinine levels of cigarette smokers (704 ng/ml and 2.736 μg/ml, respectively) and water-pipe smokers (548 ng/ml and 2.379 μg/ml, respectively). Mean nicotine and cotinine levels in cigarette and waterpipe smokers were, however, significantly higher compared with levels in passive smokers (110 ng/ml and 281 ng/ml) and nonsmokers (55 ng/ml and 7 ng/ml).

Kuwait Al Mutairi et al. (2006) studied 168 subjects (aged 24–65 years) consisting of 77 waterpipe smokers, 75 cigarette smokers, and 16 control subjects who did not smoke. In this sample, mean urinary cotinine levels were significantly higher in cigarette smokers (1.321 μg/ml) than in waterpipe smokers (677.6 μg/ml). We found no apparent correlation between number of pipes smoked per day and urinary cotinine or nicotine.

Long duration of use (>10 years) was, however, correlated with higher urinary cotinine and nicotine levels among waterpipe users.

Summary and meta-analysis of the human studies

Findings in Table 2 indicate that daily waterpipe smokers (in Kuwait, India, and Lebanon) had higher urinary cotinine levels (0.678–6.08 μg/ml) than those who engaged in a single waterpipe smoking session (0.184 μg/ml) during a 4- to 5-day period (Jordan). The data from Lebanon indicating a mean urinary cotinine of 6.08 μg/ml for daily waterpipe smokers is likely skewed upward by extreme outliers, an effect supported by the large standard deviation of 7.2 μg/ml.

To determine an overall urinary cotinine value for daily waterpipe smoking, we conducted a meta-analysis in which we pooled the data from the Kuwait, Lebanon, and India studies using the methods described in the statistical analysis section above. We found a pooled mean value for urinary cotinine among daily waterpipe smokers of 0.785 μg/ml (95% *CI* = 0.578–0.991).

Using the cigarette equivalency methods described earlier, we translated the cotinine values from Table 2 and the meta-analysis into the following conclusions:

- Daily waterpipe smoking produced a 24-hr urinary cotinine level that is equivalent to smoking 10 cigarettes/day (95% *CI* = 7–13 cigarettes/day).
- Occasional waterpipe smoking (one session of waterpipe use during a 4-day period) produced a 24-hr urinary cotinine level equivalent to having smoked two cigarettes in one pipe session.

Discussion

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The findings summarized in this report indicate that biologically important levels of nicotine are present in the smoke condensate of waterpipes and in the urine of daily and occasional waterpipe smokers. Specifically, smoking-machine studies (Table 1) indicate that the nicotine yield (2.94 mg) from a single session of waterpipe smoking exceeds the nicotine yield from smoking an entire typical U.S. cigarette (0.88 mg). This finding alone does not provide insight into the etiologic or public health consequences of waterpipe use, since the nicotine yield from smoke condensate is not highly correlated with the amount of nicotine absorbed (Benowitz et al., 1983) into the circulation of the smoker.

Therefore, we also examined the nicotine absorption of waterpipe smokers using the pooled findings (Table 2) from 117 adults from four nations (Lebanon, Jordan, Kuwait, and India). These findings indicate that daily waterpipe smoking in the range of 1–10 pipeloads/day produces a 24-hr urinary cotinine level of 0.785 μg/ml, an absorption rate equivalent to daily smoking of 10 cigarettes. Additionally, occasional waterpipe smoking during a 4-day interval seems to produce a urinary cotinine level equivalent to having smoked two cigarettes in 24 hr.

Does the waterpipe filter out an important fraction of nicotine from the inhaled smoke?

The articles reviewed for this report identify long-held regional and cultural beliefs in the Middle East and other areas that waterpipe smoking is safer than cigarette smoking. This popular view is linked to the fact that nicotine is water soluble and that it and other harmful substances will be filtered out as the smoke passes through the pipe water. Taken together, the findings in this report do not support the prevalent belief that the water filtration of the commonly used waterpipe removes an important fraction of the nicotine in the tobacco. Shafagoh and Mohammed (2002) reported that less than 5% of the nicotine content of the waterpipe tobacco is trapped in the water. Shihadeh (2003) concluded that although the water does remove some nicotine from the smoke, a considerable amount (more than 2 mg in a single session) remains in the mouthpiece. Even under the assumption that the nicotine content of the smoke has been reduced (per unit volume relative to cigarettes), Macaron et al. (1997) speculated that waterpipe smokers could titrate their smoking behavior to achieve the desired dose effect. If true, then the effectiveness of water filtering out nicotine would diminish, as each smoker will continue to smoke until his or her nicotine level is satisfied. Concern also exists that this "titrating" behavior will expose the waterpipe smoker to higher levels of carbon monoxide (Shihadeh & Saleh, 2005). Overall, given that titrating behavior is well documented among cigarette smokers who switch to light or ultra-light brands (Djordjevic, Hoffman, & Hoffman, 1997; Scherer, 1999), it seems possible that waterpipe smokers might follow a similar behavior pattern.

In the studies in Lebanon and India depicted in Table 2, the urinary nicotine and cotinine levels of waterpipe smokers and cigarette smokers were not significantly different. In Kuwait, Al Mutairi et al. (2006) reported that urinary nicotine and cotinine levels of cigarette smokers were higher than the levels in waterpipe smokers. Factors that may have contributed to the variation in the waterpipe-cigarette comparisons in these three studies include (a) puff frequency, (b) frequency and amount of tobacco used (cigarettes and water pipe), (c) variation in type and size of the waterpipe, (d) variation in nicotine exposure from other sources (i.e., environmental tobacco smoke), and (e) difference in the methodology of using a washout period (used only in the study from Kuwait), (f) small sample size criteria (studies from Lebanon and India had comparison groups of less than 40 subjects, and (g) classification of waterpipe smokers into "heavy" or "light" categories. Further large-scale comparative studies are needed to ascertain standardized measures of the nicotine absorbed by cigarette smokers and water-pipe users.

Waterpipe use and nicotine addiction

Benowitz and Henningfield's (1994) proposal that an intake of 5 mg of nicotine per day represents an "addiction threshold" level indicates that the threshold is met for those who smoke 5 or more cigarettes per day (1 mg nicotine per cigarette). Acknowledging the numerous variables involved with smoking, the American Medical Association (1998) suggested that such a threshold will vary from person to person, and that the proposed value probably represents the highest threshold value that should be considered.

The meta-analysis in the present report suggested that daily waterpipe smoking produces nicotine absorption comparable with the daily smoking of 10 cigarettes (95% *CI* = 7–13 cigarettes). Thus the range of the current evidence clearly classifies daily use of the waterpipe as an addictive behavior. The meta-analysis further suggests that occasional use of the waterpipe is equivalent to smoking two cigarettes during a 24-hr period and thus is below an "addictive threshold." These data should be interpreted with caution when considering Al Mutairi et al.'s (2006) findings that long-term waterpipe smokers (>10 years of use) absorb more nicotine than do short-term waterpipe smokers (≤10 years). These data suggest that long-term occasional use may translate into a higher nicotine exposure and cigarette equivalency than determined in the present analysis.

Limitations of the current evidence

The evidence in the present report permits a good evaluation of whether waterpipe smokers experience a biologically important level of nicotine exposure (Tables 1 and 2). However, a number of limitations regarding the current evidence hinder investigation of more specific hypotheses about nicotine exposure and other health effects of waterpipe use. Specifically, investigations of waterpipe use need to consider in detail variables such as equipment, smoking patterns, time, and tobacco quality to ensure comparable results. Also, an increasing need exists for standardization of assessment tools, data collection procedures, and the terminology and categories used specifically for waterpipe research (Maziak, Ward, Soweid, & Eissenberg, 2005; Shihadeh et al., 2004). Some of these issues and limitations are discussed further.

Equipment The amount of smoke inhaled from a waterpipe varies based on the size of the waterpipe, water bowl capacity, and the length of the flexible hose (Nuwayhid, Yamout, Azar, & Kambris, 1998; Sajid, Akhter, & Malik, 1993). Constituents of the waterpipe mainstream smoke also vary depending on the type and amount of charcoal used and the point of measurement during a single waterpipe smoking session (the highest levels of particulate matter occur toward the end; Shihadeh & Saleh, 2005).

Smoking patterns Given that a waterpipe session is generally characterized as a social event, puffing on the waterpipe can be intermittent, and smoking patterns can vary based on quantity, rate, depth, and duration of smoke inhalation (Shihadeh et al., 2004). For example, in some areas the average duration of a waterpipe session is reported to be 45–60 min smoking time with 10–20 g of tobacco consumed (Knishkowy & Amitai, 2005), whereas in other areas the average smoking time is described as 1–2 hr (Kiter, Ucan, Ceylan, & Kiling, 2000) with as much as 200 g of tobacco consumed (Zahran, Yousef, & Baig, 1982). These differences can influence the amount of addictive components inhaled (Maziak, Eissenberg et al., 2005). Also, data indicate that a primary waterpipe smoker (one who has not previously smoked another type of tobacco) does not inhale as deeply as a secondary smoker (Shafagoj & Mohammed, 2002).

Type of tobacco An important variable that affects the delivery of nicotine is the type or brand of tobacco and its preparation for smoking. There are two general categories of waterpipe tobacco: unflavored (tumbak, or other local names) and flavored (maassel; Hadidi & Mohammed, 2004), the latter of which has recently become more popular. The unflavored tobacco is plain and dry, whereas the flavored tobacco mixes additives such as glycerin, honey, or molasses with flavors such as mint or fruits. The result is a moist tobacco paste that is allowed to ferment.

A study on waterpipe tobacco analyzed 13 commercial brands for their nicotine content (Hadidi & Mohammed, 2004). Among the 11 tested brands of flavored tobacco, the average nicotine content was 3.35 mg/g (range 1.8 mg/g to 6.3 mg/g), which is equivalent to 67 mg for one run when using a waterpipe head that holds an average of 20 g of tobacco. Unflavored tobacco greatly increases nicotine exposure, with the two tested brands having 30 mg/g and 41 mg/g of nicotine, for a mean of 35.65 mg/g, which is equivalent to 713 mg per head. This high nicotine content is about 10 times greater than the nicotine in each gram of flavored waterpipe tobacco. In cigarette equivalency, the nicotine content in a single run of flavored tobacco is 6.5 regular cigarettes, and for unflavored tobacco, 70 cigarettes (Hadidi & Mohammed, 2004).

Two factors relating to the wide variation in nicotine levels in unflavored and flavored tobacco are the added ingredients in flavored tobacco that dilute the quantity of tobacco smoked, and the use of more stems and less nicotine-rich tobacco leaves in the flavored brands. The role of glycerin in the fermentation process also is thought to affect the nicotine level (Hadidi & Mohammed, 2004).

Conclusion

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Our quantitative synthesis of the limited human data from 117 adults from Lebanon, Jordan, Kuwait, and India indicate that daily waterpipe use produces nicotine absorption of a magnitude similar to that of daily use of cigarettes. This equivalence with cigarette use of about 10 cigarettes/day further indicates that daily waterpipe use can be an effective means of initiating and maintaining nicotine addiction.

Additional research is needed to focus on the tobacco dependence associated with waterpipe smoking. For example, research is needed to examine the relationship between waterpipe smoking and other forms of tobacco use. Does cigarette smoking serve as a gateway for waterpipe use? Does initiation of a waterpipe smoking habit open the pathway to use of other tobacco products? A multiyear prospective study may be required to answer these questions. Also, what possible detrimental effects may result when various ingredients, such as glycerin, are added to maassel tobacco? More needs to be learned about the overall morbidity and mortality associated with waterpipe smoking. As more women become water-pipe smokers, studies of gender-specific issues also will be necessary.

A possible reason for the scarcity of scientific knowledge on waterpipe smoking is that the practice has traditionally been confined to certain geographic regions, affecting a relatively small portion of the world's population (Behera et al., 2003). With waterpipe smoking growing in popularity in Western Europe and North America (Knishkowy & Amitai, 2005; Shihadeh et al., 2004), more resources will likely be invested in waterpipe research. In addition, researchers in countries where waterpipe smoking is popular are conducting and publishing new research. Tobacco research centers, with water-pipe research as one of their primary objectives, have been established recently in Egypt (Egyptian Smoking Prevention Research Institute) and Syria (Syrian Center for Tobacco Studies).

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