Original investigation

The Relationship Between Waterpipe Smoking and Body Weight: Population-Based Findings From Syria

Kenneth D. Ward PhD^{1,2}, SangNam Ahn PhD, MPSA¹, Fawaz Mzayek MD, MPH, PhD^{1,2}, Radwan Al Ali MD², Samer Rastam MD, PhD², Taghrid Asfar MD^{2,3}, Fouad Fouad MD^{2,4}, Wasim Maziak MD, PhD^{2,5}

¹School of Public Health, University of Memphis, Memphis, TN; ²Syrian Center for Tobacco Studies, Aleppo, Syria; ³University of Miami Miller School of Medicine, Miami, FL; ⁴American University of Beirut, Beirut, Lebanon; ⁵Robert Stempel College of Public Health and Social Work, Florida International University, Miami, FL

Corresponding Author: Kenneth D. Ward, PhD, Division of Social and Behavioral Sciences, School of Public Health, University of Memphis, Memphis, TN 38152, USA. Telephone: 901-678-1706; Fax: 901-678-1715; E-mail: kdward@memphis.edu

Abstract

Introduction: Cigarette smoking has well known effects on body weight, with current smokers weighing less than never-smokers, and cessation producing weight gain. Use of waterpipe (or “hookah”) is increasing in many parts of the world but its effects on body weight are not known.

Methods: We compared body mass index (BMI) among 2,536 adults (age ≥18 years old), who were never, former, current nondaily, or current daily waterpipe smokers, drawn from 2 representative, population-based household surveys of adults in Aleppo, Syria.

Results: Overall, 84.1% ($n = 2,134$) never-smoked waterpipe, 4.6% ($n = 116$) were former smokers, 9.9% ($n = 251$) were current nondaily smokers, and 1.4% ($n = 35$) were current daily smokers. Mean BMI of the sample was 30.2 kg/m² ($SD = 6.3$). Adjusted for cigarette smoking, number of chronic diseases, age, gender, income, and marital status, daily waterpipe users were 2.26 BMI units greater than never-smokers (beta = 2.26, 95% CI = 0.79–3.72), and had nearly threefold odds of being obese (odds ratio = 2.87, 95% CI = 1.06–7.76). Nondaily and former waterpipe users were similar to never-smokers in terms of BMI and obesity risk.

Conclusion: Results indicate that daily waterpipe users, compared to never-users, have higher BMI, translating into 6 extra kilograms of weight on average, and are 3 times as likely to be obese.

Introduction

Waterpipe is a centuries-old tobacco use method with links to south-west Asia and North Africa.¹ Its use in the Middle East experienced a resurgence in the 1990s² and has spread to other regions, including Europe and North America.^{3,4}

There is growing evidence that waterpipe use conveys many of the same health risks as cigarette smoking, including heart disease, lung cancer, respiratory illness, and low birth weight.^{5,6} A recent study reported that waterpipe smokers had more than three times

the odds of having metabolic syndrome than nonsmokers.⁷ In this study, waterpipe users also had greater abdominal obesity, indicated by waist circumference,⁷ a key component of the metabolic syndrome that increases risk of diabetes and cardiovascular diseases.⁸

It is unknown whether waterpipe use is associated with body weight or overall level of obesity, which is an important determinant of mortality from all causes, cardiovascular diseases, and several cancers.^{9,10} Cigarette smokers weigh 4–5 kg less than nonsmokers, on average, and are less likely to be obese according to body mass index (BMI) criteria (BMI ≥ 30.0 kg/m²),^{11–14} but have greater abdominal

obesity.^{15–17} In addition, cigarette smoking cessation produces weight gain in the majority of quitters, averaging 3–5 kg after 12 months of abstinence.^{14,18–22}

We examined associations of waterpipe use status with BMI and obesity status using data from two population-based household surveys of adults in Aleppo, Syria. It was hypothesized that, similar to what is commonly observed in cigarette smokers, waterpipe use would be associated with lower body weight compared to never-smokers, and quitting waterpipe would be associated with increased BMI.

Methods

Description of Population and Sampling Procedures

This study combined data from two population-based cross-sectional household surveys of adults conducted in Aleppo, Syria in 2004 and 2006. Aleppo is the second largest city in Syria with a population of approximately 2,500,000. To maximize the sample size of waterpipe use categories (e.g., current daily waterpipe smokers, who make up only about 1% of Syria's population; Ward et al.²³) we combined the two datasets, keeping the original weights, and calculated overall estimates directly from the pooled data. This pooling approach is recommended when the estimates from different surveys measure the same parameter and are derived from the same target population,²⁴ as was the case for this study. Data from the two surveys used, the first and second Aleppo Household Surveys (AHS-1 and AHS-2), were obtained from the same target population of adults in Aleppo, Syria, using the same tools for assessing smoking, body size, and covariates.

Study One

AHS-1 was conducted in 2004 to characterize and compare major health problems and risk factors among adults.²⁵ The target population of AHS-1 was adults 18–65 years of age who could understand the study procedures and provide consent. A two-stage, stratified cluster sampling with probability proportional to size (PPS), was used to obtain the study sample. In this design, each cluster (neighborhood) is assigned a probability of selection that is proportional to its relative size in the total population, that is, larger clusters have a greater chance of being selected. A list of names of administrative residential units (neighborhoods) was obtained from Aleppo municipality's records and divided into two strata, formal and informal, to improve the representativeness of the sample. Informal zones refer to residential areas where housing is not in compliance with current planning and building regulations. From each stratum, neighborhoods (27 formals, 18 informals) were randomly selected with PPS. Each neighborhood was assigned a range of numbers that was proportional to its size. Random numbers were computer-generated and the neighborhood in whose range the random number fell was selected. If the number fell in the range of an already selected neighborhood, the number was discarded and another one was generated. In the second stage, households were randomly selected from each neighborhood using a random-walking method because of absence of individual household enumeration. Specifically, within each selected neighborhood, a random starting point was selected from an enlarged map of the area. From that point, every 10th household was selected for inclusion in the study. When the street ended, the interviewer turned to the right according to an a priori defined plan and continued on in the next street, and so on, until the targeted sample size from that neighborhood was reached. If the 10th building was not a residence, the next residence was selected. In the home, the interviewer prepared a list of the names and ages of all household members, assigned a

number to those in the target age range, and used a computerized random number generator to select an eligible household member to participate. If the selected household member was not available for the interview, a second interview was scheduled, and if this interview could not be completed because of unavailability or refusal to participate, an adjacent household was selected. These selection procedures resulted in a sample of 2,038 participants.

To be included in this study, respondents had to be between 25 and 65 years of age and have answered survey items used to categorize dependent and independent variables of interest. We excluded 478 participants who were younger than 25 or older than 65, and 6 participants who were missing data on any of the variables analyzed in this study, resulting in a final analytic sample of 1,554.

Study Two

AHS-2 was conducted in 2006.²⁶ The target population was adults 25 years of age and older who could understand the study procedures and provide consent to participate. A two-stage cluster sampling with PPS was used to select 27 out of 83 formal neighborhoods, using the same approach described above, to randomly select neighborhoods, households, and participants, resulting in a sample of 1,168 participants. To be included in this study, respondents had to be between 25 and 65 years of age and have answered survey items used to categorize dependent and independent variables of interest. We excluded 81 participants who were older than age 65, and 104 participants who were missing data on any of the variables analyzed in this study, resulting in a final analytic sample of 982.

Protocols for both studies were approved by the Institutional Review Boards of The University of Memphis and Syrian Center for Tobacco Studies (SCTS). Written informed consent was obtained from all participants in both studies prior to data being collected.

Data Collection Procedures

For both surveys, questionnaires were administered, and clinical and anthropometric measurements taken, at the participant's home by a mixed gender pair of trained interviewers. Questionnaires were administered using a computer-based interface for the recording of responses and measurements. Interviewers were native to the city and, in most cases, to the areas being studied. The interviewers received 1-week training at the SCTS before the survey started. An interviewer-administrated questionnaire was used to collect information on sociodemographic variables, personal and family history of health conditions, lifestyle-related risk factors, and the use of medications.

Measures

Variables analyzed in this study included objectively measured height and weight (to calculate BMI) and self-reported waterpipe and cigarette use, chronic health conditions, and sociodemographics. All self-reported items were in Arabic and were developed by our team for previous studies in Syria.^{27,28} Prior to beginning data collection for AHS-1, the survey was piloted in 20 households to fine-tune the sampling and data collection procedures and to assess the suitability of the language and terminology of all items for the target population.

Height, Weight, and BMI

Height was measured to the nearest cm with a portable stadiometer, and weight was measured to the nearest 0.1 kg using a digital scale equipped with a high-precision strain gauge sensor. From these,

two-dependent variables were calculated: BMI (weight in kg divided by the square of height in meters), and weight status (A BMI range of 18.0–24.9 was defined as normal weight, 25.0–29.9 as overweight, and ≥ 30 as obese).

Waterpipe Use

The independent variable, waterpipe use status was derived from two questionnaire items: current waterpipe use (reported as daily, occasionally, or never), and for participants who were not current waterpipe users, a “yes” response to an item indicating that they were a former user of waterpipe.

Covariates

Covariates for these analyses included age, gender, marital status, monthly family income (<10,000 Syrian lira [SL], 10,000–19,999 SL, 20,000–39,999 SL, and $\geq 40,000$ SL), the number of chronic conditions diagnosed by a physician (including heart disease, hypertension, and hypercholesterolemia, chest pain, and diabetes), and cigarette smoking status. Cigarette smoking status was derived from a questionnaire item assessing current cigarette use (daily, occasionally, or never), and for participants who were not current cigarette smokers, a “yes” to response to an item indicating whether they were a former daily user of cigarettes.

Statistical Analyses

Descriptive statistics are presented as means (*SD*) or percentages as appropriate. Linear regression models were used to assess the

association between waterpipe smoking status and BMI. Waterpipe smoking was included in the model as an independent variable with four categories: current daily, current nondaily, former, and never-smoker (referent). Gender, age, income, marital status, number of chronic conditions, and cigarette smoking status were included in the model as covariates. Interaction terms for age $\times$ gender and gender $\times$ water pipe use status also were tested. Logistic regression was used to regress obesity on the same set of independent variables as above. In both multivariable analyses, a weighting variable was included that was calculated by multiplying the neighborhood weight by the family weight (number of eligible candidate in each family). In the AHS-1 sample, the weighting function also included strata (formal vs. informal zone).

Results

Sample Characteristics

Participation rates were 86% in AHS-1 and 92% in AHS-2. As shown in Table 1, study participants were 41 years old on average, 88% were married, and 52% were female. On average, study participants reported having 0.7 chronic conditions (*SD* = 0.9). Of the total sample, 4.6% were former waterpipe users, 9.9% were current nondaily users, and 1.4% were daily users. Of the 286 current waterpipe smokers (daily or nondaily) in the study, 25% (*n* = 71) smoked only waterpipe (i.e., no cigarettes). More than 35% of participants were daily cigarette smokers of whom 8% also smoked waterpipe. Mean BMI was 30.2 kg/m² (*SD* = 6.3). Table 1 also shows that the AHS-2

Table 1. Characteristics of the Study Population (Weighted Estimates) (*n* = 2,536)

	N (%) or M (<i>SD</i>)			<i>p</i>
	Total (<i>n</i> = 2,536)	AHS-1 (<i>n</i> = 1,554)	AHS-2 (<i>n</i> = 982)	
Age (years)	40.8 (10.5)	39.7 (10.3)	42.6 (10.7)	<.001
Gender				
Male	1,220 (48.1)	733 (47.2)	487 (49.6)	.234
Female	1,316 (51.9)	821 (52.8)	495 (50.4)	
Marital status				
Married	2,226 (87.8)	1,369 (88.1)	857 (87.3)	.537
Living alone	310 (12.2)	185 (11.9)	125 (12.7)	
Income				
<10,000 SL	1,343 (53.0)	916 (58.9)	427 (43.5)	<.001
10,000–20,000 SL	934 (36.8)	513 (33.0)	42.9 (42.9)	
20,000–40,000 SL	211 (8.3)	97 (6.2)	114 (11.6)	
>40,000 SL	49 (1.9)	28 (1.8)	20 (2.0)	
Body mass index (BMI) (kg/m ²)	30.2 (6.3)	30.1 (6.3)	30.4 (6.3)	.359
Dichotomized BMI				
Normal or overweight (<30)	1,363 (53.8)	838 (53.9)	525 (53.5)	.820
Obese (≥ 30)	1,173 (46.3)	716 (46.1)	457 (46.5)	
Water pipe smoking				
Never	2,134 (84.2)	1,297 (83.5)	837 (85.2)	.026
Former	116 (4.6)	80 (5.2)	36 (3.7)	
Current nondaily	251 (9.9)	162 (10.4)	89 (9.1)	
Current daily	35 (1.4)	15 (1.0)	20 (2.0)	
Cigarette smoking				
Never	1,276 (50.3)	732 (47.1)	544 (55.4)	<.001
Former	190 (7.5)	130 (8.4)	60 (6.1)	
Current nondaily	179 (7.1)	112 (7.2)	67 (6.8)	
Current daily	891 (35.1)	580 (37.3)	311 (31.7)	
Currently smoke both waterpipe and cigarettes (%)	195 (7.7)	126 (8.1)	69 (7.0)	.319
Number of chronic conditions (0–5)	0.7 (0.9)	0.8 (0.9)	0.7 (1.0)	.075

AHS = Aleppo Household Survey; SL = Syrian lira. *p* value for χ^2 test for categorical and *t* tests for continuous variables.

participants, compared to those in AHS-1, tended to be younger (by an average of 3 years), have higher household income, and have slightly higher proportions of individuals who had never used either waterpipe (85.2 vs. 83.5%) or cigarettes (55.4 vs. 47.1%). The two samples did not differ significantly in terms of gender, marital status, BMI, obesity status, or average number of chronic conditions.

Association of Water Pipe Smoking With BMI

Mean unadjusted BMI was 30.4 ($SD = 6.4$, $n = 2,134$) for participants who had never-used waterpipe, 27.8 ($SD = 4.8$, $n = 116$) for former waterpipe smokers, 29.1 ($SD = 6.2$, $n = 251$) for current nondaily waterpipe smokers, and 31.9 ($SD = 5.0$, $n = 35$) for current daily waterpipe smokers.

Adjusting for age, gender, marital status, income, cigarette smoking status, and number of chronic conditions, mean BMI was 30.4 ($SE = 0.3$) for participants who had never-used waterpipe, 29.6 ($SE = 0.6$) for former users, 30.9 ($SE = 0.4$) for current nondaily users, and 32.5 ($SE = 1.0$) for current daily users. As shown in Table 2, former and current nondaily waterpipe use was not associated with BMI, but the BMI of daily waterpipe smokers averaged 2.26 units greater than that of never-smokers (95% CI = 0.79–3.72). A gender $\times$ water pipe use status interaction was not significant ($\beta = 0.176$, $p = .70$) and was not included in the final model.

BMI (Table 2) was positively associated with number of chronic health conditions ($\beta = 1.40$; 95% CI = 1.084–1.711) and negatively associated with living alone ($\beta = -1.89$; 95% CI = -2.871 to -0.909). The BMI of daily cigarette smokers averaged 0.83 units less (95% CI = -1.58 to -0.08) than never-smokers. In addition, there was a significant age by gender interaction, indicating

that BMI tended to be higher among older women than their male counterparts.

The above model controlled for cigarette smoking, since many waterpipe smokers also smoke cigarettes, which may confound the waterpipe/weight association. We also examined the issue of confounding by rerunning the model excluding participants who formerly or currently smoked cigarettes. The association between waterpipe use and BMI remained positive and statistically significant ($\beta = 2.41$, 95% CI = 0.14–4.68, $p = .037$; $n = 1,276$). The beta coefficient of 2.41 was similar to the beta of 2.26 in the original model.

Association of Water Pipe Smoking With Obesity Status

The unadjusted odds ratio (OR; along with 95% CI and p value) for former, current nondaily, and current daily waterpipe smokers, compared to never-smokers, were 0.70 (95% CI = 0.40–1.21, $p = .202$), 0.58 (95% CI = 0.39–0.85, $p = .006$), and 1.98 (0.72–5.47, $p = .186$), respectively.

As shown in Table 3, current daily waterpipe smokers had a nearly threefold higher odds ($OR = 2.87$; 95% CI = 1.058–7.765) of being obese, compared to never-smokers, adjusted for cigarette smoking, chronic health conditions, and demographics. Current daily cigarette smokers had a significantly lower odds of being obese compared to never cigarette smokers adjusted for other variables ($OR = 0.73$; 95% CI = 0.54–0.99). A greater number of chronic health conditions and being married were associated with greater odds of being obese, and an age by gender indicated that older women were more likely to be obese compared to their male counterparts. A gender

Table 2. Results of Linear Regression Analysis Examining the Association Between Water Pipe Smoking and BMI (Weighted Estimates) ($n = 2,536$)

	Coefficient	<i>t</i>	<i>p</i> > <i>t</i>	95% CI
Water pipe smoking				
Never				
Former	-0.58	-1.0	.330	-1.744 to 0.587
Occasionally	0.08	0.2	.854	-0.791 to 0.955
Daily	2.26	3.0	.003	0.789 to 3.722
Cigarette smoking				
Never				
Former	-0.09	-0.2	.871	-1.136 to 0.963
Occasionally	0.43	0.7	.490	-0.794 to 1.657
Daily	-0.83	-2.18	.030	-1.585 to -0.082
Number of chronic condition	1.40	8.8	<.001	1.084 to 1.711
Marital status				
Married				
Living alone	-1.89	-3.8	<.001	-2.871 to -0.909
Age	-0.16	-3.3	.001	-0.257 to -0.066
Sex				
Male				
Female	-4.80	-3.6	<.001	-7.459 to -2.150
Age $\times$ sex	0.20	6.1	<.001	0.132 to 0.258
Income				
>10,000 SL				
10,000–20,000 SL	0.00	0.01	.989	-0.594 to 0.602
20,000–40,000 SL	0.85	1.37	.170	-0.365 to 2.062
>40,000 SL	1.55	1.31	.190	-0.766 to 3.862
Constant	31.39	14.7	<.001	27.212 to 35.577

BMI = body mass index; CI = confidence interval; SL = Syrian lira.

Table 3. Results of Logistic Regression Analysis Examining the Association Between Water Pipe Smoking and Obesity Status (BMI < 30 vs. ≥ 30) (Weighted Estimates) (n = 2,536)

	Odds ratio	<i>t</i>	<i>p</i> > <i>t</i>	95% CI
Water pipe smoking				
Never				
Former	1.22	0.7	.502	0.675–2.230
Occasionally	0.93	–0.3	.739	0.623–1.400
Daily	2.87	2.1	.038	1.058–7.765
Cigarette smoking				
Never				
Former	1.42	1.3	.194	0.836–2.420
Occasionally	1.37	1.3	.181	0.864–2.174
Daily	0.73	–2.0	.043	0.535–0.990
Number of chronic condition	1.59	6.2	<.001	1.372–1.840
Marital status				
Married				
Living alone	0.60	–2.4	.017	0.390–0.913
Age	0.95	–2.7	.008	0.911–0.986
Sex				
Male				
Female	0.18	–3.1	.002	0.062–0.539
Age × sex	1.07	5.2	<.001	1.043–1.098
Income				
>10,000 SL				
10,000–20,000 SL	0.99	–0.05	.963	0.769–1.285
20,000–40,000 SL	1.20	0.78	.436	0.760–1.893
>40,000 SL	1.47	0.89	.374	0.630–3.474

BMI = body mass index; CI = confidence interval; SL = Syrian lira.

by waterpipe use status interaction was not significant ($OR = 1.23$; $p = .28$) and was not included in the final model.

When the above model was rerun excluding former and current cigarette smokers, the direction and magnitude of the association between waterpipe use and obesity status was similar to the original model ($OR = 2.76$ vs. 2.87 , respectively), although it was not statistically significant ($p = .13$, 95% CI = 0.74 – 10.33 ; $n = 1,276$).

As sensitivity analyses, we regressed obese versus normal weight ($18.0 \leq BMI \leq 24.9$), or overweight ($25.0 \leq BMI \leq 29.9$) versus normal weight, on waterpipe use, controlling for the same set of covariates as in Table 3. Consistent with the model reported in Table 3, current daily waterpipe smokers were more likely than never-smokers to be obese than normal weight ($OR = 7.71$, 95% CI = 1.73 – 34.28 , $p = .007$). In contrast, daily waterpipe smokers compared to never-smokers were not significantly more likely to be overweight than normal weight ($OR = 2.19$; 95% CI = 0.48 – 10.03 , $p = .311$).

Discussion

In this population-based study of Syrian adults, daily waterpipe use was associated with greater BMI and obesity. BMI of daily waterpipe smokers averaged 2.26 BMI units greater than never-smokers. For an adult of average height in Syria (161.4 cm)²⁹ this BMI difference translates into 6 extra kgs (13 lbs) of body weight. Daily waterpipe users also had a nearly threefold greater odds of being obese. No such effect on body mass was observed for nondaily waterpipe users. Likewise, BMI and obesity status of former waterpipe smokers was not different from never-smokers. All these effects were independent of sociodemographic characteristics, health status (using number of chronic conditions as a proxy), and cigarette smoking. Although a majority of waterpipe smokers also smoke cigarettes, the waterpipe/

body weight association does not appear to be substantially confounded by cigarette smoking, based on the consistency of findings when cigarette smoking was adjusted in multivariable models, and when participants who had ever smoked cigarettes were excluded from the models.

The positive association between waterpipe smoking and BMI in our study parallels recent findings that waterpipe users, compared to non users, are more likely to have metabolic syndrome and several of its constituent abnormalities, including abdominal obesity (assessed by waist circumference).⁷ These results are concerning given that both overall and abdominal obesity contribute to metabolic syndrome³⁰ and predict total mortality, cardiovascular mortality, and diabetes.^{31,32} Syria already has very high rates of obesity as well as several other CVD risk factors, including hypertension, diabetes, physical inactivity, cigarette smoking, and unhealthy diet patterns.^{26,29,33,34} Further, obesity is also linked to several cancers, including breast, colorectal, prostate, and renal,⁹ many of which are on the rise in Syria and other middle eastern nations.³⁵

The positive association between daily waterpipe use and BMI is opposite of the well documented effect for cigarette smokers to have lower body weight and BMI than non smokers.^{11,13,36} This effect occurs in populations of cigarette smokers as a whole, and likely reflects nicotine's modest acute metabolic-enhancing and anorectic effects.^{8,15,37,38} However, similar to our finding that weight and obesity risk are increased in daily, but not occasional, waterpipe smokers, heavy cigarette smokers (e.g., those who smoke more than a pack per day) are more likely to be overweight or obese than light smokers in several^{39–41} but not all¹³ populations. Reasons for this different effect in heavy smokers are unclear, but it has been suggested that the clustering of obesogenic behaviors in heavy smokers (e.g., unhealthy diet, physical inactivity) may "override" the metabolic and anorectic effects of smoking.^{40,42–45} Two aspects of waterpipe use

suggest a similar mechanism may underlie the positive association we observed in our study. First, waterpipe use is a social habit frequently practiced around food and/or in cafés and restaurants.^{46–48} Second, waterpipe is smoked while sitting and relaxing, unlike cigarettes which can be smoked “on the go.” It is possible that daily waterpipe smokers, compared to nonsmokers, on average tend to have higher energy intake and lower energy expenditure. Likewise, the positive association we observed between daily waterpipe smoking and weight, which is opposite of the association of cigarette smoking on weight, may be related to differential balance of physical activity relative to tobacco intake (i.e., compared to daily cigarette smokers, daily waterpipe smokers may not only be less active but also have lower nicotine intake, which jointly work to produce negative energy balance). The nicotine absorption rate in daily waterpipe users is equivalent to smoking 10 cigarettes/day,⁴⁹ so the metabolic “boost” received by daily waterpipe smokers may indeed be less than that of daily cigarette smokers. Unfortunately, we were unable to assess physical activity and energy intake in this study but this should be a focus of future research.

Average BMI or obesity rate of former waterpipe users were not different, from that of never-smokers in our study. This is the first study to examine this issue among waterpipe smokers but most cigarette smokers who quit gain weight,^{11,14,18,22,50} averaging 4–5 kg over one year.^{14,18,20} However, postcessation weight gain does not continue indefinitely, and is most likely to occur during the first few years after cessation.^{14,41,50,51} We were not able to determine the duration of abstinence among former waterpipe users, but it is likely that many had quit years before, which may account for the lack of difference in BMI between former and never waterpipe users in this study.

It should be noted that only about 1.3% of the Syrian adult population are daily waterpipe smokers (~11% of adults currently use waterpipe, and only about 12% of them smoke daily). Thus, any weight-enhancing effect of daily waterpipe use affects only a small percentage of the population. However, waterpipe use is on the rise³ and there is growing evidence that some users experience nicotine dependence and transition from occasional, social use, to daily, individual use,^{52,53} suggesting that these effects could become more problematic in the future.

Several limitations of this study should be noted. First, although two representative, population-based surveys were used, the number of waterpipe users was relatively small ($n = 286$, including 251 nondaily and 35 daily users), which may limit our ability to detect effects. Second, because of the limited number of female waterpipe smokers in our sample (3.8% [$n = 97$] currently smoked waterpipe and only 0.9% [$n = 12$] smoked water pipe daily) we lacked power to determine definitely whether the associations between waterpipe use and weight were equally robust for both genders. However, the associations remained statistically significant after controlling gender, and gender by waterpipe interactions were not significant in the multivariable models for either obesity status or BMI. Third, we were not able to assess several potentially important determinants of the smoking/BMI association. Our inability to assess physical activity levels is an important limitation, which along with information on dietary habits and length of time of cessation, would have provided useful information on potential mechanisms of the observed waterpipe/weight association. Fourth, although effects are adjusted for several important potential confounders, including sociodemographic characteristics, cigarette smoking, and health status, there is some element of misclassification in all self-reported variables, including health status^{54,55} which may introduce random or

systematic bias. It also is possible that unmeasured variables could confound the observed waterpipe/weight association. Lastly, the cross-sectional design limits causal inference, and further studies are needed, using larger, prospective cohorts in diverse populations.

In conclusion, this is the first study to document an association between waterpipe smoking and BMI. Daily waterpipe users, compared to nonusers, have higher BMI, translating into six extra kg (13 pounds) of weight on average, and are three times as likely to be obese. This extra body weight may increase their risk of several health conditions, including metabolic syndrome, diabetes, and coronary heart disease.

Funding

This research was funded by Public Health Service grants R01TW05962, R21TW006545, R01DA035160, and R01DA024876.

Declaration of Interests

None declared.

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