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Waterpipe Smoking Patterns and Symptoms of Nicotine Dependence: The Waterpipe Dependence in Lebanese Youth Study

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Abstract

Introduction—Waterpipe typically is smoked intermittently over long smoking sessions. Waterpipe is addictive and its users show symptoms of nicotine dependence (ND). This study examined the risk of developing ND symptoms across waterpipe use patterns among Lebanese youth.

Methods—Waterpipe use patterns (length of smoking session, smoking a whole waterpipe without sharing, past-30 day use frequency, number of waterpipes smoked) were assessed. Symptoms of ND were assessed using the 10-item Hooked on Nicotine Checklist (HONC; endorsement of 1 symptom) and the 6 criteria of the International Classification of Diseases-10th revision (ICD-10 ND; presence of 3 criteria during 12 months).

Results—Both the proportion of participants endorsing ND symptoms and the average number of endorsed ND symptoms increased with increasing waterpipe use frequency, number of waterpipes smoked, and length of smoking session. The risk of endorsing 1 HONC symptom increased with increasing number of waterpipes smoked in the past 30-days (10 vs. <4 waterpipes; Hazard ratio (HR) =2.05, 95% CI: 1.52–2.58, p=0.007), and session length (>60 min

vs. <30 min; HR=2.87, 95% CI: 2.83–2.91, $p=0.001$). The risk of attaining ICD-10 ND increased with increasing number of waterpipes used in the past 30-days (10 vs. <4 waterpipes; HR=2.56, 95% CI: 1.89–3.22, $p=0.006$), and smoking every day/almost every day vs. less than once weekly (HR=2.86, 95% CI: 2.12–3.60, $p=0.007$).

Conclusions—Increasing use frequency, number of waterpipes smoked, and longer smoking sessions were associated with higher risk of ND. The length of smoking session emerged as a novel indicator of ND among waterpipe smokers.

Keywords

Waterpipe; survival analysis; smoking patterns; Lebanon; length of smoking session; nicotine dependence

INTRODUCTION

Waterpipe use has emerged as a new strain of the global tobacco epidemic, mainly affecting youth (WHO 2015). In many Eastern Mediterranean countries, waterpipe has exceeded cigarettes as the most common tobacco used among youth (WHO 2015). Waterpipe users are exposed to the same toxic chemicals found in cigarettes, such as polycyclic aromatic hydrocarbons, carbon monoxide, and nicotine (Eissenberg and Shihadeh 2009). Many waterpipe users are at risk of smoking-related health problems such as lung cancer, cardio-respiratory illnesses (El-Zaatari et al. 2015), and nicotine dependence (ND) (Aboaziza and Eissenberg 2015). In contrast to cigarettes, waterpipe consists of different components (head, body, water bowl, hose), is less accessible (Maziak et al. 2015), and usually is smoked intermittently over smoking sessions that can last 60 minutes (Sidani et al. 2016). During these long smoking sessions, waterpipe smokers inhale approximately 50–80 L of tobacco smoke compared with 0.5–0.8 L from smoking a single cigarette (Eissenberg 2013). So, while less accessibility and intermittent smoking might reduce the exposure to nicotine, the length of a smoking session can play an important role in exposure to higher doses of nicotine and emergence of ND symptoms among waterpipe smokers. Moreover, the time spent during a single smoking session and a total volume of inhaled nicotine-containing tobacco smoke correlate positively with plasma nicotine levels (Maziak et al. 2011). As nicotine is easily absorbed through the mouth and lungs into the blood circulation (Benowitz et al. 2009), levels of plasma nicotine accumulate gradually over long smoking sessions which may explain why waterpipe smokers take more time, compared with cigarette smokers, to experience abstinence-induced withdrawal/craving symptoms (Cobb et al. 2011; Rastam et al. 2011).

Waterpipe smoking patterns may influence ND symptoms differently than cigarettes (Aboaziza and Eissenberg 2015). Few studies have examined the association between use patterns and ND symptoms among waterpipe smokers and these studies have limitations. For example, some studies failed to control for important factors related to ND (e.g., use of cigarettes/other tobacco) (Primack et al. 2014; Kassim et al. 2014), while others applied cigarette-based measures of ND that may not be applicable to waterpipe-specific use patterns (Auf et al. 2012; Sidani et al. 2016).

Available evidence shows that cigarette smoking frequency (e.g. number of cigarettes or days of smoking) is correlated with ND symptoms among adolescents (Caraballo et al. 2009; O'Loughlin et al. 2003; Lessov-Schlaggar et al. 2008). As waterpipe has unique use patterns that differ from cigarettes, whereby exposure intensity can be related to both length of smoking session (averaging an hour compared to 5 minutes for cigarettes; Maziak et al. 2015) as well as frequency of smoking, it is important to include other aspects of waterpipe use such as the length of a smoking session in assessing determinants of ND among young waterpipe smokers.

Using baseline data from the *Waterpipe Dependence in Lebanese Youth* (WDLY) study, we showed that smoking a whole waterpipe without sharing and the length of a smoking session were among the factors strongly associated with ND (Bahelah et al. 2016a). Using a survival analysis, the current study aims to examine the risk of attaining the first ND symptom (as measured by Hooked on Nicotine Checklist "HONC") and the full syndrome of ND (as measured by ICD-10 ND criteria) and how this risk differs by smoking patterns among adolescent waterpipe smokers. We hypothesize that the risk of attaining the first symptom and full syndrome of ND will be positively associated with the length of smoking session, higher smoking frequency and number of waterpipes smoked, and smoking a whole waterpipe without sharing, as all of these behaviors would result in more frequent or more intense nicotine dosing. Findings from this study will facilitate the understanding of the relationship between unique use patterns of waterpipe such as the length of a smoking session and experiencing ND symptoms among adolescent smokers.

METHODS

Participants

The sample for this study consists of 160 current waterpipe smokers recruited at baseline from the WDLY study. WDLY is a cohort study of 498 adolescent smokers and never smokers (mean $\pm$ SD age at baseline for the whole sample = 14.1 $\pm$ 1.1 years) enrolled in 8th and 9th school grades from 4 regions in Lebanon (Beirut, Mount Lebanon, Nabatiye, South Lebanon). Inclusion criteria were evaluated using in-class, self-administered questionnaires. Never smokers who had the intention to initiate smoking and those who smoked either waterpipe or cigarettes, but not both, in the past 30 days were eligible to participate. Dual users of waterpipe and cigarettes were ineligible because it would not be possible to determine the unique contribution of waterpipe use to ND symptoms among dual users. We inquired about lifetime and past 30-day use of tobacco products (waterpipe, cigarettes, cigar/cigarillos, smokeless tobacco, electronic cigarettes) at the initial screening to determine eligibility. No student reported use of tobacco products other than cigarettes and waterpipe. We limited the sample of this study to those used waterpipe in the past 30-days as this is the standard measure of current use in adolescent smokers (U.S. Department of Health and Human Services 2014), and that less frequent use is less likely to be associated with ND among adolescents (O'Loughlin et al. 2003). More details about the WDLY study can be found elsewhere (Bahelah et al. 2016a).

Procedures

Using interviewer-administered questionnaires, participants provided information about their tobacco use patterns and responded to measures of ND (Bahelah et al. 2016a; DiFranza et al. 2007). Interviewers met participants individually in private rooms on school premises and school personnel were not allowed during interviews to minimize social-desirability bias. During interviews, participants provided exact dates for first developing important milestones that include ever smoking a whole waterpipe without sharing, endorsement of ND symptoms from the Hooked on Nicotine Checklist (HONC), and the criteria of ND using the International Classification of Diseases-10th revision (ICD-10 ND). Recall of the dates of these milestones was facilitated by the use of 4 techniques proved to improve recall of past events: decomposition, bounded recall, personal landmarks, and the depiction of these landmarks visually to create a personal calendar for each student (Bahelah et al. 2016a; DiFranza et al. 2007). However, if the exact date could not be recalled, we recorded the 7th for events in the beginning of the month, the 14th for middle of the month, and the 21st for events toward the end of the month (Bahelah et al. 2016a). The study protocol was approved by the institutional review boards of Florida International University and the American University of Beirut.

Measures

Selection of smoking patterns and important covariates in this study was guided by a review of the factors associated with ND among adolescent smokers (Kleijan et al. 2012; Racicot et al. 2013) and symptoms of ND among waterpipe smokers (Bahelah et al. 2016a; Maziak et al. 2005). Smoking patterns assessed in this study were: (a) *Past 30-day use frequency* (smoked waterpipe less than once a week, smoked at least once a week but not every day, smoked every day/almost every day), (b) *Past 30-day number of waterpipes smoked* (divided into 3 categories: <4, 4–9, and 10), (c) *Usual length of a waterpipe smoking session* (<30 min, 30–60 min, >60 min), and (d) *Ever smoking a whole waterpipe without sharing* (Yes, No). Smoking a whole waterpipe without sharing was asked as a lifetime measure rather than a past 30 day measure, as this was considered a milestone, similar to asking cigarette smokers if they have *ever* smoked a whole cigarette (e.g., Hu et al. 2006).

Outcomes assessed were the loss of autonomy and ND. Loss of autonomy is a useful concept to describe the onset of ND even at low levels of tobacco use and was validated among adolescent smokers (DiFranza et al. 2007). Endorsement of at least one among the 10 HONC items (e.g., Have you ever had strong cravings to smoke waterpipe?; Have you ever tried to quit waterpipe smoking but could not do it?) is an acceptable approach to detect smokers who have “lost autonomy” over tobacco (DiFranza et al. 2007; O’Loughlin et al. 2002). HONC shows an excellent predictive validity of continued smoking over 3 years follow-up among adolescent smokers (DiFranza et al. 2002). Presence of 3 among the 6 ICD-10 criteria (e.g., A strong desire or sense of compulsion to use tobacco; A physiological withdrawal state) were used to make a diagnosis of ND (O’Loughlin et al. 2002). We chose HONC and ICD-10 to assess ND in this study because they are not tobacco method-specific, making them suitable for assessing ND regardless of the tobacco product. Both HONC and the ICD-10 were pilot-tested and translated into Arabic, the official language in Lebanon, with back translation into English for comparison and fine-tuning following conventional

methods (Brislin 1970). Both HONC and ICD-10 had acceptable reliability and convergent validity in this cohort (Bahelah et al. 2016a, b).

Statistical analysis

We compared the proportion of participants who lost autonomy (1 HONC) or developed ICD-10 ND (3 ICD-10 criteria) in relation to smoking patterns using Mantel-Haenszel test for linear trend. We also compared the average number of endorsed HONC items and ICD-10 ND criteria in relation to smoking patterns using Mann-Whitney *U* or Kruskal-Wallis tests as appropriate. Time interval (in months) between smoking initiation and experiencing the 1st HONC symptom or attaining the 3rd criterion of ICD-10 ND was obtained by subtracting the date of smoking initiation from the date when the 1st HONC symptom or 3rd criterion of ICD-10 ND were endorsed. In order to analyze hazards of reaching the 1st HONC symptom and the 3rd criterion of ICD-10 ND (time-to-event), Cox proportional hazards modeling was applied as the method of choice for this kind of analysis (for example, see Kandel et al. 2007).

Time-to-event intervals were plotted using Kaplan-Meier survival curves stratified by smoking patterns (past 30-day smoking frequency, past 30-day number of waterpipes smoked, smoking a whole waterpipe without sharing, usual length of smoking session). We obtained estimates of past-30 number of waterpipes smoked but we chose to categorize this variable for the ease of presenting and interpreting the results. Because the proportional hazards assumption was violated in this sample, a Weighted Cox regression model (Kohl et al. 2015) was applied to test the hazards of experiencing the 1st HONC symptom or attaining ICD-10 ND diagnosis across levels of each waterpipe use pattern. Known covariates associated with ND among adolescent smokers (Kleinjan et al. 2012; O'Loughlin et al. 2003; Bahelah et al. 2016a) were included in all models: gender, age at baseline, age at smoking initiation, school type, depression, self-esteem, and waterpipe smoking among siblings. Analyses accounted for clustering of students within schools using SAS 9.3 (SAS Institute Inc., Cary, NC, USA). All statistical tests were two-tailed and statistical significance was set at $p < 0.05$.

RESULTS

Among 160 current waterpipe smokers, 46.9% smoked less than once per week, 37.5% smoked weekly but not every day, and 15.6% smoked every day/almost every day. In terms of the number of waterpipes smoked in the past 30 days, 45.9% smoked <4, 27.7% smoked 4–9, and 26.4% smoked 10. Almost half (47.8%) of participants usually smoke waterpipe for <30 min, 38.4% for 30–60 min, and 13.8% for >60 min. Finally, 34.4% participants ever smoked a whole waterpipe without sharing.

Bivariate associations between waterpipe use patterns and loss of autonomy/ICD-10 ND

Table 1 presents the proportion of participants who lost autonomy and met ICD-10 ND across levels of each waterpipe use pattern. Overall, the proportion of participants who lost autonomy and who had an ICD-10 ND diagnosis increased with increasing levels of waterpipe use. For example, a loss of autonomy was present in 57.3% of those who smoked

waterpipe less than once a week, in 80% with weekly use, and in 88% with daily use. For these same use levels, ICD-10 ND was present in 18.7%, 46.7% and 76%, respectively. Also shown in table 1 are the average number of endorsed HONC symptoms and ICD-10 ND criteria by waterpipe use patterns. Similarly, a consistent pattern was observed with the average number of endorsed HONC symptoms and ICD-10 ND criteria increasing as a function of smoking frequency/number of waterpipes smoked, longer smoking sessions, and ever smoking a whole waterpipe without sharing (Table 1).

Kaplan-Meier survival curves for the loss of autonomy and ICD-10 ND

Several Kaplan-Meier curves were plotted to show the time (in months) from initiating waterpipe use till reaching the first HONC symptom (loss of autonomy, panel 1) or attaining ICD-10 ND (panel 2) stratified by the 4 studied use patterns. There were no statistical differences in time to reaching the first HONC symptom between those who smoked a whole waterpipe without sharing and those who did not (Logrank $p=0.26$, figure 1-A). Time to reaching the first HONC symptom was significantly different by length of smoking session (Logrank $p=0.04$, figure 1-B), past 30-day smoking frequency (Logrank $p=0.04$, figure 1-C), and past 30-day waterpipes smoked (Logrank $p=0.03$, figure 1-D).

Time to meeting ICD-10 ND was significantly different in relation to smoking a whole waterpipe without sharing (Logrank $p=0.002$, figure 2-A), length of smoking session (Logrank $p=0.01$, figure 2-B), past 30-day smoking frequency (Logrank $p=0.001$, figure 2-C), and past 30-day number of waterpipes smoked (Logrank $p<0.001$, figure 2-D).

Weighted Cox regression hazards models

Table 2 shows unadjusted and adjusted hazard ratios (HR) from Cox regression models with time to the loss of autonomy and time to ICD-10 ND since initiating waterpipe use as outcomes (both in months). In the unadjusted models, smoking 10 waterpipes, smoking waterpipe for 30–60 min, and smoking every day/almost every day were associated with higher hazards for both the loss of autonomy and meeting ICD-10 ND criteria. Ever smoking a whole waterpipe without sharing was associated with higher hazards of meeting ICD-10 ND (Table 2).

Results from adjusted model for the loss of autonomy show that smoking 10 waterpipes in the past 30-days was associated with higher hazards for the loss of autonomy compared with smoking <4 waterpipes (HR=2.05, $p=0.007$). Smoking waterpipe for >60 minutes was associated with higher hazards for the loss of autonomy compared with smoking waterpipe <30 minutes (HR=2.87, $p=0.001$). Results from adjusted Cox regression model for ICD-10 ND show that smoking waterpipe every day/almost every day was associated with higher hazards of meeting ICD-10 ND relative to smoking waterpipe less than once a week (HR=2.86, $p=0.007$). Finally, smoking 10 waterpipes in the past 30-days was associated with higher hazards of meeting ICD-10 ND compared with smoking <4 waterpipes (HR=2.56, $p=0.006$).

DISCUSSION

This study is the first to examine the association between waterpipe-specific use patterns and ND symptoms using validated measures of ND among adolescent smokers. This study shows that higher frequency of use, increasing number of waterpipes smoked, and longer smoking sessions were associated with a higher risk of ND symptoms. This is consistent with studies of ND among adolescent smokers which showed consistent relationships between nicotine exposures and the number of ND symptoms (O'Loughlin et al. 2003; DiFranza et al. 2007). As ND develops, individuals experience a need to increase the frequency of smoking and the number of cigarettes smoked in a period of time.

Use patterns for waterpipes are different from those for cigarettes and this study adds a new finding: symptoms of ND can be predicted by the length of a waterpipe smoking session. As waterpipe is less accessible and thus smoked less frequently, the length of a smoking session offers an indirect measure of nicotine exposure.

The risk of attaining ICD-10 ND increased with increasing number of waterpipes smoked. This observation is consistent with findings from a study among young adult men (mean age=29.5 years, 58% Arabs) in the UK in which ND scores, measured by the Lebanon Waterpipe Dependence Scale, increased in dose-response fashion with increasing number of waterpipes smoked per week (Kassim et al. 2014). In this study, smoking frequency was associated with ICD-10 ND, but not loss of autonomy, while the length of smoking session was associated with loss of autonomy but not ICD-10 ND (Table 2). It is plausible that more addicted adolescents will smoke more frequently in response to cravings (O'Loughlin et al. 2003), while those in the early stages of ND may enjoy longer smoking sessions as waterpipe is a pleasurable social phenomenon than just a means to avoid withdrawal symptoms.

The development and trajectories of ND have been explained using different theories. One of such theories that can provide a relevant model for explaining the onset and trajectories of ND among waterpipe smokers is the *Sensitization-Homeostasis Theory*. This theory holds that withdrawal symptoms can appear during infrequent tobacco use and defines the latency to withdrawal as the time interval between finishing smoking and the onset of withdrawal symptoms (DiFranza and Ursprung 2008). Moreover, as tolerance develops, smokers find that their latency to withdrawal shortens and they must smoke more frequently to keep withdrawal symptoms at bay (DiFranza 2015). This physiological phenomenon explains why ND measures correlate moderately with measures of the frequency of tobacco use. The observation that two measures of ND were related to multiple characteristics of waterpipe use in this study extends prior observations for cigarette smoking to the waterpipe. A study of adolescent cigarette smokers demonstrated that ND symptoms and smoking frequency increased in a mutually reinforcing upward spiral (Doubeni et al. 2010). The observed increase in the number of HONC and ICD-10 symptoms in relation to multiple patterns of waterpipe use in this study is consistent with the picture of a mutually reinforcing spiral. As the latency to withdrawal shortens, addicted smokers must smoke more frequently, and more frequent exposures to nicotine contribute to the development of more advanced symptoms of ND. This can be true for waterpipe smokers as it is for cigarette smokers, despite the less

frequent use patterns associated with waterpipe smoking. As observed in this study, an ICD-10 diagnosis of ND could be made in nearly half (47%) of youths who smoked at least once per week, but not daily, and eighty percent of weekly users had experienced a loss of autonomy (table 1). The temporality among ND symptoms and waterpipe use patterns can be further investigated in our longitudinal study.

This study has limitations. First, recall errors of past events is possible. We tried to minimize this limitation by the use of four recall assistance methods to maximize recall accuracy of past events (DiFranza et al. 2007). Second, some variables in the weighted Cox regression model did not reach statistical significance perhaps as a result of a relatively small sample size. This study will have more power as the sample size of smokers will likely increase during follow up. Third, while we inquired about lifetime ND symptoms, smoking behavior was assessed over the past 30-days. This is a common limitation of time-to-event analysis that involves reports of multiple consequential events occurring in the past. However, such studies still offer an indication of the relation between smoking patterns and ND (e.g., Kandel et al. 2015; Breslau et al. 2001). As mentioned earlier, smoking patterns affect the development of ND and vice versa (Doubeni et al., 2010), and we hope to clarify this issue further based on our planned longitudinal analysis of multiple data points. Fourth, due to the cross-sectional nature of the study, causality cannot be established and results should be interpreted cautiously. Finally, smoking status and ND symptoms were self-reported and no biochemical tests (e.g., cotinine) were used. Generally, self-reports of smoking status and ND symptoms among adolescents are valid (O'Loughlin et al. 2003). This study is the first to examine smoking patterns and their association with the development of ND symptoms among adolescent waterpipe smokers. The observed associations with multiple measures of tobacco use provide evidence for the concurrent validity of the HONC and ICD-10 criteria for use among adolescent waterpipe smokers. The use of two validated measures of ND is one of the strengths of this study.

In conclusion, these findings highlight the association between waterpipe-specific use patterns and the development of ND symptoms among waterpipe smokers. These findings also suggest that it might be helpful to adapt current guidelines derived from the cigarette literature to address some unique use patterns of the waterpipe. Specifically, the length of a smoking session emerged as a novel marker of ND that can be considered in future psychometric work to refine instruments of ND among adolescent waterpipe users, and as an easy-to-assess, single item for assessing ND in clinical practice (e.g., by pediatricians and substance use counselors).

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Figure 1.

Kaplan-Meier survival curves for time to the loss of autonomy (in months, X-axis) and survival probability (Y-axis) by smoking a whole waterpipe without sharing (A), length of smoking session (B), past 30-day smoking frequency (C), and past 30-day number of waterpipes smoked (D).

Figure 2.

Kaplan-Meier survival curves for time to nicotine dependence (in months, X-axis) and survival probability (Y-axis) by smoking a whole waterpipe without sharing (A), length of smoking session (B), past 30-day smoking frequency (C), and past 30-day number of waterpipes smoked (D).

Table 1

Proportion of participants who lost autonomy and met criteria of nicotine dependence and the average number of endorsed Hooked on Nicotine Checklist (HONC) symptoms and criteria of nicotine dependence by waterpipe use patterns

Waterpipe use pattern	Lost autonomy n (%)	Mean number of HONC symptoms Mean (SD)	Nicotine dependent n (%)	Mean number of nicotine dependence criteria Mean (SD)
Smoking frequency in past 30 days				
Smoked less than once a week	43 (57.3) ^a	1.2 (1.4) ^d	14 (18.7) ^a	1.4 (1.4) ^d
Smoked at least once a week but not every day	48 (80.0) ^a	2.3 (2.1) ^d	28 (46.7) ^a	2.7 (1.5) ^d
Smoked every day or almost every day	22 (88.0) ^a	3.7 (2.4) ^d	19 (76.0) ^a	3.4 (1.2) ^d
Number of waterpipes smoked in past 30 days				
<4	43 (58.9) ^a	1.2 (1.3) ^d	14 (19.2) ^a	1.5 (1.4) ^d
4–9	32 (72.7) ^a	2.0 (1.9) ^d	16 (36.4) ^a	2.3 (1.5) ^d
10	38 (90.5) ^a	3.5 (2.4) ^d	31 (73.8) ^a	3.5 (1.3) ^d
Usual length of a waterpipe smoking session				
<30 min	41 (53.9) ^a	1.0 (1.3) ^d	16 (21.1) ^a	1.5 (1.4) ^d
30–60 min	53 (86.9) ^a	2.9 (2.1) ^d	34 (55.7) ^a	2.9 (1.6) ^d
>60 min	19 (86.4) ^a	3.0 (2.6) ^d	11 (50.0) ^a	2.8 (1.1) ^d
Smoked a whole waterpipe head without sharing				
No	64 (61.0) ^e	1.3 (1.6) ^h	24 (22.9) ^e	1.6 (1.4) ^h
Yes	49 (89.1) ^e	3.3 (2.3) ^h	37 (67.3) ^e	3.3 (1.5) ^h

^a p<0.01 using the Mantel-Haenszel linear-by-linear association test (for linear trend)

^d p<0.001 using Kruskal-Wallis test

^e p<0.01 using Person Chi-Square test

^h p<0.001 using Mann-Whitney U test

Loss of autonomy was defined as endorsement of 1 Hooked on Nicotine Checklist (HONC) symptom, and nicotine dependence was defined as the presence of 3 criteria of the International Classification of Diseases-10th revision (ICD-10 ND) over a 12-month period.

Table 2

Results of Weighted Cox regression models for the loss of autonomy and nicotine dependence by waterpipe use patterns

	Loss of autonomy			Nicotine dependence			
	Unadjusted HR (95% CI)	p-value	Adjusted HR * (95% CI)	p-value	Unadjusted HR (95% CI)	Adjusted HR * (95% CI)	p-value
Smoking frequency in past 30 days							
Smoked less than once a week	Ref		Ref		Ref		
Smoked at least once a week but not every day	1.21 (0.79–1.83)	0.36	0.79 (0.45–1.14)	0.19	2.13 (1.12–4.04)	1.00 (0.49–1.51)	0.98
Smoked every day or almost every day	1.95 (1.15–3.29)	0.01	1.73 (1.10–2.35)	0.08	3.75 (1.87–7.51)	2.86 (2.12–3.60)	0.007
Number of waterpipes smoked in past 30 days							
<4	Ref		Ref		Ref		
4–9	1.05 (0.60–1.51)	0.83	1.03 (0.65–1.40)	0.87	1.60 (0.78–3.29)	1.25 (0.43–2.07)	0.58
10	1.72 (1.45–2.47)	0.02	2.05 (1.52–2.58)	0.007	3.45 (1.83–6.50)	2.56 (1.89–3.22)	0.006
Usual length of a waterpipe smoking session							
<30 min	Ref		Ref		Ref		
30–60 min	1.62 (1.07–2.44)	0.02	1.13 (0.74–1.52)	0.53	2.35 (1.29–4.28)	1.36 (0.53–2.18)	0.44
>60 min	1.03 (0.55–1.69)	0.90	2.87 (2.83–2.91)	0.001	1.18 (0.38–1.85)	1.34 (0.47–2.20)	0.51
Smoked a whole waterpipe head without sharing							
No	Ref		Ref		Ref		
Yes	1.24 (0.55–1.17)	0.26	1.36 (0.55–2.16)	0.44	2.15 (1.32–2.18)	1.79 (0.98–2.59)	0.07

* Adjusted for school type, depression, self-esteem, gender, age at baseline, age at smoking initiation, waterpipe smoking among siblings

Bold indicates p<0.05

Loss of autonomy was defined as endorsement of 1 Hooked on Nicotine Checklist (HONC) symptom, while nicotine dependence was defined as the presence of 3 criteria of the International Classification of Diseases-10th revision (ICD-10 ND) over a 12-month period