



Latent class analysis of initial nicotine dependence among adult waterpipe smokers

Davoud Adham¹ · Mohammad Ebrahimi Kalan² · Mehdi Fazlzadeh^{3,4} · Abbas Abbasi-Ghahramanloo¹

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Abstract

Waterpipe (WP) tobacco smoking increases the risk of smoking-related health problems. In this study, we sought to identify the unobserved class memberships of WP-associated initial nicotine dependence (ND) symptoms and assess the predictors of each latent class. This cross-sectional study was conducted among a convenience sample of 900 current (past 30-day) WP smokers who were recruited from 94 WP-serving venues surrounding Tehran and Ardebil metropolitans in Iran. All participants completed a self-administrated questionnaire. We performed latent class analysis using PROC LCA in SAS to identify class memberships of initial ND symptoms using 10-item Hooked on Nicotine Checklist. Five latent classes were identified as non-dependent (25.4 %), low dependent (7.1 %), low-moderate dependent (19.6 %), moderate dependent (15.6 %), and high dependent (32.2 %). Using flavored WP tobacco significantly increased the odds of belonging to low-moderate dependent class [adjusted OR (aOR) = 1.89; 95 % confidence interval (CI): 1.07–3.34] compared to non-dependent class. Also, having academic education decreased the odds of belonging to low-moderate dependent (aOR = 0.43; 95 %CI: 0.26–0.67) and moderate dependent (aOR = 0.39; 95 %CI: 0.23–0.67) class in comparison to non-dependent class. Also, WP smoking initiation at an older age was associated with belonging to high dependent (OR = 2.05; 95 %CI: 1.39–3.03) class compared to non-dependent. This study revealed that nearly half of WP smokers fell under moderate and high-dependent classes. Our findings showed that some items of HONC had more role in the clustering of participants based on ND symptoms. The WP-specific cessation programs and targeted clinical trials should consider the diversity of ND levels among smokers to achieve successful quit rates among these smokers. Additionally, limiting flavors would be a strong strategy to limit the rate of ND, especially among young people who are eager to smoke flavored WP tobacco.

Keywords Waterpipe smoking · Nicotine dependence · Latent class analysis · Iran

Introduction

Tobacco smoking is the leading cause of morbidity and mortality, contributing to more than 8 million deaths every year [1]. Among combustible tobacco products that cause most of this burden, waterpipe (WP) tobacco smoking has emerged as a new strain of the global tobacco epidemic that mostly affects young people worldwide [2]. Due to some salient features associated with WP smoking, such as socializing, relaxation, pleasure, flavored tobacco, and entertainment, this tobacco smoking mode has exceeded cigarette smoking—in some countries—as the most common tobacco used, especially among youth [2, 3].

The majority of WP users think this habit is associated with fewer adverse health effects than cigarette smoking because of a purported filtering effect of water through which the smoke passes prior to inhaled [2]. However, well-established

✉ Mehdi Fazlzadeh
M.fazlzadeh@arums.ac.ir; m.fazlzadeh@gmail.com

✉ Abbas Abbasi-Ghahramanloo
abbasi.abbas49@yahoo.com

¹ Department of Public Health, School of Health, Ardabil University of Medical Sciences, Ardabil, Iran

² Department of Epidemiology, Robert Stempel College of Public Health, Florida International University, Miami, FL, USA

³ Social Determinants of Health Research Center, Ardabil University of Medical Sciences, Tehran, Iran

⁴ Department of Environmental Health, School of Health, Ardabil University of Medical Sciences, Ardabil, Iran

evidence suggests that WP smoking is addictive and is associated with smoking-related diseases such as esophageal cancer, decreased pulmonary and cardiovascular function, low birth weight, infertility, dental problems and infectious diseases [4, 5]. Therefore, it is crucial to better understand how initial nicotine dependence (ND) symptoms emerge in WP smokers as well as the associated factors to prevent the aforementioned diseases and mortalities caused by these health complications.

WP smokers are exposed to a substantial amount of toxic chemicals found in cigarettes, including polycyclic aromatic hydrocarbons, carbon monoxide, volatile organic matter, heavy metals, particle matters, and nicotine [6–14]. A robust body of evidence show that smoking WP can lead to nicotine dependence (ND) [15–17], which is a fundamental reason for being a life-long smoker and inability to wean off smoking, even when motivated to do so [18, 19]. Unlike cigarettes, the WP device indirectly heats the tobacco, then resulting smoke passes through the water before being inhaled through the hose using a mouthpiece [20]. Because of these features, WP is less portable and usually is smoked occasionally—accompanying friends or family—over smoking sessions that can last on average 30–60 min [5, 21]. Despite less portability and intermittent use of WP that could reduce exposure to nicotine, the length of a smoking session can increase the chance of exposure to higher dose of nicotine and finally lead to emergence of early ND symptoms [15, 22].

Studies from Iran show higher prevalence of WP smoking across different age groups [23–26], which is mostly rooted in culture as other Middle Eastern nations [5]. This popular mode of tobacco use hooks many Iranians on nicotine that is evident from previous studies [27]. It is crucial to disentangle the unobserved grouping of ND levels among smokers to develop and better assist WP-specific smoking cessation programs, increase the quit rate among those already hooked on nicotine, and subsequently, decrease WP-smoking-caused health issues.

To achieve this, using latent class analysis (LCA) module—a cluster analysis model—we sought to identify unobserved classes of ND and associated predictors among Iranian WP smokers.

Materials and methods

Study sample and setting

We have conducted a questionnaire-based cross-sectional study in 44 WP-serving venues randomly selected from 15 municipality regions of Tehran, Iran, and 50 venues from 5 municipality regions of Ardabil, Iran. In these cities, three types of WP-serving venues are active [28]. The study period spanned between May 5th and October 30th, 2019. Detail of study design and methodology can be found elsewhere [29].

In brief, 10–12 WP smokers from each venue using nonprobability (convenience) sampling. Eligible participants [i.e., ≥ 18 years old, willing to participate and sign the written informed consent, not using substances other than tobacco (e.g., opium), smoking WP over the past 6 months] were invited to complete the self-administered questionnaire. The data from 900 participants were included in this study. The study protocol was approved by the Institutional Review Board of Ardabil University of Medical Sciences and Health Services.

Measures

Outcome

The Hooked on Nicotine Checklist (HONC) was used to measure initial ND symptoms [30]. HONC is a 10-item measurement based on the autonomy theory of tobacco dependence which indicates that the appearance of a single symptom of dependency provides the appearance of initial ND symptom. Each HONC item represents a symptom of ND and has yes/no options. [31].

Covariates

Assessed covariates were age, sex (male/female), education (\leq than high school vs. $>$ high school), job status (employed vs. unemployed), having sports activity (at least once/week vs. no activity), and type of usual WP tobacco (Flavored vs. non-Flavored).

Statistical analysis

We ran LCA beginning with one class solution and continued until eight classes to identify the best model that can fit the data. Each LCA model was fit to the data 20 times using different random starting values in order to investigate model identification. For the selection of the best model, some statistical indices were calculated and compared across eight models, including the likelihood ratio statistic G₂, the Akaike information criterion (AIC), the Bayesian information criterion (BIC), entropy, and log-likelihood value. Among these indices, lower values of G₂, AIC, BIC, and the log-likelihood and higher entropy value indicate a more optimal model fit [32]. Furthermore, in the model selection stage, we have considered the interpretability and parsimony of a model.

The 10 items of HONC were used to subgroup the WP smokers based on their initial ND symptoms.

A multinomial regression model was performed to examine the association between opted class memberships and covariates, with 1st class being as a reference group.

All analyses were performed using SPSS 16 and SAS 9.2 software. To conduct LCA, we used PROC LCA in SAS 9.2

software. P-value < 0.05 was considered statistically significant.

Results and discussion

Participants’ average age ± standard deviation (SD) was 33.4 ± 13.1 years, ranging from 18 to 75) years. Most of the participants (86.4 %) were male, and 49.6 % had > high school education, and 34.3 % were unemployed. Among all participants, 43.6 % used non-flavored WP tobacco. A summary of responses to initial ND symptoms is shown in Table 1.

According to model selection criteria, parsimonious and interpretability of the results, we concluded that the five-class model of initial ND symptoms was appropriate for WP smokers (Table 2). Table 3 presents the result of the LCA model. As can see in this table, the first class, non-dependent, described 25.4 % of the participants. Also, the second class (low dependent), third class (low-moderate dependent), fourth class (moderate dependent), and fifth class (high dependent) represented 7.1 %, 19.6 %, 15.6 %, and 32.2 % of the participants, respectively.

Latent class 1, non-dependent, was characterized by a low probability of yes response to all of HONC questions, and latent class 5, high dependent, was characterized by the high probability of yes response to most of the questions. In latent class 5, except for two questions, other ones had a high probability of a yes response. These two questions were “Do you smoke or use WP now because it is really hard to quit?” and “Is it hard to keep from smoking or using WP where you are not supposed to, like school?”. There were also three other latent classes that reflected different patterns of ND

symptoms. Latent class 2, low dependency, was characterized by the high probability of a yes response to the two questions of HONC. These two questions were “When you tried to stop smoking or using WP (or, when you haven’t used it for a while.) did you feel more irritable because you couldn’t smoke WP?” and “When you tried to stop smoking or using WP (or, when you haven’t used tobacco for a while.) did you feel a strong need or urge to smoke or WP?”. Latent class 3, low-moderate dependency was characterized by the high probability of yes response to the four questions of HONC. These questions were “Have you ever tried to quit WP, but couldn’t?”, “Have you ever felt like you were addicted to WP?”, “Have you ever had strong cravings to smoke or use WP?”, and “Have you ever felt like you really needed a WP?”. Finally, latent class 4, moderate dependency, was characterized by the high probability of yes response to the five questions of HONC. These five questions were “Have you ever tried to quit WP, but couldn’t?”, “When you tried to stop smoking WP (or, when you haven’t used it for a while.) did you find it hard to concentrate because you couldn’t smoke?”, “When you tried to stop smoking WP (or, when you haven’t used WP for a while.) did you feel more irritable because you couldn’t smoke?”, “When you tried to stop smoking WP (or, when you haven’t used WP for a while.) did you feel a strong need or urge to smoke?”, and “When you tried to stop smoking WP (or, when you haven’t smoked WP for a while.) did you feel nervous, restless or anxious because you couldn’t smoke?”.

After identifying the optimal model (the five-class model in this study), we conducted an LCA with covariates to detect the effect of predictors of latent class membership. Table 4 shows the adjusted odds ratio of membership in each class compared to the first class associated with the type of WP tobacco and

Table 1 Percentages of participants responding to nicotine dependency questions

Items	Total(n=900)	
	No N (%)	Yes N (%)
Have you ever tried to quit, but couldn’t?	456(50.7)	444(49.3)
Do you smoke or use WP now because it is really hard to quit?	634(70.4)	266(29.6)
Have you ever felt like you were addicted to tobacco?	459(51.0)	441(49.0)
Have you ever had strong cravings to smoke or use WP?	379(42.1)	521(57.9)
Have you ever felt like you really needed a cigarette or a WP?	432(48.0)	468(52.0)
Is it hard to keep from smoking or using WP where you are not supposed to, like school?	653(72.6)	247(27.4)
When you tried to stop smoking or using WP... (or, when you haven’t used tobacco for a while.)		
Did you find it hard to concentrate because you couldn’t smoke or WP?	562(62.4)	338(37.6)
Did you feel more irritable because you couldn’t smoke or WP?	460(51.1)	440(48.9)
Did you feel a strong need or urge to smoke or WP?	434(48.2)	466(51.8)
Did you feel nervous, restless or anxious because you couldn’t smoke or WP?	557(61.9)	343(38.1)

Table 2 Comparison of LCA Models with different latent classes based on model selection statistics

Number of latent class	Number of parameters estimated	G ²	df	AIC	BIC	Entropy	Maximum log-likelihood
1	10	3592.92	1013	3612.92	3660.94	1.00	-5998.99
2	21	1806.03	1002	1848.03	1948.88	0.84	-5105.55
3	32	1277.65	991	1341.65	1495.33	0.89	-4841.36
4	43	964.62	980	1050.62	1257.12	0.88	-4684.84
5	54	875.19	969	983.19	1242.52	0.88	-4640.13
6	65	831.46	958	961.46	1273.62	0.87	-4618.27
7	76	793.92	947	945.92	1310.90	0.86	-4599.49
8	87	754.47	936	928.47	1346.28	0.86	-4579.77

Note. LCA = latent class analysis; AIC = Akaike information criterion; BIC = Bayesian information criterion

other covariates. This index compares the odds of membership in each class with the reference class (i.e., non-dependent).

As shown in Table 4, the odds of membership in class 2 increased significantly by age. This table also shows that having > high school education significantly decreased the odds of being in classes 3 and 4. Having regular sports activity significantly increased the odds of membership in classes 3 and 4 compared to class (1) However, having sports activity decreased these odds in class (2) Older age of WP smoking initiation increased the odds of being in class 5 compared to class 1. Finally, smoking flavored WP significantly increased the odds of being in latent class 3 than latent class 1.

This study evaluated the pattern of initial ND symptoms (using previously validated HONC scale) among WP smokers with the LCA approach. We were able to find five distinct

classes of dependency named as non-dependent, low dependent, low-moderate dependent, moderate dependent, and high dependent that represented 25.4 %, 7.1 %, 19.6 %, 15.6 %, and 32.2 % of the WP smokers in our study sample, respectively. Raed et al. found that 38.1 % of Lebanon students had the full syndrome of ND. Our study indicated that 32.2 % of the participants were high dependent [33]. The development of ND has been explained using different theories. For example, *Sensitization-Homeostasis Theory* demonstrated that withdrawal symptoms could appear during infrequent tobacco use and defines the latency to withdrawal as the time interval between finishing smoking and the onset of withdrawal symptoms. Our findings showed that some items of HONC had more role in the clustering of participants based on ND. In this study, “irritability” and “strong need to smoke” had high probability in three classes. These factors may be more

Table 3 The five latent classes model of nicotine dependency among Iranian waterpipe smokers

Items	Latent class				
	Non dependent	Low dependent	Low-moderate dependent	Moderate dependent	High dependent
Latent class prevalence	0.254	0.071	0.196	0.156	0.322
Item-response probabilities					
Have you ever tried to quit, but couldn't?	0.183	0.255	0.547	0.637	0.689
Do you smoke or use WP now because it is really hard to quit?	0.041	0.042	0.303	0.463	0.467
Have you ever felt like you were addicted to tobacco?	0.031	0.034	0.707	0.372	0.879
Have you ever had strong cravings to smoke or use WP?	0.110	0.267	0.954	0.161	0.993
Have you ever felt like you really needed a waterpipe or a WP?	0.041	0.052	0.903	0.185	0.932
Is it hard to keep from smoking or using WP where you are not supposed to, like school?	0.058	0.005	0.265	0.421	0.440
When you tried to stop smoking or using WP... (or, when you haven't used tobacco for a while.)					
Did you find it hard to concentrate because you couldn't smoke or WP?	0.003	0.003	0.180	0.557	0.784
Did you feel more irritable because you couldn't smoke or WP?	0.010	0.823	0.040	0.688	0.970
Did you feel a strong need or urge to smoke or WP?	0.007	0.857	0.132	0.738	0.975
Did you feel nervous, restless or anxious because you couldn't smoke or WP?	0.046	0.062	0.299	0.523	0.698

Table 4 Predictors of membership in latent classes of nicotine dependency among Iranian waterpipe smokers

Predictors	Low dependent OR(95 %CI)	Low-moderate dependent OR(95 %CI)	Moderate dependent OR(95 %CI)	High dependent OR(95 %CI)	P- value
Age	1.06(1.03–1.10)	1.00(0.98–1.03)	0.97(0.93–1.00)	1.00(0.97–1.02)	0.0002
Male vs. Female	0.97(0.19–4.86)	0.87(0.45–1.65)	0.87(0.42–1.77)	1.05(0.60–1.85)	0.9764
Education (higher than diploma)	1.66(0.67–4.11)	0.43(0.26–0.67)	0.39(0.23–0.67)	0.72(0.48–1.07)	0.0001
Job status (being employed)	0.72(0.25–2.01)	1.09(0.63–1.88)	0.92(0.50–1.70)	1.13(0.71–1.80)	0.8745
Having sport activity	0.23(0.08–0.66)	2.15(1.31–3.53)	2.62(1.42–4.80)	1.05(0.70–1.55)	<0.001
Age of WP initiation (under 20 years)	1.53(0.76–3.09)	1.58(0.99–2.51)	1.29(0.75–2.21)	2.05(1.39–3.03)	0.0076
BMI (being obese)	1.18(0.46–3.01)	1.60(0.82–3.09)	1.20(0.53–2.68)	1.23(0.69–2.20)	0.7493
Type of waterpipe (flavored)	0.35(0.10–1.14)	1.89(1.07–3.34)	0.97(0.53–1.77)	1.48(0.94–2.33)	0.0090

The reference class: non user

OR: odds ratio

CI: confidence interval

important in designing interventional programs for WP quitting, highlighting the importance of withdrawal symptoms.

WP smoking is associated with a variety of adverse short-term and long-term health effects. These short-term effects are increased heart rate, high blood pressure, carbon monoxide intoxication, impaired pulmonary function, decreased exercise capacity, and larynx and voice changes [4, 34, 35]. Long-term effects of WP include ischemic heart disease, impaired pulmonary function, chronic obstructive lung disease, chronic bronchitis, emphysema, lung cancer, esophageal cancer, gastric cancer, low birth weight, pulmonary problems at birth, periodontal disease, larynx and voice changes, and lower bone density and increased fracture risk [4]. Some prior person-centered studies revealed that WP smoking has a distinct class in identifying patterns of tobacco product use and risk-taking behaviors [36, 37]. It means that some youths are only WP smokers without using any other tobacco products and doing risk taking behaviors. In such conditions, because of some features of WP smoking, the emergence of ND symptoms—at different levels— could be expected [38]. Among the Iranian population, several factors are likely to increase the WP initiation and lead to the development of ND symptoms—especially among young people. These factors included the increased presence of attractive WP devices in public venues such as teahouses and restaurants, accessibility, affordability, being considered as acceptable practice among Iranian families as opposed to conventional cigarettes, and café environment being a perfect socializing and entertaining ambience for WP smokers, and maybe nonsmokers who are at risk of inistaition [37].

To our knowledge, few studies have examined the association between ND symptoms and physical activity [39–43]. These studies indicated that ND was inversely associated with physical activity. It should be noted that all of the above-alluded studies were carried out on cigarette smokers. Although one longitudinal study also showed the association

between having physical activity and low odds of emerging initial ND among Lebanese adolescents [44], the present study adds to the growing literature by examining this understudied topic—in WP literature—in a sample of Iranian WP smokers. Our findings showed that having sport activity decreases the odds of being in low dependent class, but increases this odd for low-moderate dependent and moderate dependent classes compared to non-dependent classes. Because of insufficient evidence, more investigations are warranted to assess the association between regular sports activity and the emergence of initial ND symptoms among Iranian WP smokers.

Our findings indicated that having academic education decreases the odds of membership in low-moderate dependent and moderate dependent compared to non-dependent class. Although Danaei et al. showed that, among Iranian population, individuals with a university degrees were more likely to use WP compared to people with high school diploma or less [23]. More investigations are needed to assess the association between level of education and emergence of ND symptoms over time among adult WP smokers.

This study has some limitations. First, the study was conducted in only two large cities in Iran; therefore, it may not be fully generalizable to other parts of Iran. Although our study sample was selected a conventional approach, the sites within the cities were selected randomly, hence reducing the generalizability gap for the participating areas. Second, data were self-reported and might be subject to recall, response, or social desirability bias. However,, self-report data collection in behavioral studies is a valid measure[45].

Conclusions

In the present study, we evaluated the pattern of initial ND symptoms using a valid measure among a sample of Iranian WP smokers. Our findings revealed that near-half of the

participants belonged to moderate and high dependent classes. Also, we found that older people, having academic education and regular sport activity were belong to higher dependent group. Our findings highlight a need for targeted intervention to raise awareness about the harms of WP smoking and how life-long smoking (due to the formidable grip of ND) can affect their lives, cause diseases, and increase mortality rate. Additionally, targeted WP-specific cessation programs are warranted to curb this smoking mode among smokers in the Middle East, including Iran.

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Author contribution Mohammad Ebrahimi Kalan and Abbas Abbasi-Ghahramanloo participated in the writing, reviewing and editing. Abbas Abbasi-Ghahramanloo is responsible for analysis and interpretation of data. Mehdi Fazlzadeh and Davoud Adham wrote the first draft of manuscript. All authors have read and approved the final paper as submitted.

Data availability The data used and analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Consent to publish All the authors agreed to publish the data in this journal.

Conflict of interest The authors declare that there is no conflict of interest regarding the publication of this manuscript.

Ethical approval The protocol was approved by the Institutional Review Board of Ardabil University of Medical Sciences (Approval ID: IR.ARUMS.REC.1398.310).

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