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The Syrian Center for Tobacco Studies-13 (SCTS-13): Psychometric evaluation of a waterpipe-specific nicotine dependence instrument

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Abstract

Background: Waterpipe tobacco smoking (WTS) has surged globally among young people and causes nicotine dependence (ND). No existing ND instruments are sensitive to waterpipe-specific features of ND and early stages of use.

Methods: We conducted a psychometric scale evaluation among 192 current waterpipe smokers, initially averaging 15 years of age, recruited from schools in Beirut, Lebanon, and assessed 4 times, 6 months apart. Twenty eight self-report items tapping multiple features of ND were

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Contributors

KDW, WM, and TE obtained funding. MMA and KDW designed the study. MMA performed the statistical analyses and prepared the first draft of the manuscript. RB, MEK, and TA oversaw data collection and management. All authors contributed to the interpretation of the study's findings as well as reviewed and approved of the manuscript before submission.

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Conflict of Interest
No conflict declared

submitted to exploratory and confirmatory factor analyses (EFA and CFA) to reduce items and verify factor structure. Convergent validity was assessed with the Lebanese Waterpipe Dependence Scale and the Hooked on Nicotine Checklist, and discriminant validity with the Depressive Symptom Scale and Adolescent Life Events Stress Scale. Concurrent and predictive validity measures included smoking status and intensity (amount, frequency, session duration, and change in frequency), quitting interest and success, perceived addiction, and smoking alone.

Results: The EFA yielded a single factor, 13 item solution (named the Syrian Center for Tobacco Studies [SCTS]-13) that explained 91% of variance in responses, was internally consistent (Cronbach's alpha and McDonald's omega = 0.87), and captured several positive reinforcement, negative reinforcement, and social/sensory-related features of ND. The CFA indicated good model fit. The SCTS-13 showed acceptable convergent and discriminant validity. Higher SCTS-13 scores predicted current waterpipe and dual (waterpipe and cigarette) smoking, greater intensity of use, less interest in quitting, shorter duration of abstinence, greater perceived addiction, and smoking alone (vs. socially).

Conclusion: The SCTS-13 is a promising brief, waterpipe-specific ND instrument.

Keywords

Tobacco; Waterpipe; nicotine dependence; psychometrics

1. Introduction

Waterpipe tobacco smoking (WTS) has increased globally over the past 20 years, especially among youth (Jawad et al., 2018a, Maziak et al., 2015, McKelvey et al., 2013). WTS delivers substantial amounts of nicotine (Eissenberg and Shihadeh, 2009, Neergaard et al., 2007), and many smokers experience withdrawal symptoms such as craving and irritability when abstinent or trying to quit, which are relieved by smoking (Maziak et al., 2009, Rastam et al., 2011, Maziak et al., 2011). Waterpipe smokers also manifest other common symptoms of nicotine dependence (ND) such as increasing the frequency of use over time (tolerance), considering themselves to be "hooked," and having difficulty quitting (Aboaziza and Eissenberg, 2015, Maziak et al., 2004, Ward et al., 2005, Ward et al., 2007). Behavioral adaptation to ensure access to waterpipe also occurs, e.g., owning one's waterpipe, selecting restaurants where WTS is allowed, and smoking alone (and at home) (Maziak et al., 2004, Maziak et al., 2005).

While WTS dependence has been studied mainly among established, adult smokers (Aboaziza and Eissenberg, 2015) there is emerging evidence that individuals with short WTS use histories, such as adolescents, also exhibit ND symptoms. The prospective Waterpipe Dependence Among Lebanese Youth (WDLY) study assessed changes in tobacco use and ND symptoms over two years. At baseline, 71% of participants endorsed at least one symptom from the Hooked on Nicotine Checklist (HONC) (DiFranza et al., 2002) and 38% already had developed the full ND syndrome (3 of 6 criteria from the International Classification of Diseases, 10th revision [ICD-10]) (Bahelah et al., 2016a, 2016b). The most commonly reported ND symptoms were craving, feeling addicted, and failed quit attempts and were associated with greater WTS (number of waterpipes smoked, frequency of WTS,

and average length of WTS session) (Bahelah et al., 2017). ND symptoms among waterpipe smokers, compared to cigarette smokers, appeared at fairly low levels of consumption (median 7.5 waterpipes/month vs. 27.5 cigarettes/month, $p < 0.001$) and frequency of use (median 6 days/month for waterpipe smokers vs. 13.5 days/month for cigarette smokers, $p = 0.09$) (Bahelah et al., 2016a). The majority of waterpipe users reported positively reinforcing, negatively reinforcing, and socially- and sensory-cued features of ND, such as “feeling happy” (71.9%), “difficulty concentrating” (80.6%), “sight or smell triggers WTS” (82.5%) and “difficulty not smoking in a restaurant” (78.1%) (Bahelah et al., 2016a).

Few waterpipe-specific ND instruments have yet been developed, and none adequately capture early stages of ND. Current instruments borrow heavily from the cigarette ND literature, although ND among waterpipe smokers has several distinct features, including responsiveness to social and sensory cues. Existing instruments, including the Lebanon Waterpipe Dependence Scale (LWDS-11) (Salameh et al., 2008) its derivative (the LWDS-10J) (Primack et al., 2014), and instruments developed in Egypt (Auf et al., 2012) and Jordan (Alzyoud et al., 2016) adapted items from the Fagerstrom Test for Cigarette Dependence (FTCD) (Fagerstrom, 2012) which was developed for cigarette smokers. Adapted FTCD items reflect heaviness of smoking which may not adequately capture important, waterpipe-specific features of ND development among adolescents and young adults who often exhibit symptoms of ND before use is regular or frequent (Bahelah et al., 2016a).

To fill this gap, the Syrian Center for Tobacco Studies (SCTS) conducted formative research to identify waterpipe-specific features of ND. Details are available elsewhere (Kedia et al., 2020, Hammal et al., 2008). Briefly, we reviewed the WTS ND literature and conducted focus groups with adult waterpipe smokers in Syria to learn about perceptions of ND. Groups also were conducted with Syrian cigarette smokers to compare perceived dependence features for these two tobacco products (Hammal et al., 2008). Participants were asked about early and ongoing experiences related to the development and manifestation of dependence. Dependence experts then mapped identified WTS dependence features to specific domains such as positive reinforcement, negative reinforcement, and social/sensory features, and an initial item pool of 200 items was generated. This pool of items was reduced iteratively to ensure clarity, relevance, and non-redundancy based on expert consensus and testing with two additional samples of Syrian waterpipe smokers, resulting in a battery of 28 test items. These test items were administered in the WDLY prospective cohort study (Bahelah et al., 2016a, 2016b). In Wave 1 of the WDLY, items were administered to verify that they captured dependence features that were relevant for youth; all items were endorsed by between 15–92% of waterpipe smokers, with half of items being endorsed by more than 50% of the sample (Bahelah et al., 2016a). The present study psychometrically tested these 28 features of ND from Wave 2 of the WDLY study to determine their factor structure, reliability, and validity. We hypothesized that a multidimensional scale would result that captured several general and WTS-specific features of ND and would predict several important smoking-related outcomes at subsequent study waves, including smoking status and intensity (amount, frequency, session duration, and change in frequency), quitting interest and success, perceived addiction, and smoking alone.

2. Methods

2.1. Study setting

The WDLY cohort was assembled by identifying all schools with 8th and 9th grades from four regions of Lebanon (Beirut, Mount Lebanon, Nabatiye, and South Lebanon). Of 178 eligible schools, 38 agreed to participate and were enrolled, and had a total of 3,027 8th and 9th graders enrolled. Of these, 1,225 students returned a parental consent form allowing them to be screened to determine study eligibility. To be eligible to participate in the WDLY, students had to exclusively smoke either waterpipe or cigarettes (but not both) in the past 30 days or indicate that they were likely to initiate waterpipe or cigarette smoking in the next year. A total of 498 screened students were eligible and enrolled in the study. Survey development/administration procedures are described elsewhere (Bahelah et al., 2016a, 2016b, 2017, 2019). The study was approved by the Institutional Review Boards of Florida International University, American University of Beirut, and The University of Memphis.

2.2. Procedures and analytic sample for the psychometric evaluation

Psychometric procedures included exploratory and confirmatory factor analyses (EFA and CFA, respectively) to reduce items and verify factor structure, testing of instrument reliability (internal consistency) and validity (convergent, discriminant, concurrent, and predictive).

The analytic sample consisted of all exclusive current WTS smokers (i.e., none smoked cigarettes) at Wave 2 (n=192). Wave 2 data were used to perform the EFA and to assess internal consistency and validity (convergent, discriminant, and concurrent). CFA was conducted on the Wave 3 sample (n=190), and Waves 3, 4 (n=178), and 5 (n=141) were used to evaluate predictive validity. Sample sizes varied somewhat across waves due to attrition, which ranged from 1.0% at Wave 3 to 26.6% at Wave 5.

2.3. Measures

2.3.1. Sociodemographic—Age, grade in school, and sex were recorded from Wave 2 surveys.

2.3.2. Test measures—Participants responded to the set of 28 ND test items described above and presented in the Appendix A. Respondents indicated the extent to which the behavior, attitude, or symptom applied to them on a 3-point scale: not true (0), somewhat true (1), or true (2).

2.3.3. Convergent and Discriminant validity measures—The LWDS-10J (Primack et al., 2014) and HONC (DiFranza et al., 2002) were used to measure convergent validity with the expectation that they would be positively correlated ($r > 0.50$; Abma et al., 2016, Hair et al., 2014, Carlson and Herdman, 2012) with the developed ND instrument. Discriminant validity was measured using the Depressive Symptom Scale (DSS) (Brunet et al., 2014) and the Adolescent Life Events Stress (ALES) scale (Racicot et al., 2013) with expected low positive correlation ($r < 0.50$) (Shadish et al., 2002). We selected depression and perceived stress because these conditions are associated with adolescent waterpipe use (Akl

et al., 2013, Bahelah et al., 2016b, Bahelah et al., 2017, Roohafza et al., 2011, Sabahy et al., 2011) but are distinct from ND.

2.3.4. Concurrent and predictive validity measures—All outcome measures summarized below were assessed at Wave 2 to describe concurrent validity, and at Waves 3–5 to describe predictive validity. They are described in more detail in Appendix B. Measures tapped several dependence-related outcomes including:

- a. ‘Current smoking status’ was categorized as (1) No tobacco use, (2) Current (past 30 days) waterpipe only use, and (3) Current dual (waterpipe & cigarette) use.
- b. ‘Perceived addiction’ was measured by asking ‘In your opinion, how hooked are you on smoking waterpipe?’ (“Not hooked” vs. “Hooked”).
- c. ‘Intensity of smoking’ was assessed among current and dual smokers by asking ‘What is the average time you usually spend during a waterpipe smoking session?’ (< 30 minutes, 30–60 minutes, or > 60 minutes); ‘What best describes your waterpipe smoking during the past month (30 days)?,’ (“less than once per week” vs. “at least once per week.”); ‘During the past month, how many waterpipes did you smoke approximately?’; and ‘Over the past 6 months, would you say your frequency of waterpipe smoking has increased, stayed the same or decreased?’ (“Increased” vs. “Did not increase”).
- d. ‘Interest and success in quitting’ were measured by asking ‘Do you want to quit waterpipe smoking?’ (yes, no); ‘During the past 6 months, have you attempted to quit waterpipe smoking?’ (yes, no); and ‘What was the longest period of abstinence during the past 6 months?’ (expressed in days).
- e. ‘Smoking alone (vs. socially)’ was assessed by asking ‘Do you smoke waterpipe alone?’ (yes, no).

2.4. Data analysis

Responses to the 28 test items initially were evaluated for missing values, skewness, multivariate outliers, and item relevancy (Tabachnick and Fidell, 2013, Costello and Osborne, 2005). Next, we applied EFA using principal axis factoring (PAF) for item reduction; PAF is preferred over other extraction techniques when data are not normally distributed (Costello and Osborne, 2005), which was the case with our test items. We assessed sampling adequacy using the Kaiser-Meyer-Olkin (KMO) with a value of .60 indicating adequacy (Hair et al., 2014, Tabachnick and Fidell, 2013). The number of factors to retain was determined using an Eigenvalue score (>1.0) (Tabachnick and Fidell, 2013, Pituch and Stevens, 2016) and the Velicer’s Minimum Average Partial (MAP) factor retention method to establish and cross-check the number of factors retained (Zwick and Velicer, 1986, Velicer, 1976, O’Connor, 2000). Since ND features co-occur in the same individual and are inter-correlated, we used an oblique rotation technique (promax) (Hair et al., 2014, Tabachnick and Fidell, 2013, Costello and Osborne, 2005, Pituch and Stevens, 2016). The minimum cutoff value for factor loading of a test item was set for 0.45, explaining approximately 20% of the variance (common variance) of the test item. Next, we

checked communality of the initial retained items and removed items that produced communality value < 0.20 (Child, 2006). The EFA was re-run until a satisfactory factor loading (> 0.45) and communality (> 0.20) for each item were achieved (Hair et al., 2014, Child, 2006). Next, both the Cronbach's alpha and McDonald's Omega (McNeish, 2018) were calculated to assess and cross-check internal consistency, with $\alpha=0.70$ considered acceptable (Tavalok and Dennick, 2011).

We applied CFA using structural equation modeling (SEM) (Tabachnick and Fidell, 2013, Costello and Osborne, 2005, Pituch and Stevens, 2016) to examine model fit of the retained items at Wave 3. We considered model chi-square (chi-square and degree of freedom ratio); Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Comparative Fit Index (CFI), and Non-Normed Fit Index (NNFI) for interpreting model fit in the SEM since these indices are less influenced by sample size, model misspecification, and parameter estimates (Hooper et al., 2008).

Convergent, discriminant, concurrent, and predictive validity of the ND instrument was assessed by evaluating its associations with outcome measures (described above) using ordinary least square (OLS) linear regression, binary logistic regression, or multinomial logistic regression for continuous, dichotomous, and polytomous outcome variables, respectively. All statistical analyses were performed using SAS 9.4 (SAS Institute Inc., 2016). We standardized the total score of the developed instrument to facilitate comparisons of associations across outcomes. Beta coefficients and odds ratios with 95% confidence intervals were generated to interpret associations. In addition, the response pattern of two continuous outcome variables ('During the past month (30 days) how many waterpipe did you smoke approximately?' and 'What was the longest period of abstinence from waterpipe smoking in days?') were skewed and log-transformed to normalize them. To express the resulting beta coefficients as non-logged transformed values, they were exponentiated using anti-log and expressed as percent change $[(\text{exponentiated beta} - 1)] * 100$. Coefficient values (labelled OR) represent exponentiated OLS regression coefficients and can be interpreted as odds ratios.

3. Results

3.1. Initial reduction of dependence items and cases

Initially, there were 207 past month waterpipe smokers at Wave 2, 12 had missing values on at least six of the 28 test items. Three additional participants were multivariate outliers based on Mahalanobis distance of $p < .001$ (Hair et al., 2014). These 15 cases were removed from the initial sample. Three test items were highly skewed (± 2.0) (Tabachnick and Fidell, 2013, Costello and Osborne, 2005); and two items were judged not to be appropriate for an adolescent waterpipe ND instrument, including 'Do you want to quit waterpipe smoking?' (which is not usually considered to be a feature of ND, e.g., Aboaziza & Eissenberg, 2015, Piper et al., 2006) and was conceptualized in our study as a consequence of dependence and therefore analyzed as an outcome) and 'When I smoke waterpipe, I have less insomnia or trouble sleeping' (sleep difficulties are not a feature of ND among adolescents) (Ramji et al., 2018). These initial deletions left an analytic sample of 192, and 23 test items, available for testing using EFA.

3.2. Demographic and waterpipe use characteristics of the analytic sample

The mean age of the analytic sample of 192 students at Wave 2 was 14.9 years ($SD=1.4$), 54.2% were female, and 80.2% were in 9th or 10th grade. Other demographic and tobacco use characteristics are presented in Table 1.

3.3. Exploratory factor analysis (EFA)

The EFA of 23 items yielded a one factor solution (Eigenvalue > 1.0) with 13 items (named the SCTS-13) and factor loadings 0.45 for each item. Factor loadings of the 10 other items were < 0.45 and therefore excluded. Velicer's MAP test also confirmed a one factor solution. The communality values for the items ranged from 0.22 to 0.44, indicating that no items needed to be removed from the scale. The resulting SCTS-13 had high internal consistency (0.87 for both Cronbach's alpha and McDonald's Omega) and explained 91% of the total variance of the items (common variance). The mean SCTS-13 score was 9.5 ($SD= 6.6$, range = 0 to 39) at Wave 2, 9.3 ($SD=7.3$, range = 0 to 39) at Wave 3, 8.2 ($SD=5.8$, range = 0 to 39) at Wave 4, and 7.7 ($SD=5.3$, range = 0 to 39) at Wave 5.

3.4. Confirmatory factor analysis (CFA)

When applied to Wave 3 data, the 13-item solution demonstrated adequate model fit on most CFA indices including chi-square and degree of freedom ratio = 2.28: 1 (recommended value < 3:1), SRMR = 0.06 (recommended adequate fit = 0.05 – 0.08), RMSEA = 0.08 (90% $CI= .07, .10$) (recommended adequate fit = 0.05 – 0.10), CFI = 0.91 (recommended value 0.90), and NNFI = 0.89 (recommended value 0.90) (Pituch and Stevens, 2016, Hooper et al., 2008).

3.5. Convergent and discriminant validity

The total score of the SCTS-13 showed moderate positive correlations with the LWDS-10J (Pearson $r= 0.75$) and HONC (Pearson $r= 0.58$), establishing its convergent validity. Likewise, the SCTS-13 was minimally and positively correlated with the DSS (Pearson $r= 0.32$) and ALES (Pearson $r= 0.25$), establishing its discriminant validity.

3.6. Concurrent and predictive validity

As shown in Table 3, higher scores on the SCTS-13 predicted both current WTS and dual (waterpipe and cigarette) use. A one standard deviation increase in SCTS-13 score (roughly a 7 point increase on the 39 point scale) was associated with more than three-fold greater odds of current WTS and dual smoking (vs. no tobacco use) at Wave 3. Similar associations were observed at Waves 4 and 5, with the exception that the SCTS-13 did not predict dual smoking at Wave 5.

Higher SCTS-13 scores were associated with nearly six-fold greater odds of perceiving oneself to be "hooked" on WTS at Wave 2 and nearly three-fold greater odds at Wave 3. Associations at Wave 5 were positive but weaker and not statistically significant.

Higher SCTS-13 scores also were associated with greater intensity of WTS including two- to three-fold greater odds of smoking at least weekly vs. less than weekly at all waves. SCTS-13 score was associated with smoking a greater number of waterpipes in the past

month, ranging from 18% more at Wave 4 to 42% more at Wave 2. At waves 2 and 3, a higher SCTS-13 score was associated with greater average duration of the session and higher odds of having increased the frequency of smoking over the past 6 months.

The SCTS-13 also predicted quitting behavior, including 43% reduced odds of wanting to quit WTS at Wave 2 and 46% reduced odds at Wave 3. SCTS-13 score did not predict whether a quit attempt was made in the past 6 months, but among those who made a quit attempt in the past 6 months, it predicted shorter duration of abstinence at Waves 2, 3, and 4, ranging from 17% to 29% fewer days at Waves 2–4.

A higher SCTS-13 score also was associated with greater likelihood of smoking alone (vs. with others) at all waves, ranging from 61% increased odds at Wave 2 to 248% greater odds at Wave 3.

4. Discussion

This paper reports the psychometric evaluation of a WTS-specific ND instrument among adolescents. The SCTS-13 was derived using an iterative, theory-driven process involving a review of theoretical concepts and models of ND from the cigarette and waterpipe literatures, item development based on qualitative and quantitative studies with waterpipe smokers and expert consensus, and, finally, psychometric testing. It has several desirable practical and psychometric properties, including using a self-report format, being brief, capturing important features of ND development before WTS has become firmly established, being internally consistent, having a stable factor structure over time, and predicting important tobacco-related outcomes.

The SCTS-13 captures unique social and sensory aspects of WTS that appear to be central to the development of ND, consistent with cognitive and social learning models of ND (Brandon et al., 2004) but which are emphasized to a lesser extent in other instruments. The SCTS-13 assesses having a preponderance of friends who smoke, usually smoking with friends in cafes/restaurants, and finding it difficult not to smoke in a social situation. The social nature of WTS provides ample opportunity for its use to become established and to escalate; greater WTS smoking frequency and session length are linked to ND symptoms among adolescents (Bahelah et al., 2017). Reporting difficulty refraining from WTS while in a restaurant was the strongest predictor of progression of ND symptoms in the WDLY cohort (Bahelah et al., 2019). Likewise, the SCTS-13 captures sensory aspects of WTS (sight or smell eliciting a desire to smoke), reflecting associative processes known to reinforce tobacco use (Brandon et al., 2004) and to trigger craving (Bahelah et al., 2016a).

The SCTS-13 also captures positive (Glautier, 2004) and negative reinforcement (Eissenberg, 2004) features of ND, and impaired control, codified in ICD-10 dependence criteria (World Health Organization, 2004). These ND features include feeling happy, energetic, and using WTS as a reward (positive reinforcement), smoking for relief of withdrawal symptoms such as sadness and irritability (negative reinforcement), difficulty refusing WTS, trouble not smoking in a restaurant or café, and persisting in WTS even if the cost doubled or one's health was in jeopardy (indicative of impaired control). Continuing to

engage in WTS despite increased cost indicates a relative financial inelasticity, which is common in substance abuse, including tobacco (Jawad et al., 2018b) and reflects a willingness to engage in behavioral adaptation to ensure access to waterpipe, since increased price reduces one's ability to engage in other reinforcing activities. Behavioral adaptation to ensure access to WTS has been shown to be a feature of ND among established, adult waterpipe smokers (Aboaziza and Eissenberg, 2015, Maziak et al., 2004, 2005).

The SCTS-13 showed good predictive validity with a variety of important outcomes assessed as much as 1.5 years later. Those scoring higher on the SCTS-13 were more likely to continue WTS at follow-up and to transition to dual WTS/cigarette use. Other studies have reported that WTS predicts the initiation and progression of cigarette smoking (Jensen et al., 2010, Mzayek et al., 2011). Our study adds to this literature by indicating that ND is a driver of this transition.

Higher scores on the SCTS-13 predicted perceived dependence and several indices of more extensive and chronic WTS, including smoking frequently, longer duration of sessions, and having increased the frequency of WTS during the past six months. The SCTS-13 also predicted smoking alone (vs. socially), consistent with the notion that transitioning from social to individual WTS is a symptom of ND (Maziak et al., 2004, 2005). Those who scored higher on the SCTS-13 were less interested and successful in quitting as indicated by greater likelihood of currently smoking even 1.5 years later, and shorter duration of abstinence for those who tried to quit. These results suggest that the SCTS-13 may be useful to determine risk of accelerating tobacco use and for targeting those most in need of cessation intervention.

We hypothesized that a multidimensional factor structure would be produced that captured all or most of the 28 items, representing broad coverage of dependence domains, consistent with other ND instruments for both cigarettes (Heatherton et al., 1991, Piper et al., 2004) and WTS (Salameh et al., 2004). Instead, we obtained a single factor solution made up of just 13 items. Although only 13 of the 28 items loaded on the factor, coverage of dependence domains was fairly broad, as described above, including items that tapped positively and negatively reinforcing features, impaired control, behavioral adaptation, and social/sensory cues. A single factor solution may reflect the relatively short WTS histories of youth in the WDLY, resulting in insufficient time to develop differential dependence-related responses, as is seen in established adult smokers. Alternately, it is possible that the single factor solution is due to sample size or response choice limitations (discussed in more detail below).

This study has several limitations. First, using only three response choices limited variability and may have obscured a multi-factor solution (Leung, 2011). Second, we did not have access to a different sample to verify the robustness of the factor structure. Both these concerns are alleviated somewhat by replication of the factor structure in a later wave, but testing in other samples is needed. Third, the sample size was relatively small, although it met minimum requirements to validly perform an EFA (Tabachnick and Fidell, 2013, Costello and Osborne, 2005, Pituch and Stevens, 2016). A larger sample size may provide a better test of optimal model fit. Numerous validity outcomes were analyzed to broadly examine the SCTS-13's predictive validity, which increases the possibility of Type I error. Thus,

some statistically significant outcomes may be spurious, but the overall pattern of results demonstrates that the instrument is able to predict a variety of important tobacco-related outcomes. Finally, the sample for this study was adolescents recruited from Lebanon and generalizability to other countries and age groups is not known.

5. Conclusion

The SCTS-13 is the first waterpipe-specific ND instrument that captures important features of ND development including reinforcing symptoms, social and sensory cues, markers of impaired control, and behavioral adaptation. The SCTS-13 showed excellent internal consistency, stable factor structure, and ability to predict several important tobacco-related outcomes. If results are verified in other samples, the SCTS-13 may be a useful instrument for research purposes and to help clinicians assess and intervene on ND among waterpipe smokers.

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Appendix A:: List of 28 test items (Items 1–13 comprise the final SCTS-13)

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1. Most of my friends smoke waterpipe
 2. Just the sight or smell of waterpipe is enough to make me want to smoke
 3. Even if I was sure that waterpipe is not good for my health, I would still smoke as often
 4. Smoking waterpipe makes me feel happy
 5. Smoking waterpipe makes me feel energetic
 6. If the cost of waterpipe smoking doubled, I would still smoke as often
 7. When I smoke waterpipe, I feel less sad, blue, or depressed
 8. It would be very difficult for me to be in a restaurant, and not smoke waterpipe
 9. Smoking waterpipe is a good way to reward myself
 10. It would be difficult for me to refuse an invitation to smoke waterpipe
 11. I smoke waterpipe usually with friends or in cafés/restaurants
 12. If my waterpipe smoking session was to get interrupted, I would be annoyed
 13. When I smoke waterpipe, I feel less irritable, frustrated, or angry
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14. I enjoy blowing waterpipe smoke from my mouth and nose and the feeling of inhaling waterpipe smoke into my mouth and lungs
 15. I am confident that I can quit smoking waterpipe anytime I want
 16. Smoking waterpipe makes me feel sociable
 17. If I was with someone who objected to my waterpipe smoking, I would smoke it anyway
 18. My favorite waterpipe is the one I smoke after having gone an extended period without smoking it
 19. I always make sure I have an adequate supply of waterpipe materials (tobacco, coal, foil, etc.)
 20. Smoking waterpipe helps me to concentrate
 21. If I could not smoke waterpipe for a while, I would have difficulty concentrating

22. I usually allocate a special time of the day for smoking waterpipe
23. If I could not smoke waterpipe for a while, I would feel an urge or craving to smoke
24. I spend too much money on waterpipe
25. I want to quit smoking waterpipe
26. I have family or friends who would like me to quit smoking waterpipe
27. When I smoke waterpipe, I have less insomnia or trouble sleeping
28. When I smoke waterpipe I usually share it with others

* Response choices: not true (0), somewhat true (1), and true (2).

* The first 13 items constitute the SCTS-13

Appendix B:: Outcome measures

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- a. Current smoking status: Based on responses to questions 'Have you smoked a waterpipe in the past month?' and 'Have you smoked a cigarette in the past month?' (yes/no), each participant was classified at each wave as a non-tobacco use ("no" to both waterpipe and cigarettes), a current exclusive waterpipe smoker ("yes" to waterpipe, "no" to cigarettes), or a current dual smoker ("yes" to both waterpipe and cigarettes). Dual use was examined separately from waterpipe only use since transitioning to multiple tobacco products may be a consequence of ND (Aboaziza and Eissenberg, 2015). There were too few exclusive cigarette smokers at most waves for analysis.
 - b. Perceived addiction: By asking current smokers 'In your opinion, how hooked are you on smoking waterpipe' with response choices "Not at all," "Somewhat hooked," or "Very hooked." This variable correlates positively with frequency of WTS (Maziak et al., 2004, 2005). For analyses, this variable was dichotomized as "Not hooked" vs. "Hooked" (by collapsing "Somewhat hooked" and "Very hooked" since few participants reported being "very hooked"). Due to an administration error, this item was collected on only a minority of participants during Wave 4 and is not reported for that wave in this study.
 - c. Intensity of smoking: This was assessed among current smokers using four items: (1) Average duration of sessions was assessed by asking 'What is the average time you usually spend during a waterpipe smoking session?' (< 30 minutes, 30–60 minutes, or > 60 minutes). (2) Frequency of smoking was assessed by asking 'What best describes your waterpipe smoking during the past month (30 days)?,' with response choices "Smoked less than once a week," "Smoked at least once a week but not every day," and "Smoked every day or almost every day." For analyses, response choices were dichotomized as "less than once per week" vs. "at least once per week." (3) Number of waterpipes smoked was assessed by asking 'During the past month, how many waterpipes did you smoke approximately?' Respondents provided a whole number. (4) Change in smoking frequency in the past 6 months was assessed by asking 'Over the past 6 months, would you say your frequency of waterpipe smoking has increased, stayed the same or decreased?' Respondents also could indicate that they smoked waterpipe for less than six months. For analyses, responses were dichotomized as "Increased" vs. "Did not increase" (Stayed the same or decreased). For this particular item, at each wave, current (past month) smokers who had not smoked for the entire 6 month period since the previous wave were excluded from analysis.
 - d. Interest and success in quitting: Three measures were collected: (1) Wanting to quit was assessed by asking 'Do you want to quit waterpipe smoking?' (yes, no). (2) Making a quit attempt was assessed by asking 'During the past 6 months, have you attempted to quit waterpipe smoking?' (yes, no). (3) Success at quitting was assessed by asking 'What was the longest period of abstinence during the past 6 months' (expressed in days).
 - e. Smoking alone (vs. socially) was assessed by asking 'Do you smoke waterpipe alone?' (yes, no).
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Highlights

- The SCTS-13 is the first waterpipe-specific nicotine dependence scale
- It has a stable factor structure and good reliability and convergent, discriminant, concurrent, and predictive validity.
- The instrument captures several important features of dependence including positive reinforcement, negative reinforcement, and social/sensory-related cues, and impaired control.
- The SCTS-13 is a promising brief, self-report instrument to assess nicotine dependence among waterpipe smokers.

Table 1

Sociodemographic and waterpipe use characteristics of the analytic sample at Wave 2 (n=192).

Variables	n (%)
Age	
12	1 (0.5)
13	18 (9.4)
14	56 (29.2)
15	66 (34.4)
16	30 (15.6)
17	8 (4.2)
18–21	13 (6.7)
Mean (<i>SD</i>)	14.9 (1.4)
Gender (n, % male)	88 (45.8)
Class attended	
8 th grade	20 (10.4)
9 th grade	93 (48.4)
10 th grade	61 (31.8)
11 th grade	3 (1.6)
12 th grade	-
Professional/technical/Vocational	9 (4.7)
Others	6 (3.1)
Do you want to quit waterpipe smoking? (% yes)	65 (34.2)
During the past 6 months, have you attempted to quit waterpipe smoking? (% yes)	61 (31.9)
Have you smoked a waterpipe (hookah, argghile, shisha) in the last 30 days? (% yes)	192 (100.0)
In your opinion, how hooked are you on smoking waterpipe?	
Not hooked	84 (45.2)
Hooked	102 (54.8)
Do you smoke waterpipe alone? (%yes)	33 (17.3)
What is the average time you usually spent during a waterpipe smoking session?	
< 30 minutes	84 (44.4)
30–60 minutes	73 (38.6)
> 60 minutes	32 (16.9)
What best describes your waterpipe smoking in the past 30 days?	
< once a week	88 (46.6)
At least once a week but not everyday	59 (21.2)
Smoked almost everyday	42 (22.2)
Over the past 6 months, would you say your frequency of waterpipe smoking increased, stayed the same or decreased?has	
Stayed the same	106 (55.8)
Increased	48 (25.3)
Decreased	36 (18.9)
During the past month (30 days) how many waterpipe did you smoke approximately? [Mean(<i>SD</i>)]	10.7 (17.8)
What was the longest period of abstinence from waterpipe smoking in days? [Mean (<i>SD</i>)]	42.5 (67.7)

* The analytic sample consisted of participants who currently smoked waterpipe only (not cigarettes) at Wave 2.

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Table 2

Factor loading and communality for the SCTS-13.

Items	Factor loading	Communality
Most of my friends smoke waterpipe	0.66	0.44
Just the sight or smell of waterpipe is enough to make me want to smoke	0.64	0.42
Even if I was sure that waterpipe is not good for my health, I would still smoke as often	0.64	0.41
Smoking waterpipe makes me feel happy	0.58	0.34
Smoking waterpipe makes me feel energetic	0.62	0.38
If the cost of waterpipe smoking doubled, I would still smoke as often	0.62	0.39
When I smoke waterpipe, I feel less sad, blue, or depressed	0.59	0.35
It would be very difficult to me to be in a restaurant, and not smoke waterpipe	0.57	0.33
Smoking waterpipe is a good way to reward myself	0.56	0.31
It would be difficult for me to refuse an invitation to smoke waterpipe	0.55	0.30
I smoke waterpipe usually with friends or in cafes/restaurants	0.52	0.27
If my waterpipe smoking session was to get interrupted, I would be annoyed	0.51	0.26
When I smoke waterpipe, I feel less irritable, frustrated, or angry	0.47	0.22
Internal consistency (Cronbach's alpha)	0.87	
Internal consistency (McDonald's omega)	0.87	
Total variance explained	91%	

Table 3

Results from bivariate and multinomial logistic and OLS linear regression models, regressing SCTS-13 score at Wave 2 on outcomes at Wave 2 (concurrent validity) and Waves 3–5 (predictive validity).

Logistic regression analyses for categorical outcome variables				
Wave (N)	OR	95% CI	p	B (SE)
What is your current smoking status?				
Wave 3 (N=190)				
No tobacco use (ref) (n = 36)	ref	ref	ref	ref
Current waterpipe only (n = 132)	3.70	2.08, 6.57	.001	1.31 (.29)
Current dual (waterpipe & cigarette) (n = 15)	3.49	1.64, 7.46	.001	1.25 (.38)
Wave 4 (N=178)				
No tobacco use (ref) (n = 38)	ref	ref	ref	ref
Current waterpipe only (n = 116)	3.05	1.82, 5.13	.001	1.12 (.26)
Current dual (waterpipe & cigarette) (n = 19)	2.22	1.13, 4.37	.021	.80 (.34)
Wave 5 (N=141)				
No tobacco use (ref) (n = 32)	ref	ref	ref	ref
Current waterpipe only (n = 90)	2.60	1.51, 4.47	.001	.95 (.27)
Current dual (waterpipe & cigarette) (n = 16)	1.78	.86, 3.69	.119	.58 (.37)
How hooked are you on smoking waterpipe? ²				
(ref = not hooked)				
Wave 2 (N=186)				
Hooked (n = 102)	5.78	3.42, 9.76	.001	1.75 (.26)
Wave 3 (N=132)				
Hooked (n = 86)	3.59	2.09, 6.16	.001	1.27 (.27)
Wave 5 (N=90)				
Hooked (n = 37)	1.25	.81, 1.94	.318	.22 (.22)
What is the average time you usually spend during a waterpipe smoking session?				
(ref = <30 minutes)				
Wave 2 (N=189)				
30–60 minutes (n = 73)	2.17	1.47, 3.19	.001	.77 (.19)
>60 minutes (n = 32)	4.16	2.50, 6.91	.001	1.42 (.26)
Wave 3 (N=132)				
30–60 minutes (n = 74)	2.17	1.32, 3.56	.002	.77 (.25)
>60 minutes (n = 21)	3.41	1.80, 6.46	.001	1.23 (.32)
Wave 4 (N=116)				
30–60 minutes (n = 72)	1.22	.71, 2.11	.470	.20 (.28)
>60 minutes (n = 26)	1.37	.73, 2.57	.324	.32 (.32)
Wave 5 (N=90)				
30–60 minutes (n = 43)	1.60	.78, 3.29	.203	.47 (.37)
>60 minutes (n = 34)	1.82	.86, 3.81	.114	.60 (.38)
What best describe WP smoking in the past 30 days?				
(ref = Less than once a week)				

Logistic regression analyses for categorical outcome variables				
Wave (N)	OR	95% CI	p	B (SE)
Wave 2 (N=187)				
At least once per week (n = 42)	3.06	2.03, 4.61	.001	1.12 (.21)
Wave 3 (N=131)				
At least once per week (n = 39)	2.70	1.73, 4.22	.001	.99 (.23)
Wave 4 (N=114)				
At least once per week (n = 49)	2.12	1.37, 3.28	.001	.75 (.22)
Wave 5 (N=87)				
At least once per week (n = 74)	2.30	1.07, 4.92	.032	.83 (.39)
Over the past 6 months, would you say your frequency of waterpipe smoking has increased, stayed the same or decreased? (ref = Did not increase)				
Wave 2 (N=185)				
Increased (n = 48)	1.88	1.33, 2.64	.001	.63 (.17)
Wave 3 (N=131)				
Increased (n = 51)	1.51	1.05, 2.16	.026	.41 (.18)
Wave 4 (N=116)				
Increased (n = 38)	.98	.66, 1.46	.920	-.02 (.20)
Wave 5 (N=90)				
Increased (n = 41)	1.44	.92, 2.24	.107	.36 (.23)
Do you want to quit waterpipe smoking? (ref = No)				
Wave 2 (N=190)				
Yes (n = 65)	.57	.40, .80	.001	-.56 (.17)
Wave 3 (N=132)				
Yes (n = 43)	.54	.36, .82	.004	-.61 (.21)
Wave 4 (N=116)				
Yes (n = 15)	.74	.42, 1.33	.320	-.29 (.30)
Wave 5 (N=90)				
Yes (n = 15)	.82	.45, 1.48	.505	-.20 (.30)
During the past 6 months, have you attempted to quit waterpipe smoking? (ref = No)				
Wave 2 (N=191)				
Yes (n = 61)	.93	.68, 1.26	.629	-.07 (.15)
Wave 3 (N=132)				
Yes (n = 45)	.78	.54, 1.13	.187	-.25 (.19)
Wave 4 (N=116)				
Yes (n = 13)	1.82	.99, 3.33	.051	.60 (.31)
Wave 5 (N=90)				
Yes (n = 15)	.96	.54, 1.71	.894	-.04 (.29)
Do you smoke waterpipe alone? (ref = No)				
Wave 2 (N=191)				

Logistic regression analyses for categorical outcome variables				
Wave (N)	OR	95% CI	p	B (SE)
Yes (n = 330)	1.61	1.11, 2.34	.011	.48 (.19)
Wave 3 (N=132)				
Yes (n = 30)	2.48	1.57, 3.91	.001	.91 (.23)
Wave 4 (N=135)				
Yes (n = 23)	1.88	1.17, 3.04	.009	.63 (.24)
Wave 5 (N=90)				
Yes (n = 12)	2.26	1.17, 4.35	.015	.81 (.33)
Linear regression analyses for continuous outcome variables ³				
Wave	e ^B *	95% CI	t-value	p
During the past month (30 days) how many waterpipe did you smoke approximately?				
Wave 2 (N=188)	1.42	1.31, 1.53	9.14	.001
Wave 3 (N=132)	1.34	1.21, 1.47	5.46	.001
Wave 4 (N=115)	1.18	1.09, 1.28	3.94	.001
Wave 5 (N=87)	1.22	1.11, 1.35	3.78	.001
What was the longest period of abstinence from waterpipe smoking in days?				
Wave 2 (N=60)	.83	.73, .93	-3.26	.002
Wave 3 (N=116)	.73	.54, 1.00	-1.90	.059
Wave 4 (N=15)	.71	.55, .91	-2.62	.021
Wave 5 (N=14)	.93	.65, 1.32	-.38	.714

B(SE): OLS regression coefficient and its standard error;

¹ SCTS-13 total score was standardized at Wave 2 in regression models.

² Due to an administration error, the item 'How hooked are you on waterpipe smoking?' was assessed only among a minority of participants and is not reported here.

³ beta coefficient for continuous outcome is exponentiated using anti-log and has been denoted as 'e^B', or simply the odds ratios; the t-value and associated tail significance are from the OLS regression estimates.