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**Original Investigation**

# Measuring Nicotine Dependence Among Adolescent and Young Adult Cigarillo Users

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## Abstract

**Introduction:** Current measures of nicotine dependence (ND) were developed and validated for cigarette smokers only, limiting their utility for other combustible tobacco users. This study evaluates the psychometric properties of a pool of new and adapted items to measure ND among cigarillo and multiple tobacco product users.

**Aims and Methods:** Items were drawn from the PROMIS Nicotine Dependence Item Bank which were adapted to be product neutral and new items were developed from a qualitative study of 60 adolescent and young adult cigarillo smokers. A total of 42 ND items were included in a web-based survey. Eligible participants were 14–28 year olds who smoked a minimum of 2 cigarillos per week. Analyses included confirmatory factor analysis, item response theory analysis, analysis of differential item functioning, and reliability. Ordinary least square regression was used to test the association of ND score with deciles of nicotine consumption.

**Results:** Among the 1089 participants, the median number of cigarillos smoked per week was 20; 54% of participants also smoked cigarettes. All PROMIS items and 8 of 10 new items met the item response theory fit criteria. Two PROMIS items had nonignorable differential item functioning. The pool of 40 items had good score reliability for a range of 2 SDs. Twenty-, eight-, and four-item short forms showed similarly good measurement properties; each was positively associated with decile of nicotine consumption, $p < .001$; $R^2 = 0.33$.

**Conclusions:** This adapted bank of ND items is psychometrically sound and includes items that are product neutral, making it suitable for assessing ND among cigarillo and polytobacco users.

**Implications:** This study rigorously evaluates adapted items to measure ND among cigarillo and polytobacco users and reports the reliability initial evidence of validity of short form scores.

## Introduction

Nicotine dependence (ND) is a core construct for understanding patterns of tobacco use and informing the development and implementation of smoking cessation interventions. ND is characterized by cravings for tobacco, compulsive use, tolerance, and withdrawal symptoms upon cessation, and is typically measured along a continuum of self-reported symptoms.[1] Over the past four decades, many measures of ND have been developed and extensively tested. Early efforts, such as the Fagerström Tolerance Questionnaire (FTQ),[2] were criticized for not representing the diversity of features that characterize ND or not reflecting the diagnostic criteria for ND.[3,4] Subsequent measures, such as the Nicotine Dependence Syndrome Scale (NDSS)[4] and the Wisconsin Inventory of Smoking Dependence Motives (WISDM),[5] were designed to capture this diversity of features, and are psychometrically stronger than the FTQ; however, their length makes them impractical in many clinical or research settings where time is limited.[6] More recently, the PROMIS Nicotine Dependence item bank identified the best performing items across a pool of 277 items, and used item response modeling to derive a measure for cigarette users. The measure consists of 32 items; 22 common items and 5 items each that are specific for daily smokers and nondaily cigarette smokers.[6] Measurement properties of a 20-, 8-, and 4-item short forms show good reliability among cigarette smokers. Work to validate the measure has focused on adults and individuals with chronic diseases[7]; and a Spanish version has also been developed.[8]

The PROMIS Nicotine Dependence item bank and the main measures from which the items were drawn[4,5,9] were constructed to assess ND symptoms associated with cigarette use. In their current form, these items cannot be used to assess ND for non-cigarette tobacco products. The sale of cigar products has increased over the past two decades and while cigarette use has declined, use of cigars has held steady or increased in some demographic groups,[10–12] especially among adolescents and young adults.[13,14] Cigarillos have the highest prevalence of use among cigar products.[15,16] The National

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Youth Tobacco Survey indicates that in 2019, among high schoolers, e-cigarettes were the most commonly used (27.5%) tobacco product, followed by cigars (7.6%), cigarettes (5.8%), smokeless tobacco (4.8%), hookahs (3.4%), and pipe tobacco (1.1%).[17] Cigarillos are attractive to youth in part because they are available in a variety of flavors, can be purchased as a single stick and are inexpensive. Studies have also confirmed that cigarillos deliver amounts of nicotine capable of initiating or sustaining dependence, along with carbon monoxide and other toxicants that are detrimental to health.[18,19] Further, a growing body of research suggests that cigarillo users have behavioral patterns of use that substantially differ from those of cigarette-only users.[20–22] Recent studies indicate that cigarillo users engage in polytobacco use, defined as the use of two or more tobacco products. About 70% of cigarillo users[23,24] and 35% of tobacco users overall engage in this practice.[25,26] Measures of ND rely on self-report of dependence symptoms, which are grounded in the smoking patterns, beliefs, and practices of the tobacco users. Establishing a measure of ND that is valid and reliable for cigarillo and polytobacco users can inform regulation of these products and communication strategies about their harm and would be of great benefit in addressing tobacco control. Research toward this goal has included evaluation of measures of ND drawing items from different sources and tested among users of a range of tobacco products, including cigars.[19,26–30] Findings to date show an ability to use these sets of items to measure ND across varied tobacco product use and evidence of validity with demonstration of predictive associations of ND scores with reported frequency and quantity of tobacco use.[28,30] Additional study is needed to examine measures among youth and young adults, as most of this work to date has focused on adults, and to address the limited range of the measures, particularly for lower levels of ND which may be important for individuals who are not daily tobacco users, youth and those who smoke cigarillos.

The purpose of this study is to evaluate items to measure ND among adolescent and young adult cigarillo and polytobacco product users. The item pool draws on two sources: the PROMIS ND measure for which items were adapted to be product neutral; and items generated from the findings of a qualitative study of 60 young adult and adolescent cigarillo smokers that examined patterns of cigarillo smoking and experiences of smoking and addiction. The current study evaluates the psychometric properties of the set of new and adapted items to measure ND and evaluates item performance for subgroups by age, sex, race, and multiple tobacco use and the association with nicotine consumption as an indicator of validity.

## Methods

### Study Design and Sample Recruitment

This cross-sectional study invited 14–28 year olds that reported smoking 2 or more cigarillos per week to complete a web-based survey. Participants were recruited using advertisements on Facebook, Instagram, and Twitter social media platforms. Advertisements were geographically targeted to ten metropolitan areas with high levels of youth cigar product use[31] and included Baltimore, MD; Broward County (Ft. Lauderdale), FL; DeKalb County (Atlanta), GA; Detroit, MI; Duval County (Jacksonville), FL; Fort Worth, TX; Houston, TX; Philadelphia, PA; Washington, DC; and Cuyahoga County (Cleveland), OH. Details of the study recruitment are reported elsewhere.[32] Briefly, individuals completed a screening survey to determine eligibility and those that met eligibility criteria were invited to complete the survey. Up to three reminders were sent to those who had not yet completed the survey and respondents who submitted completed surveys were remunerated with a $15 gift card. The survey was designed and administered using Qualtrics survey software (Qualtrics, 2018) and could be completed via smart phone or computer. Instructions and survey items were written at a sixth grade literacy level and the survey took about 30 minutes to complete. A total of 1089 individuals completed the survey. A subsample of participants was invited to complete a survey including the ND items 1 week after the first administration to evaluate test–retest reliability. Survey data were collected from July 2017 to April 2018 and this study protocol was approved by the Institutional Review Board at Case Western Reserve University.

### Measures

#### *Tobacco Product Use*

Use of different tobacco products including tipped and untipped cigarillos, little cigars, traditional cigars, and cigarettes was assessed using a series of questions. The instructions and wording of items used to assess cigarillo, little cigar, and traditional cigar consumption were informed by prior work indicating the importance of (1) using brand-specific labels (eg, "Black & Mild")[15,33] and pictures,[34] and (2) specifying that the product was used only to consume tobacco and not for the purpose of mixing or replacing it with marijuana.[35,36]

Detailed data on the number of days per week tobacco was consumed, amount on those days, and whether these products were shared were assessed. In addition, questions asked about past 30-day use of e-cigarettes or vapes, hookah or waterpipes, bidis, kreteks or clove cigarettes, and chewing tobacco, snuff or snus. Given the prevalence of coadministration of cigarillos with marijuana (ie, blunts),[37,38] the survey instructions also specified "for the following questions, please think about your use of tobacco products, such as cigarettes, cigars, chewing tobacco, etc. for TOBACCO ONLY."

#### *Nicotine Dependence*

A total of 42 items were used to assess ND. Items were drawn from two sources. First, 32 items from the PROMIS Nicotine Dependence Item Bank (5 daily, 5 nondaily, and 22 common items)[6] were reviewed for applicability to non-cigarette users. Fourteen items that included the word "cigarette" were adapted to be tobacco product neutral by replacing the word "cigarette" with "tobacco product," "tobacco," or "smoke." Ten additional ND items were generated based on findings from qualitative interviews with 30 young adults and 30 adolescents that identified patterns of cigarillo smoking and experiences of smoking and addiction.[20,35,39] An initial set of 25 items addressed salient issues identified in qualitative analyses such as preparing to always have tobacco products on hand for when they are needed and sharing the product versus smoking the whole product by oneself. Candidate items were reviewed, refined, and pilot tested with eight participants using a cognitive interview approach of talking back through questions and responses. The final set of 10 items were included in the online survey administration, and

were formatted using the same structure and 5-point scale response options as the PROMIS items. The two response options were: 1 never, 2 rarely, 3 sometimes, 4 often, 5 always; and 1 not at all, 2 a little bit, 3 somewhat, 4 quite a bit, 5 very much. Example adapted items and new items are below.

Example adapted item:
If I quit smoking, I will experience intense cravings for tobacco products.

Example item derived from qualitative study:
I prepare so I have a tobacco product available when I need it.

### *Estimate of Nicotine Consumption*

Using data collected via a timeline follow-back method assessing use in the past week, we calculated the number of cigarillos and the number of cigarettes (if used) per week. Nicotine (NIC) consumption was then estimated using the number of cigarillos and cigarettes smoked in the past 7 days × the average grams of tobacco in each product × the average nicotine concentration in each product (mg of NIC/g of tobacco). The average grams of tobacco and nicotine concentration of each product were derived from estimates reported in the literature.[40–42] Given that comparable details were not collected across all tobacco products, and the relatively high prevalence of cigarette use among cigarillo users, nicotine concentration amounts were only calculated for cigarettes and cigarillos.

### *Participant Characteristics*

Additional measures included sex, age, and race. Participants were classified as adolescents (ages 14–20) or young adults (ages 21–28). Participant race or ethnicity was categorized as White, Black, Hispanic, and Other.

### Analysis

Descriptive statistics of all ND items and participant characteristics were generated. Evaluation of the ND items included an assessment of dimensionality of the items using confirmatory factor analysis. Model fit was evaluated using the root mean squared error of approximation (RMSEA) <0.08 and comparative fit index (CFI) >0.90. Items were then evaluated using a 2PL item response theory (IRT) model and item discrimination (*a* parameter) and difficulty (*b* parameters) were calculated. Each item was evaluated in terms of fit statistics, item curve characteristics, and local dependence. Poorly performing items were examined for content and considered for removal from the item bank.

Items were further evaluated for differential item functioning (DIF) by sex, age group, race, and cigarillo only versus cigarillo and cigarette use. DIF occurs when an item has different levels of endorsement by individuals of different groups at the same level of the attribute. DIF for the item discrimination (*a*) and difficulty (*b*) parameters was examined for the groups noted above and group differences were examined using a Wald test and $p < .01$. Items with significant DIF after adjusting for multiple testing[43] were further examined. Item curves and the weighted area between the curves (wABC) were computed; items with a wABC >0.4 were considered as having nonignorable DIF.[44]

With the final item pool, we used a 2PL IRT model to compute item parameters (*a* and *b* parameters) and report IRT-based test information, score precision across the metric and marginal reliability. The 32 PROMIS ND items were scored using the HealthMeasures Scoring Service.[45] Scores for the 20 items common to both daily and nondaily smokers and the items comprising the 8- and 4-item short forms from the original PROMIS ND measure were evaluated in parallel with previous PROMIS ND measure reports.[6] The scores are first estimated using an item response model and the IRT-calibrated scores are transformed to a *T*-score metric using a linear transformation. The PROMIS normative mean is 50 and the SD is 10 for each of the *T* scores. We compared the mean *T* scores generated for this sample to this normative mean using 1-group *t* tests. We also examined the internal consistency reliability of the 20-, 8-, and 4-item scores.

To examine the construct validity of the measure, we tested the association of the ND scores with an estimate of nicotine consumption. Nicotine consumption was coded into deciles and the association with the ND score was examined graphically and by using ordinary least squares regression (OLS). OLS was also used to test the association of a continuous measure of nicotine consumption (log transformed) and the 20-, 8-, and 4-item ND scores. To control for the effect of use of other tobacco products, a count of the number of noncigarillo and noncigarette products used in the past 30 days was included in the OLS analyses as a covariate. A subsample of 284 participants were invited to complete the ND items again 1 week after the first administration; 126 returned completed retest surveys. Test–retest reliability was estimated as an intraclass correlation coefficient (ICC), using a single-measurement, absolute-agreement, 2-way mixed-effects model. AMOS and SPSS v24 and IRTPro v4.2 were used to conduct the analyses.

## Results

Table 1 shows the characteristics of the sample. Among the 1089 participants, 47% were female, the mean age was 22.6, and 40% were White, 31% Black, 18% Hispanic, and 11% other or multiple races. The mean number of cigarillos smoked per week was 9.9 (SD = 10.3); the median was 20. The majority of the sample (86%) reported using at least one other tobacco product in the past 30 days. More than half of participants (54%) reported cigarette use and among those, the mean weekly cigarette consumption was 31.8 (SD = 41.6); the median was 17. More than one-third of the sample used e-cigarettes and/or waterpipes or hookah in the past month. Past month use of traditional and little cigars was reported by less than one-quarter of participants, and less than 10% reported using chewing tobacco or snuff or snus or other products.

The ND item pool reasonably represents a single factor RMSEA <0.80 and CFI >0.90. Using a 2PL model, 40 of the 42 items met the IRT fit criteria; two of the 10 new items did not meet the fit criteria and were dropped from further consideration. We next examined DIF for sex, age, race, and use of cigarillo only versus cigarillo + cigarette. DIF was examined using the graded response for two group IRT model with a Benjamini–Hochberg multiple testing correction with a $p < .01$ threshold, data visualization and computation of the wABC for each set of comparisons. Using a wABC of >0.4, we identified nonignorable DIF for two items: between Whites and Blacks for the item: "I smoke when I am alone" and between the younger and older age respondents for the

**Table 1.** Descriptive Characteristics of Sample ($N$ = 1089)

| | *n* | % |
|---|---|---|
| Female | 509 | 46.7 |
| Age group | | |
| Adolescent (14–20) | 250 | 23.0 |
| Young adult (21–28) | 839 | 77.0 |
| Race or ethnicity[a] | | |
| White | 436 | 40.1 |
| Black | 335 | 30.8 |
| Hispanic | 196 | 18.0 |
| Other | 120 | 11.0 |
| Cigarillo and cigarette use | | |
| Weekly cigarillo amount, mean (SD) | 9.87 (10.26) | |
| Cigarette use (% yes) | 585 | 53.7 |
| Weekly cigarette amount, mean (SD)[b] | 31.83 (41.62) | |
| Other tobacco product use (% yes) | | |
| E-cigarettes | 459 | 42.1 |
| Waterpipes or hookah | 400 | 36.7 |
| Traditional cigars | 226 | 20.8 |
| Little cigars | 207 | 19.0 |
| Chewing tobacco or snuff | 80 | 7.3 |
| Other[c] | 67 | 6.2 |

[a]Two cases missing on race; other race also includes those of multiple races.
[b]Among those who reported using cigarettes.
[c]Includes kreteks or clove cigarettes and bidis.

item "After eating I want to smoke tobacco." The details of this analysis are reported in Supplementary Table 1.

Table 2 shows the item stems and the item parameters for the 40 items retained. Items are sorted by the *a* parameter which represents the item discrimination. For example, the item "if I quit smoking I experience intense cravings" has the highest level of discrimination in this sample with $a$ = 4.01. Items generated by the study team are labeled "new" in the source column and as shown in Table 2, several of the new items fill gaps at the lower end of the ND continuum. Across the *a* parameters, there are no gaps 0.3 or greater and they range from 1.36 to 4.01. This set of 40 items has a reliability of 0.95. It is notable that the 8-item short form items (SF8) and 4-item short form items (SF4) are somewhat concentrated in the middle of the distribution of items indicating that these items provide the most test information in the middle of the ND continuum. Table 2 also reports the factor loadings ($\lambda$) from the confirmatory factor analysis for each item. The *b* parameters are shown in Supplementary Table 2.

The 20-, 8-, and 4-item short forms scored as raw scores and as normed *T* scores are shown in Table 3. Using a one sample *t* test, compared with the PROMIS normed population (mean 50, SD 10) the 20-item score in this sample (mean = 40.7, SD 11.4) was significantly lower, $p < .001$. Also shown in Table 3, similar patterns are observed for the 8- and 4-item scores. Each of the short forms had very good internal consistency reliability. The test–retest reliability ICC estimate was 0.90 (95% CI = 0.86, 0.93) for the 40 items, indicating excellent reliability. Time 1 ND scores did not differ between those invited to complete the test–retest survey and completed it (mean = 105.03, SD = 40.43) versus those invited who did not complete the test–retest survey ($M$ = 103.25, SD = 41.14), $t$ = 0.37, $p$ = .71.

Finally, as shown in the box and whisker plot in Figure 1, the 20-item ND score was positively associated with decile of nicotine consumption. Examining each ND measure as a predictor of the measure of nicotine consumption, and controlling for the number of noncigarillo and noncigarette products used: the 40-item score explained 40% of the variance in nicotine consumption ($R^2$ = 0.40) and the 20-item score explained 36% of variance in nicotine consumption ($R^2$ = 0.36). The 8- and 4-item short form scores show a similar pattern of association and the measure of nicotine consumption explained the same amount of variance, $R^2$ = 0.33.

## Discussion

The findings from this study of cigarillo users, among whom 86% reported using another tobacco product, indicate that the adapted pool of ND items is psychometrically sound, demonstrating acceptable item fit, and very good internal consistency reliability and 1-week test–retest reliability. In this sample, the full set of items and subsequent short forms (20-, 8-, and 4-item) have a monotonic, positive, and significant association with decile of nicotine consumption for cigarillos and cigarettes, providing initial evidence for the validity of the adapted measure in this population. We conclude that the items evaluated are relevant, reliable, and have initial evidence of validity to measure ND among cigarillo and polytobacco users.

Several findings from our evaluation of the measure are worth noting. While all of the original items from the PROMIS ND measure were free from DIF by age, sex, and race for the normative sample,[6] two items had nonignorable DIF for subgroups examined in this study. This means that the precision of the scores including these items may be biased for these subgroups. Those two items should be tested further before making a decision about their utility to measure ND for cigarillo and polytobacco users; if DIF persists, using weighted scoring approaches for these items may be needed.

Prior to survey development our team conducted qualitative studies to deepen understanding of common behavioral patterns and perceptions of addiction among cigarillo users.[20,35,39] This work informed 10 new survey items tested along with the adapted PROMIS items. Eight of these 10 items met the fit criteria and contributed to the overall measure. In particular, they helped fill in the gaps in items at the low end of the ND continuum. These items may prove useful and appropriate for studies that include individuals with low levels of tobacco consumption and lower levels of ND. Additional testing of these items alongside the adapted PROMIS items and across tobacco user groups will further inform their utility.

It is important to acknowledge that the sample for this study was substantially different from the PROMIS normative sample in three ways: (1) it was focused on cigarillo users rather than cigarette users, (2) the mean age was 22.6 (SD 2.9) compared with 46.3 (SD 11.6) in the PROMIS sample, and (3) 60% of the sample was non-white compared with 28% of the PROMIS sample.[46] These differences are important as we consider the interpretation of the ND scores normed to the PROMIS data. The comparison of the 20-, 8-, and 4-item ND scores to the PROMIS normed group reveals that the average scores for our cigarillo using sample are lower than the

**Table 2.** Item Performance

| Item | Source[a] and score | *a* | s.e. | | *λ* |
|---|---|---|---|---|---|
| If I quit smoking, I will experience intense cravings for tobacco products. | Nondaily | 4.01 | 0.19 | b,c | .880 |
| When I go without smoking for a few hours, I experience craving. | SF20 | 3.87 | 0.18 | b,c | .873 |
| When I go too long without smoking tobacco, I feel impatient. | SF20 | 3.74 | 0.18 | c | .868 |
| When I run out of tobacco products, I find it almost unbearable. | SF20 | 3.55 | 0.17 | c | .852 |
| It is hard for me to go without smoking for a whole day. | Daily and nondaily | 3.35 | 0.16 | b | .858 |
| My urges to smoke keep getting stronger if I don't smoke. | SF20 \| SF8 | 3.34 | 0.15 | b | .847 |
| When I go too long without smoking tobacco, I get strong urges that are hard to get rid of. | SF20 | 3.32 | 0.15 | c | .845 |
| I frequently crave tobacco. | SF20 | 3.30 | 0.15 | b,c | .857 |
| When I haven't been able to smoke for a few hours, the craving gets intolerable. | SF20 \| SF8 \| SF4 | 3.28 | 0.16 | | .829 |
| My desire to smoke seems overpowering. | SF20 | 3.25 | 0.16 | b | .834 |
| The idea of not having any tobacco products causes me stress. | SF20 | 3.19 | 0.15 | b,c | .836 |
| It is hard to ignore urges to smoke. | SF20 | 3.18 | 0.15 | b | .842 |
| Smoking is a large part of my daily life. | SF20 | 3.12 | 0.15 | b | .838 |
| Cravings to smoke make it difficult for me to quit. | SF20 | 3.08 | 0.15 | b,c | .835 |
| After not smoking for a while, I need to smoke in order to avoid feeling any discomfort. | SF20 \| SF8 | 2.95 | 0.14 | | .816 |
| I feel anxious when I run out of tobacco products. | New | 2.70 | 0.13 | | .797 |
| I get a real gnawing hunger for tobacco products when I haven't smoked in a while. | SF20 | 2.68 | 0.12 | c | .804 |
| I get irritated if I can't smoke a tobacco product when I feel like smoking one. | New | 2.57 | 0.12 | | .784 |
| When I'm really craving tobacco, it feels like I'm in the grip of some unknown force that I cannot control. | SF20 \| SF8 | 2.54 | 0.13 | c | .773 |
| I would go crazy if I couldn't smoke. | Nondaily | 2.50 | 0.12 | b | .772 |
| I drop everything to go out and buy tobacco products. | SF20 \| SF8 \| SF4 | 2.42 | 0.13 | c | .739 |
| I am tempted to smoke when I realize I haven't smoked for a while. | SF20 | 2.27 | 0.11 | | .752 |
| I smoke more before going into a situation where smoking is not allowed. | SF20 \| SF8 \| SF4 | 2.26 | 0.11 | | .755 |
| I feel like I smoke all the time. | Nondaily | 2.17 | 0.11 | b | .741 |
| I have cravings to smoke at certain times of day. | SF20 \| SF8 | 2.09 | 0.10 | b,c | .731 |
| The thought of never smoking again is overwhelming. | Daily | 1.99 | 0.10 | b | .710 |
| I find myself reaching for tobacco products without thinking about it. | SF20 \| SF8\| SF4 | 1.97 | 0.10 | c | .715 |
| I smoke even when I am so ill that I am in bed most of the day. | SF20 | 1.97 | 0.11 | | .685 |
| I become more addicted the more I smoke. | Nondaily | 1.96 | 0.10 | b | .703 |
| The only thing that can calm me down is a tobacco product. | New | 1.94 | 0.10 | | .703 |
| After eating I want to smoke tobacco. | Daily | 1.91 | 0.10 | c | .709 |
| My life is full of reminders to smoke. | Nondaily | 1.85 | 0.10 | b | .684 |
| I think about how I will get my next tobacco product. | New | 1.76 | 0.09 | | .668 |
| I plan ahead to have tobacco products available when I need them. | New | 1.71 | 0.09 | | .666 |
| I prepare so I have a tobacco product available when I need it. | New | 1.58 | 0.09 | | .621 |
| I keep a couple of tobacco products on hand. | New | 1.52 | 0.08 | | .615 |

**Table 2.** Continued

| Item | Source[a] and score | *a* | s.e. | λ |
|---|---|---|---|---|
| I chain smoke tobacco products. | New | 1.50 | 0.08 | .615 |
| I am tempted to smoke when I am driving. | Daily | 1.40 | 0.08 | .583 |
| I am tempted to smoke when I am happy. | Daily | 1.37 | 0.08 | .571 |
| I smoke when I am alone. | Daily | 1.36 | 0.08 | .562 |

*a* = slope, CFI = comparative fit index, s.e. = standard error, λ = CFI factor loading.
[a]Item source: new items were derived from qualitative study; all other items are from PROMIS ND item bank. The items that contribute to the 20-item score, and to the 8- and 4-item short forms are noted (ie, SF20, SF8, and SF4). Remaining PROMIS items are not included in the summary scores.
[b]Item response format: 1 not at all, 2 a little bit, 3 somewhat, 4 quite a bit, 5 very much. The remaining items used this response format: 1 never, 2 rarely, 3 sometimes, 4 often, and 5 always.
[c]Item wording modified by replacing "cigarette" with "tobacco product," "tobacco," or "smoking," with permission.

cigarette smoking normative group. Taken at face value, this means that the cigarillo using sample scores are about 1 SD lower on this measure of ND than the normative group of cigarette smokers. We interpret this with abundant caution given the substantial differences in age, race, and most importantly, tobacco product use of the two samples. Unfortunately, this is the only normative group to which we can compare item scoring and we can only speculate about reasons for the lower ND scores. For example, group differences in average nicotine consumption per day and the number of years of tobacco use history may explain the ND score mean difference. As the original PROMIS measure is implemented in a variety of settings and populations, it may be possible to derive a normative comparison group that is representative of younger tobacco users. However, establishing comparative data for individuals who use cigarillos, other tobacco products and polytobacco users will require the use of items worded in a product-neutral way. Data collection using product-neutral items, like those evaluated in this study, makes it possible to assess ND among groups that have largely been excluded from such assessments in the past. Measure development and evaluation is an intensive multistep and often multistudy process, and our work builds on the foundational work of the PROMIS tobacco initiative team and those that developed and tested the items and measures on which the pool of PROMIS items was based.[4–6,9]

We specifically revised item stems to be neutral to the type of tobacco product smoked, making them suitable for assessing ND among the cigarillo and multiple combustible tobacco product users in this study, and relevant to all combustible tobacco product users. Prior investigators have suggested that tobacco product-specific measures may be necessary to meaningfully assess ND because patterns of use may differ, although most of this work is focused on cigarette and ENDS use.[47,48] A more recent argument for product-specific measures was grounded in data showing that baseline product-specific ND scores among dual product users (ie, cigarette and ENDS) was associated with subsequent within- but not cross-product use.[49] In contrast, our study adds to the work of others who have examined sets of common ND items among multiple tobacco product users[26–30,50] and demonstrate initial evidence of validity of such measures.[28,30] We proffer that a universal measure that is relevant, reliable, and valid across multiple combustible tobacco products is highly valuable. A universal measure reduces the number of measures that must be developed, evaluated, and ultimately, completed by participants. This is increasingly important given the growing prevalence of polytobacco use and the varied combinations of tobacco products that individuals use.[24,25,51,52] Further, for some polytobacco users, specific product use may be much more fluid, with behaviors such as substituting one product for another and varying use based on social, financial, and

**Table 3.** 20-, 8-, and 4-Item Summary Score Distribution and Internal Consistency Reliability

| | *N* = 1089 |
|---|---|
| 20-Item PROMIS ND[a] | |
| Raw score (possible range: 20–100) | |
| Mean | 47.94 |
| SD | 20.93 |
| Range (Min–Max) | 20.00–100.00 |
| *T* score | |
| Mean | 40.85 |
| SD | 11.73 |
| Mean SE | 2.03 |
| Cronbach's alpha | 0.974 |
| Mean interitem *r* | 0.651 |
| 8-Item short form PROMIS ND[a] | |
| Raw score (possible range: 8–40) | |
| Mean | 18.94 |
| SD | 8.03 |
| Range (Min–Max) | 8.00–40.00 |
| *T* score | |
| Mean | 42.06 |
| SD | 11.28 |
| Mean SE | 3.40 |
| Cronbach's alpha | 0.925 |
| Mean interitem *r* | 0.612 |
| 4-Item short form PROMIS ND[a] | |
| Raw score (possible range: 4–20) | |
| Mean | 9.19 |
| SD | 4.03 |
| Range (Min–Max) | 4.00–20.00 |
| *T* score | |
| Mean | 42.05 |
| SD | 10.87 |
| Mean SE | 4.76 |
| Cronbach's alpha | 0.841 |
| Mean interitem *r* | 0.584 |

[a]Scoring algorithm for all smokers (PROMIS daily and nondaily smokers) applied to generate scores.

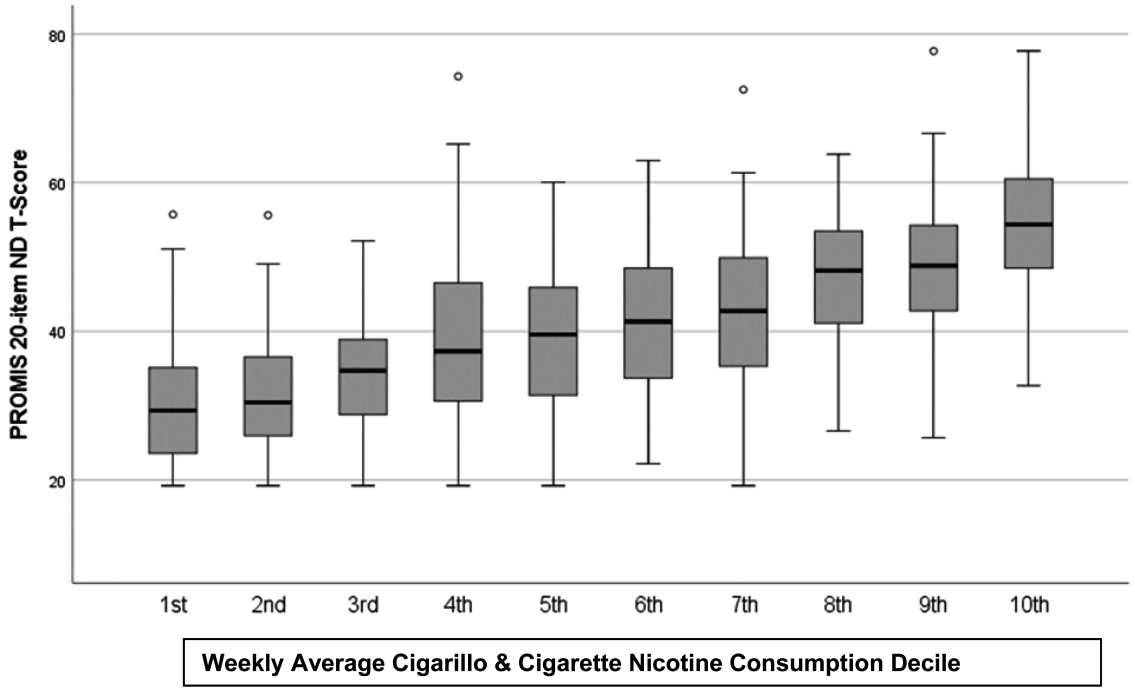


**Figure 1.** Association of 20-item ND *T*-score with decile of nicotine consumption. Height of boxes = interquartile range (IQR); thick line inside each box = median value; whiskers extend to show the minimum and maximum values, excepting potential outliers (defined as lying beyond 1.5 box lengths from the median value and indicated by small circles). ND = nicotine dependence.

environmental or restriction policy context,[53,54] making it impractical to separate reporting ND for individual products.

In this study, the items performed well for individuals who reported using cigarillos or both cigarillos and cigarettes. However, the work presented in this study is a small step toward a universal measure. A more robust evaluation of these product-neutral items is warranted and should include a broad range of age groups and include sufficient numbers of individuals to examine product use subgroups such as single product groups: eg, cigarillo only, little cigar only, and cigarette only). Further, establishing normative data on these items for other types of tobacco users, like cigarillo and little cigar users, will be valuable for future comparative work.

Our sample is limited to individuals who use cigarillos. We are not able to compare how individuals who only smoke cigarettes responded to the neutrally worded items. The study was focused on individuals between the ages of 14 and 28 because this is the age group that are the most prevalent users of cigarillos. Although the study survey was open to individuals across this age range, very few respondents were under the age of 17. A large proportion of the sample used multiple tobacco products, however, detailed information on NIC was only available for cigarillos and cigarettes. Our analyses testing the association of ND with NIC controlled for a count of other tobacco product use, but the implication is that the estimate of nicotine consumption may be underrepresented and this could influence the association with the measure of ND.

In conclusion, this adapted bank of 40 ND items is psychometrically sound and includes items that are product neutral, making it suitable for assessing ND among cigarillo and polytobacco users. Future studies that examine these items in a broader age range and across additional tobacco products are needed.

## Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

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## Declaration of Interests

*The authors have no competing interests or financial interests to disclose. Authors have had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analyses. The manuscript produced was not reviewed by the sponsor prior to submission for publication.*

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## Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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