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Predictive validity of the adult tobacco dependence index: Findings from waves 1 and 2 of the Population Assessment of Tobacco and Health (PATH) study

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Abstract

Background and aims: Building on published work[1] establishing concurrent validity of a self-report tobacco dependence (TD) index among users of different tobacco products in Wave 1 (W1) of the Population Assessment of Tobacco and Health (PATH) Study, the current study examines

[1]This article was prepared while Dr. Kevin Conway and Ms. Victoria Green were employed at the NIH/National Institute on Drug Abuse.

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Contributions

All authors made significant contributions to the conceptualization and data analysis plans for this manuscript. Drs. Strong, Frissell, Leas and Niaura led primary analyses. Ms. Noble, White, Glasser along with Drs. Katz, Taylor, Compton, Conway, Lambert, Kimmel, Silveira, Green, Cummings, and Hyland made significant contributions to the writing and editing of the final manuscript.

Disclaimer

The views and opinions expressed in this manuscript are those of the authors only and do not necessarily represent the views, official policy or position of the U.S. Department of Health and Human Services or any of its affiliated institutions or agencies.

Declaration of Competing Interest

Dr. Cummings has served on a 1-time advisory committee for Pfizer to help them find ways to promote smoking cessation in health care settings and continues to serve as an expert witness on behalf of plaintiffs in litigation against cigarette companies. Dr. Cummings has no other financial links whatsoever to a cigarette company, or other tobacco manufacturer. All other authors declare no conflicts of interest.

prospective relationships with tobacco use behaviors to establish predictive validity of the TD index. Hypotheses suggested high levels of W1 TD would be associated with persistent tobacco use at Wave 2 (W2).

Participants: A U.S. nationally representative sample of 32,320 adult W1 and W2 interviews focused on 11,615 W1 adults who were current established tobacco users and completed the W2 interview.

Findings: Higher TD scores and greater changes in TD scores were associated with greater quantity and frequency of tobacco use at the W2 interview for Cigarette Only (n=7068), Smokeless (smokeless or snus pouches) Only (n=772), Cigarette plus E-Cigarette (n=592), and Multiple Products (n=1866) users, although not significantly so for E-Cigarette Only (n=367), Cigar Only (traditional, cigarillo, or filtered) (n=584), or Hookah Only (n=366) users. Higher TD was associated with decreased odds of successful quitting for Cigarette and Multiple Product users. Higher TD was associated with increased odds of a quit attempt for those in the Hookah and Multiple Products user groups and was not associated with quit attempts or deceased odds of quit success among exclusive E-Cigarette, Cigar, Smokeless and Cigarette plus E-Cigarette users.

Conclusion: Support for the predictive validity of the PATH Study measures of adult TD will enable regulatory investigations of TD across several tobacco products.

Keywords

Nicotine dependence; Validity; Longitudinal national survey

1. Introduction

The Population Assessment of Tobacco and Health (PATH) Study, a nationally representative longitudinal study examining tobacco and health in the U.S., has enabled comprehensive examination of the psychometric properties and validity of multiple indicators of tobacco dependence (TD) across a range of tobacco products. In a prior paper (Strong et al., 2017), we analyzed data from the PATH Study using factor analytic methods and item response models (Strong et al., 2015) to test whether a common set of measures could be identified and used to characterize TD across a range of tobacco products. Reliability of a common 16-item measure of TD was established for cigarettes, e-cigarettes, cigars, hookah, and smokeless tobacco products (Strong et al., 2017). Items for the common TD measure were drawn from a variety of existing sources (Smith et al., 2010; Piper et al., 2004; Shiffman et al., 2004; Association AP, 2013), and correspond to the following domains: craving, loss of control, tolerance, automaticity, negative reinforcement, cognitive enhancement, affiliative attachment, and withdrawal. Concurrent validity was established in that TD scores for each tobacco product were positively correlated with frequency of product use (Strong et al., 2017). In addition, compared to Cigarette Only smokers (the user group representing 61 % of tobacco product users with the highest mean level of TD), levels of TD were comparable for Smokeless Only users and for users of multiple tobacco products. Compared to Cigarette Only smokers, the lowest levels of TD were seen in E-Cigarette Only users, Cigar Only users, and Hookah Only users.

While the PATH Study adult W1 interview provided reliable and valid measurement of a broad range of TD across several tobacco products, predictive validity must be established for potentially important outcomes such as escalation of product use and inability to cut down or quit. In the current study, longitudinal data obtained in W2 of the PATH Study were analyzed to further validate the TD measure.

The objectives of the current study were to 1) validate both prospective relationships of W1 TD scores and W2 quantity and frequency of tobacco use, 2) validate concurrent relationships of change in W1 to W2 TD scores with W2 quantity and frequency of tobacco use and 3) examine effects of W1 TD scores on subsequent product-specific quitting, adding tobacco products, or switching to different tobacco products at W2. It was hypothesized that high levels of TD at W1 would be associated with high levels of W2 product use (quantity, frequency) and that change in TD scores would be related to corresponding changes in W2 product use. It was also hypothesized that among those who made an attempt to quit, higher W1 TD would be associated with decreased odds of achieving abstinence from tobacco at W2.

2. Methods

2.1. Study participants

The National Institutes of Health (NIH), through the National Institute on Drug Abuse (NIDA), partnered with the U.S. Food and Drug Administration's (FDA) Center for Tobacco Products to conduct the Population Assessment of Tobacco and Health (PATH) Study under a contract with Westat. The PATH Study is an ongoing, nationally-representative, longitudinal cohort study of adults and youth in the US. The PATH Study uses audio computer-assisted self-interviews (ACASI) in English and Spanish to collect self-report information on tobacco-use patterns and associated health behaviors. W1 was conducted from September 12, 2013 to December 14, 2014; W2 was conducted from October 23, 2014 to October 30, 2015. The PATH Study recruitment employed stratified address-based, area-probability sampling design at W1 and oversampled adult tobacco users, young adults (18–24 years), and African-American adults. An in-person household screener was used at W1 to select youths and adults from households for participation in the longitudinal cohort.

Population and replicate weights were created that adjusted for the complex study design characteristics (e.g., oversampling at W1) and nonresponse at Waves 1 and 2. Combined with the use of a probability sample, the weights allow analyses of the PATH Study data to compute estimates that are robust and representative of the non-institutionalized, civilian US population ages 12 years and older. Further details regarding the PATH Study design and methods are published elsewhere (Hyland et al., 2016). Details on interview procedures, questionnaires, sampling, weighting, and information on accessing the data are available at https://doi.org/10.3886/Series606. The study was conducted by Westat and approved by the Westat institutional review board. All participants age 18 and older provided informed consent.

At W1, the weighted response rate for the household screener was 54.0 %. Among households that were screened, the overall weighted response rate at W1 was 74.0 % for the

adult interview. At W2 the overall weighted response rate was 83.2 % for the adult interview.

At W1, interviews were completed with 32,320 adults (ages 18 years and older). At W2, interviews were completed with 28,362 adults. W1 youth (ages 12–17) who completed the adult interview at W2 were not included in the current study. The differences in number of completed interviews between W1 and W2 reflect attrition due to non-response, mortality, and other factors.

The current study analyzes data from 11,615 W1 adult current established tobacco users who also completed the W2 interview. A current established tobacco user at W1 was categorized as follows: A current established cigarette user was defined as an adult who has smoked at least 100 cigarettes in his/her lifetime and now smokes every day or some days. For all other tobacco products, a current established user was defined as an adult who has ever used the product “fairly regularly” and now uses it every day or some days. Mutually exclusive past year tobacco-user groups at W1 who also completed the W2 interview include: Cigarette Only users (n=7068), E-Cigarette Only users (n=367), Cigar Only users (n=584), Hookah Only users (n=366), Smokeless Only (smokeless or snus pouches) users (n=772), Cigarette plus E-Cigarette users (n=592), and users of multiple tobacco products (n=1866). Within Cigar Only users, we also examined quantity and frequency of traditional cigar, cigarillo, and filtered cigars separately.

2.2. Tobacco use outcome

For W1, we indexed frequency of product use among those using the product in the past 30 days and categorized as daily users those reporting use during all 30 days, and non-daily users as those reporting fewer than 30 days. The average quantity of products used each day at W1 was assessed for daily and non-daily users among current established users reporting some use in the past 30 days. Daily users were asked “On average how many [product] do you use each day.” Non-daily users were asked “On average, on those days you used... how many [product] do you use.” For Hookah Only users, we assessed W1 frequency of use but did not assess quantity of product use. W2 Quit attempts were defined by reports of either “...tried to quit completely” or “...tried to quit by reducing or cutting back” in the past 12-months. Quitting success was defined by reports of no tobacco use for 6-months prior to the W2 interview. We defined additional tobacco product use outcomes at W2 accordingly: a) No Change: Continue use of same product(s), do not add use of any other product, b) Switching: Stop use of any product, add use of any other product, c) Adding: Continue use of same product(s), add use of any other product, d) Quit: Stop use of all products, do not add use of any product.

2.3. Symptoms of tobacco dependence (TD) at Wave (W)1 and W2

The PATH Study adult interview included 16 TD symptoms derived from the Wisconsin Inventory of Smoking Dependence Motives (11 items), Nicotine Dependence Syndrome Scale (4 items), and Diagnostic and Statistical Manual (DSM) Criteria (1 item). This sixteen-item index of symptoms of TD demonstrated validity for use across different tobacco product users (Strong et al., 2017). Items reflected domains of automaticity, craving,

loss of control, tolerance, withdrawal, negative reinforcement, cognitive enhancement, and affiliative attachment and were identified for use in the PATH Study interviews (Strong et al., 2017). Items were scaled to produce TD scores ranging from 0 to 100 (Strong et al., 2017).

2.4. Other independent variables

We assessed the frequency and quantity of tobacco products used at W1, and demographic characteristics at W1 (e.g., gender, age, and race/ethnicity).

2.5. Analysis

The primary independent variable was the 16-item TD score. The primary dependent variables included W1 and W2 quantity of use, W1 and W2 frequency of daily use, and reports of no tobacco use (yes, no) in the 6 months prior to the W2 interview among those who made a quit attempt between W1 and W2 (replied “yes” to the question: “In the past 12 months, have you tried to quit [tobacco product]?”). Secondary dependent variables (assessed from the W2 interview) included attempts to quit tobacco use (yes, no) and longitudinal patterns of using the same products, switching products, adding products, or quitting tobacco. Each model assessing tobacco quantity or frequency included adjustment for corresponding tobacco use at baseline, as well as planned covariates for age, gender, and racial/ethnic group. Levels of TD were scaled to a mean of 0 and SD of 1 within each product user group to enable interpretation of model estimates in standard deviation units.

Relationships between W1 TD and W2 quantity of use or frequency of daily use were evaluated in covariate adjusted regression models with further adjustment for corresponding W1 values of each outcome. Evaluation of concurrent changes in TD from W1 to W2 with W2 product use were evaluated by adding a term reflecting W2 TD to covariate adjusted models of W1 TD associations. Log-binomial and logistic regression models were used to test the association of W1 TD with a) the odds of making a quit attempt between the W1 and W2 assessments and b) quit success. Analyses of product patterns (e.g., product switching and adding) were analyzed via covariate adjusted multinomial logistic regressions. Multinomial logistic regression models estimated the relationship between levels of W1 TD and the odds of ‘Switching’, ‘Adding’, or having ‘Quit’ at W2 relative to those who reported the ‘No Change’ from their W1 product use.

All analyses used W2 survey weights with nonresponse adjustments (at W2). The Balanced Repeated Replication (BRR) method with Fay adjustment (Fay=0.3) was used for all analyses of weighted data as computed by the survey package (Lumley, 2017) in R statistical software (R Core Team, 2018). Missing data on age, gender, race, and Hispanic ethnicity were imputed as described in the User Guide to the PATH Study Restricted Use File (RUF) (United States Department of H et al., 2017).

3. Results

3.1. Descriptive analyses

The analytic sample at W1 included adults who self-identified as current established users of any tobacco product (n=14,369/32,320, weighted percent of 22.8 ± 0.3 %). Among the 14,369 W1 adult users, n=11,615 were also assessed at W2. Weighted demographic characteristics (gender, age, and race/ethnicity) of the W1 current established users of each tobacco product group who were also assessed at W2 are presented in Table 1. Weighted regression analysis found that levels of TD at W1 were significantly different among the seven product user groups ($F(6,93)=703.2549$, $p < 0.001$; full results not shown) with all other single product user groups scoring significantly lower than Cigarette Only users. Cigarette plus E-Cigarette scored higher than Cigarette Only users ($p < 0.01$) and Multiple Product users did not differ significantly from Cigarette Only users ($p=0.57$).

3.2. Association of Wave 1 TD and Wave 2 quantity and frequency of tobacco product use

Table 2 lists the number of valid respondents included in separate analyses of W2 quantity and frequency of product use. W1 TD was positively associated ($p < 0.01$) with higher average quantity of product used at W2 for Cigarette Only, Smokeless Only, Cigarette+E-Cigarette, and Multiple Product user groups after adjusting for W1 quantity of use of each corresponding product and planned covariates (p's < 0.01). We did not observe a significant association between W1 TD and W2 quantity of product use for e-cigarettes or any of the individual cigar products.

Prevalence of W2 daily frequency of tobacco use were highest for Cigarette Only (82.6 %), E-Cigarette Only (75.8 %), Smokeless Only (72.0 %), Cigarette plus E-Cigarette (83.3 %), and Multiple Products (83.0 %) user groups (See Table 2). Prevalence of daily use were lowest among Cigar Only users with 19.3 % of traditional cigar, 35.6 % of cigarillo, and 41.1 % of filtered cigar users smoking daily. Higher levels of W1 TD were associated with W2 daily use of products among Cigarette Only ($p < 0.01$), Cigarette plus E-Cigarette ($p < 0.01$), and Multiple Product Users ($p < 0.01$) with adjustment for planned covariates and daily use of corresponding products at W1. W1 TD was associated with W2 daily use of products among Filtered Cigar ($p < 0.05$) users. We did not observe a significant relationship between higher W1 TD and daily use among E-Cigarette Only ($p= < 0.71$), Cigarillo Only (p's > 0.06), or Hookah Only (p's > 0.10) user groups. Examinations of TD associations with W2 daily use among Traditional Cigar excluded gender from the planned covariate set given poor model fit. We did not observe a relationship between W1 TD and W2 daily use of Traditional Cigars (p's > 0.40).

3.3. Association of change in TD from Wave 1 to Wave 2 with Wave 2 quantity and frequency of tobacco product use

Increases in TD from W1 to W2 was positively associated ($p < 0.02$) with higher average quantity of product used at W2 for Cigarette Only, Smokeless Only, Cigarette+E-Cigarette, and Multiple Product user groups after adjusting for W1 quantity of use of each corresponding product and planned covariates (p's < 0.01). We did not observe a significant

association between changes in TD from W1 to W2 and W2 quantity of product use for e-cigarettes or any of the individual cigar products.

Increase in TD from W1 to W2 was associated with W2 daily frequency of product use among Cigarette Only ($p < 0.01$), Smokeless Only ($p < 0.01$), Cigarette plus E-Cigarette ($p < 0.01$), and Multiple Product Users ($p < 0.01$) with adjustment for planned covariates and daily use of corresponding products at W1. We did not observe a significant relationship between changes in TD from W1 to W2 and daily use among E-Cigarette Only (p=0.71), Cigarillo Only (p=0.90), Traditional Cigars Only (p=0.45), Filtered Cigars Only (p=0.81) or Hookah Only (p=0.10) user groups.

3.4. Association of Wave 1 TD with subsequent product-specific quitting adding tobacco products, or switching to different tobacco products at W2

Rates of quit attempts were similar across W1 tobacco use groups and ranged from 37.4 % for Smokeless Only users to 49.8 % among Cigarette plus E-Cigarette users (see Table 3). Coefficient estimates in Table 3 reflect the increase in log-odds of a quit attempt for every standard deviation unit increase in levels of TD for each product user group. For Hookah Only users, where lack of convergence for maximum likelihood estimates prevented fit of log-binomial models, we fit logistic models and present Odds Ratios (OR)s. All other model results are presented using a Risk Ratio (RR). Higher W1 levels of TD were significantly associated with quit attempts among Hookah Only (OR=1.34; 95 % CI=1.04,1.73) and Multiple Product users (RR=1.09; 95 % CI=1.03,1.16). We did not observe a significant relationship between higher levels of TD and quit attempts among Cigarette Only, E-Cigarette Only, Cigar Only, Smokeless Only, or Cigarette plus E-Cigarette product users.

Rates of successful quitting (see Table 3) were variable across product user groups. Cigarette Only (6.4 %) and Multiple Product (5.7 %) users had lower success rates among those who made a quit attempt. In adjusted log binomial regression models, higher levels of TD were associated with lower odds of successful quitting at W2 among Cigarette Only (RR=0.48; 95 % CI=0.39,0.59), and Multiple Product (RR=0.38; 95 % CI=0.26,0.56) users. We did not observe significant relationships between levels of TD and successful quitting among E-Cigarette Only, Cigar Only, Hookah Only, Smokeless Only or Cigarette plus E-Cigarette users who attempted to quit tobacco.

When examining changes in tobacco use patterns, rates of maintaining the ‘No Change’ pattern of use varied from a high of 65 % among Cigarette Only and Smokeless Only users to 27 % among Hookah Only users (see Table 4). While rates of ‘Adding’ a product were fairly consistent across W1 product users, rates of ‘Switching’ ranged from a high of 29.5 % among Hookah Only to a low of 7.7 % among Cigarette Only users. Rates of ‘Quit’ also varied with a high of 19.5 % among Hookah Only to a low of 3.1 % among Cigarette Only users. Increasing levels of W1 TD were associated with significantly higher odds ($p < 0.01$) of ‘Adding’ a product relative to staying ‘No Change’ (see Table 4) among both Cigarette Only and Cigar Only users. Increasing levels of TD were significantly ($p < 0.01$) associated with lower odds of ‘Switching’ among Cigarette Only and Smokeless Only ($p < 0.05$) users, and higher odds of ‘Switching’ among Cigar Only users but was not associated with ‘Switching’ in other user groups (p’s > 0.60). Increasing levels of W1 TD were significantly

associated with having lower odds of ‘Quit’ relative to staying ‘No Change’ among Cigarette Only users. Levels of W1 TD were not associated with having ‘Quit’ among E-Cigarette Only, Cigar Only, Hookah Only or Smokeless Only users (p’s > 0.06).

4. Discussion

A prior paper (Strong et al., 2017) demonstrated that a 16-item measure of TD, adapted for use with specific classes of tobacco products, identified a primary single dimension of TD that could be used to examine variability across users of different tobacco products. The present study supports the predictive validity of this index with regard to quantity and frequency of use, quit attempts, abstinence, and patterns of product switching and adding behaviors between Waves 1 and 2 of the PATH Study. Levels of TD at W1 and increases in TD from W1 to W2 were associated with increasing quantities of product used or daily patterns of product used at W2 for Cigarette Only, Smokeless Only, Cigarette+E-Cigarette, and Multiple Product user groups. W1 TD was less strongly associated with quantity or frequency measures and abstinence among E-Cigarette Only, Cigar Only, and Hookah Only product users. When examining patterns of product use, higher levels of W1 TD were associated with lower odds of ‘Switching’ products than maintaining persistent use among Cigarette Only and Smokeless Only users. With a common measure of TD and support for validity across products, we also identified the importance of better understanding how reliable quantification of use across products and changes in patterns of use may influence levels of TD and ability to quit tobacco.

Increasing levels of TD were associated with increased odds of making a quit attempt in the Hookah Only and Multiple Products user groups. TD, however, did not increase the likelihood of quit attempts among exclusive Cigarette Only, E-Cigarette Only, Cigar Only, Smokeless Only or Cigarette plus E-Cigarette product users. The lack of a uniform effect on quit attempts across tobacco product use groups suggests that other, perhaps product-specific, factors influence this general tendency. It is also possible that high and low dependence product users may have different reasons for making a quit attempt.

Results for successful quits, given a quit attempt, were more uniform in that higher TD scores at baseline were associated with decreased probability of success across all product user groups at W2, although not significantly so for some product users. Cigarette Only and Multiple Product users were significantly less likely to quit successfully if product-specific TD scores were high. The same was true for E-Cigarette Only, Cigar Only, Hookah Only, Smokeless Only, and Cigarette plus E-Cigarette users but the effects did not achieve statistical significance. It is not surprising that TD among Cigarette Only users predicted failure to quit. Numerous studies, using various measures of dependence, have already demonstrated that more dependent smokers are less likely to quit (Messer et al., 2008; Kozlowski et al., 1994; Caponnetto and Polosa, 2008). This finding appears to generalize to users of multiple tobacco products. Smoked tobacco produces rapid increases in blood and brain nicotine concentrations that could contribute to their dependence potential (Berridge et al., 2010). The only exception to this pattern was among Cigar Only and Hookah Only users where TD scores were not as strongly related to quitting. In general, Hookah Only user in this analysis tended to be infrequent and intermittent, and TD scores were lowest in Cigar

Only and Hookah Only users compared to other tobacco product users. There may not have been enough high TD Cigar Only and Hookah Only users to detect a relationship between TD and quitting, if one exists.

Similar to Cigarette Only users, TD among Smokeless Only users was high. However, unlike in Cigarette Only users, TD among Smokeless Only users was only weakly associated with inability to quit. Smokeless users' motivations for use and therefore quitting may extend beyond TD. The total amount of nicotine absorbed by both products is similar, but the speed of nicotine delivery is faster with cigarettes (Digard et al., 2013). Nicotine's dependence potential may therefore be coupled with its mode and speed of delivery when influencing the ability to quit.

It is likely that reasons for quitting other products such as e-cigarettes may extend beyond dependence, such as perceived harm reduction (Fong, et al., under review) or delivery of nicotine, and may explain some of the variation in quitting. E-cigarettes can also deliver nicotine in doses and speeds comparable to cigarettes, but this property is highly device and user specific (Fearon et al., 2018). E-cigarette users in the PATH Study are heterogeneous in the types of devices used (United States Department of H et al., 2017); future studies can determine whether device type plays a significant role in dependence and ability to quit.

Knowledge of baseline levels of TD provided incremental information regarding product use transitions between assessment waves. The majority of Cigarette Only and Smokeless Only users continued to use their chosen product, and switching was less common in these groups, with 7.7 and 11.4 % switching, respectively compared to 15.3 %, 22.9 %, and 29.5 % in E-Cigarette, Cigar, and Hookah users that switched to a new product. Higher TD was associated with lower odds of switching among Cigarette Only and Smokeless Only users. In contrast, Cigar Only users with higher W1 TD were more likely to switch products by W2. These findings are consistent with reports that among tobacco users, continued use or transitioning towards combusted tobacco or cigarette smoking was a more common pattern than switching away from combusted products and may reflect the abuse liability for cigarettes (Kasza et al., 2018). Importantly, patterns of transitions were more common among younger than older users suggesting that understanding experimentation with multiple products among youth may be critical in predictive evaluations of the development of TD (Kasza et al., 2018). Additional factors beyond TD may influence continued use of tobacco products particularly among users with overall lower levels of dependence such as E-Cigarette Only and Hookah Only user groups.

In summary, baseline TD generally predicted quit attempts and product switching one year later, but these effects were variable across products. More consistently, TD scores predicted persistent product use after one year for Cigarette Only, E-Cigarette Only, Cigarette plus E-Cigarette, and multiple tobacco products users. This measure of TD has established reliability and validity for use with multiple products. Although the instrument does not include questions about quantity of use directly, strong relationships were observed with quantity and frequency measures. Future studies to evaluate relationships with biomarkers of exposure and potential reciprocal relationships with transitions among products is important.

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Table 1

Weighted demographic characteristics (gender, age, and race/ethnicity) of the W1 current established users of each tobacco product group who were also assessed at w2.

	Cigarette Only (n = 7068)		E-cigarette Only (n = 367)		Cigar Only (n = 584)		Hookah Only (n = 366)		Smokeless Only (n = 772)		Cigarette+E-cigarette (n = 592)		Multiple Products (n = 1866)	
Demographic Factor	**n**	**% (se)**	**n**	**% (se)**	**n**	**% (se)**	**n**	**% (se)**	**n**	**% (se)**	**n**	**% (se)**	**n**	**% (se)**
Gender														
Male	3262	50.9 %	164	47.4%	434	79.8%	191	58.0%	736	95.8%	250	44.6 %	1397	78.9%
		0.6 %		3.0 %		1.9 %		2.5 %		0.9 %		2.2 %		0.9 %
Female	3806	49.1%	203	52.6%	150	20.2 %	175	42.0 %	36	4.2%	342	55.4%	469	21.1 %
		0.6 %		3.0 %		1.9 %		2.5 %		0.9 %		2.2 %		0.9 %
Age Group														
18–24	1177	10.9 %	91	17.4%	214	23.0 %	286	70.0%	136	10.7 %	110	12.9 %	790	31.7 %
		0.4 %		2.1 %		1.7 %		3.3 %		1.0 %		1.4 %		1.3 %
25 +	5890	89.1%	276	82.6 %	370	77.0%	80	30.0%	636	89.3%	482	87.1%	1076	68.3%
		0.4 %		2.1 %		1.7 %		3.3 %		1.0 %		1.4 %		1.3 %
Racial/Ethnic Group														
Non-Hispanic White	4630	68.8%	270	75.6%	275	54.5%	170	46.3 %	664	89.0%	452	80.3 %	1189	68.9%
		0.7 %		2.8 %		2.4 %		3.1 %		1.2 %		1.8 %		1.3 %
Other Non-White	2438	31.2 %	97	24.4%	309	45.5%	196	53.7%	108	11.0 %	140	19.7%	677	31.1 %
		0.7 %		2.8 %		2.4 %		3.1 %		1.2 %		1.8 %		1.3 %

Note: All percentages are weighted and sample sizes (n) are reported as unweighted.

Table 2

Association between level of Tobacco Dependence (TD) at Wave 1 (W1) and change in TD at Wave 2 (W2) with the quantity and frequency of product use at W2.

	W2 Quantity			W2 Quantity						W2: Daily					W2 Frequency: Daily Use							
	W2 Quantity			W1 TD			W1 to W2 TD								W1 TD				W1 to W2 TD			
Tobacco Use Group	**N**	**Mean**	**SE**	**Estimate**	**SE**	**P**	**Estimate**	**SE**	**P**	**N**	**Non-Daily**	**Daily**	**%**	**SE**	**Odds Ratio**	**95 %**	**CI**	**P**	**Odds Ratio**	**95 %**	**CI**	**P**
Cigarette Only	6387	13.34	0.18	0.21	0.02	0.00	0.42	0.02	0.00	6439	1099	5340	82.6 %	0.6 %	1.92	1.73	2.13	0.00	3.92	3.39	4.52	0.00
E-Cigarette Only	148	3.79	0.44	−0.04	0.08	0.62	−0.16	0.12	0.18	248	65	183	75.8 %	2.9 %	0.98	0.65	1.46	0.91	1.13	0.60	2.11	0.71
Cigar Only: Traditional Cigar[a]	152	1.51	0.15	0.05	0.05	0.33	−0.06	0.17	0.75	189	151	38	19.3 %	3.3 %	0.80	0.36	1.78	0.59	1.71	0.43	6.84	0.45
Cigar Only: Cigarillo	128	3.12	0.28	0.11	0.07	0.12	0.04	0.07	0.58	154	100	54	35.6 %	4.3 %	2.24	0.96	5.20	0.06	1.05	0.49	2.26	0.90
Cigar Only: Filtered Cigar	70	6.39	1.00	−0.40	0.22	0.07	0.25	0.24	0.31	91	55	36	41.1 %	6.3 %	0.12	0.02	0.84	0.04	1.25	0.20	7.73	0.81
Hookah Only*	-	-	-	-	-	-	-	-	-	279	270	9	NA	NA	1.69	0.72	3.94	0.23	1.98	0.88	4.44	0.10
Smokeless Only	661	6.98	0.25	0.14	0.03	0.00	0.13	0.05	0.01	740	199	541	72.0 %	1.8 %	1.26	0.93	1.70	0.14	3.84	2.46	6.00	0.00
Cigarette +E-Cigarette	524	13.01	0.39	0.26	0.06	0.00	0.70	0.07	0.00	591	108	483	83.3 %	1.5 %	1.80	1.39	2.34	0.00	4.31	3.03	6.13	0.00
Multiple Products	1511	12.47	0.27	0.29	0.04	0.00	0.41	0.06	0.00	1681	294	1387	83.0 %	1.1 %	2.27	1.77	2.91	0.00	4.88	3.78	6.29	0.00

Note:

*Hookah evaluated using days used in the past 30; Quantity metrics square-root transformed in analysis due to beneficial impact on models residuals. Sample sizes are unweighted. All percentages, model estimates, and standard errors (SE) were weighted. Regression models included age, gender, racial/ethnic group, and W1 values of corresponding outcome being assessed. W1 to W2 TD estimates reflect the value of a Wave 2 TD term when added to regression models relating W1 TD to W2 outcomes.

[a]Models excluded sex in planned covariate set given poor model fit. NA=estimate suppressed due to inadequate number of subjects.

Table 3

Association Between W1 TD and W2 Quit Attempts and Successful Quitting Among Those Who Attempted.

			Any Quit Attempt						Successful Quits Among Attempters							
Product User Group	**% Attempted**	**SE**	**Estimate**	**SE**	**Risk Ratio**	**95 %CI**		**P**	**% Succeeded**	**SE**	**Estimate**	**SE**	**Risk Ratio**	**95 %CI**		**P**
Cigarette Only (n=7068)	47.7 %	0.7 %	−0.02	0.01	0.98	0.95	1.00	0.10	6.4 %	0.6 %	−0.74	0.11	0.48	0.39	0.59	0.00
E-cigarette Only (n=367)	39.5 %	3.0 %	0.08	0.08	1.08	0.93	1.26	0.32	12.5 %	2.9 %	−0.15	0.22	0.86	0.56	1.32	0.49
Cigar Only (n=584)	37.6 %	2.3 %	0.11	0.05	1.11	1.00	1.24	0.06	19.4%	3.2 %	−0.45	0.34	0.64	0.33	1.24	0.19
Hookah Only (n=366) *	44.6 %	2.8 %	0.29	0.13	1.34	1.04	1.73	0.03	31.6%	4.1 %	−0.29	0.20	0.74	0.50	1.11	0.15
Smokeless Only (n=772)	37.4 %	2.5 %	−0.02	0.06	0.98	0.87	1.11	0.74	13.5%	2.0 %	−0.38	0.22	0.68	0.44	1.05	0.08
Cigarette+E-cigarette (n=592)	49.8 %	2.3 %	0.08	0.05	1.08	0.98	1.19	0.12	4.7%	1.2 %	−0.61	0.40	0.54	0.25	1.20	0.14
Multiple Products (n=1866)	42.4 %	1.2 %	0.09	0.03	1.09	1.03	1.16	0.00	5.7 %	1.1 %	−0.96	0.19	0.38	0.26	0.56	0.00

Note: Sample sizes are unweighted. Weighted estimates adjusted for gender, age, and racial/ethnic group. Weighted estimates of TD associations are scaled within each user group to reflect increases in standard deviations.

* Computed odds ratio rather than risk ratio given poor convergence of log-binomial model evaluating Hookah Only users' success among attempters.

Table 4

Results from multinomial model estimates of the relationship between higher levels of W1 TD and the odds of W1 current users being classified within each W2 product use category relative to the same level of use as W1.

Product	Product Status	N	%	SE	Estimate	SE	t	P
Cigarette Only								
	No Change	4553	65.0%	0.6 %	-	-	-	-
	Adding	1786	24.1 %	0.6 %	0.09	0.03	3.11	0.00
	Switching	222	7.7 %	0.4 %	−0.39	0.08	−4.57	0.00
	Quit	505	3.1 %	0.2 %	−0.79	0.07	−10.78	0.00
E-Cigarette Only								
	No Change	178	49.7%	2.5 %	-	-	-	-
	Adding	79	21.9 %	2.0 %	0.22	0.16	1.40	0.16
	Switching	50	15.3 %	2.2 %	0.10	0.19	0.52	0.61
	Quit	58	13.1 %	1.7 %	−0.27	0.30	−0.90	0.37
Cigar Only								
	No Change	179	36.1%	2.4 %	-	-	-	-
	Adding	152	25.0%	2.0 %	0.66	0.14	4.65	0.00
	Switching	108	22.9 %	2.2 %	0.56	0.15	3.75	0.00
	Quit	145	16.0%	1.8 %	0.30	0.19	1.63	0.10
Hookah Only								
	No Change	102	27.3%	2.7 %	-	-	-	-
	Adding	84	23.7%	2.9 %	0.16	0.16	0.97	0.33
	Switching	74	29.5 %	2.5 %	0.00	0.25	−0.02	0.98
	Quit	106	19.5 %	2.1 %	0.12	0.18	0.68	0.49
Smokeless Only								
	No Change	484	64.5%	1.8 %	-	-	-	-
	Adding	169	19.4%	1.5 %	−0.10	0.12	−0.82	0.41
	Switching	41	11.4 %	1.4 %	−0.53	0.26	−2.05	0.04
	Quit	78	4.8%	0.7 %	−0.32	0.17	−1.87	0.06

Note: Sample sizes are unweighted. Weighted estimates adjusted for gender, age, and racial/ethnic group. Weighted estimates of W1 TD are scaled within each user group to reflect increases in standard deviations.