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Vaping characteristics and expectancies are associated with smoking cessation propensity among dual users of combustible and electronic cigarettes

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Abstract

Background and Aims—Most e-cigarette users who also smoke combustible cigarettes (dual users) begin vaping to quit smoking, yet only a subset succeeds. We hypothesized that reinforcing characteristics of e-cigarettes (vaping reinforcement) would positively predict smoking cessation propensity (SCP) among dual users.

Design—Secondary analysis of cross-sectional baseline data from dual users in an ongoing smoking cessation trial. Exploratory and confirmatory factor analysis (EFA and CFA) created latent variables for vaping reinforcement and SCP. A structural equation modeling (SEM) approach was used to test the hypothesis.

Setting—United States.

Participants—A national sample of dual users of combustible and electronic cigarettes who smoke and vape at least once per week ($n = 2896$) were enrolled (63% male; mean age = 29.9 years) into a randomized controlled trial in which they would receive either smoking cessation materials or no smoking cessation materials.

Measurements—Vaping reinforcement was indexed by vaping frequency (days/week vaping, times/day vaping, puffs/e-cigarette use), e-cigarette characteristics [numbers of modifications and tobacco or non-tobacco flavors, nicotine content (mg) and positive e-cigarette expectancies]. SCP

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Supporting Information
Additional supporting information may be found online in the Supporting Information section at the end of the article.

was measured by items of confidence, commitment to being smoke-free, cessation motivation (contemplation ladder), change in cigarettes per day since beginning e-cigarette use and negative smoking expectancies.

Findings—Four factors emerged from the EFA: vaping propensity (vaping frequency, positive expectancies), vaping enthusiasm (e-cigarette modifications, using non-tobacco flavors, puffs per use), nicotine/tobacco flavor (nicotine strength, tobacco flavors) and SCP (negative expectancies about smoking, motivation to quit smoking, reduction in smoking). A CFA upheld the exploratory factor structure [root mean square error of approximation (RMSEA) = 0.046, CFI = 0.91]. An SEM with the three vaping latent variables directly predicting SCP had good model fit (RMSEA = 0.030, CFI = 0.97) with a positive relationship of vaping propensity (0.509, $P < 0.001$), and small negative relationships of vaping enthusiasm (−0.158, $P = 0.014$) and nicotine/tobacco flavor (−0.230, $P < 0.001$).

Conclusions—Among e-cigarette users who also smoke combustible cigarettes, frequent vaping combined with positive e-cigarette expectancies appears to predict greater smoking cessation propensity. However, vaping enthusiasm (measured by e-cigarette modifications, using non-tobacco flavors and puffs per use), higher nicotine content and use of tobacco flavored solution may reduce cessation propensity.

Keywords

Dual-use; e-cigarettes; latent variable; smoking; smoking cessation; structural equation modeling

INTRODUCTION

Electronic cigarette (ECIG) use has increased rapidly since the product was introduced to the US market a decade ago [1]. In 2016, 3.2% of US adults were current ECIG users [2] and rates are similar for the United Kingdom [3]. A recent review concluded that most ECIG users (‘vapers’) also smoke cigarettes (‘dual users’), and former smokers are the second most likely to use ECIGs [4]. Indeed, up to 85% of ECIG users in nationally representative studies (Australia, Canada, United Kingdom and United States) report beginning and continuing to use ECIGs to try to quit smoking or reduce use of combustible cigarettes [5–7]. Nevertheless, the majority of dual users remain dual users 1 year after beginning vaping [8].

A recent meta-analysis of four randomized controlled trials (RCTs) [9–12], examining the efficacy of ECIGS on smoking cessation, as well as cohort studies [13], concluded that there was positive evidence. ECIGs also have been found to have similar smoking cessation rates as in clinical trials of nicotine replacement therapies (NRT) [14], although results are less certain [15].

Characteristics of the ECIG device

ECIGs design has been evolving since their introduction to the US market in 2007, now offering diverse vaping experiences. First-generation ECIGs look very similar to combustible cigarettes, and are either disposable or reloadable with prefilled nicotine solution. Because the user cannot customize e-liquids or modify characteristics of the

device, they are often considered ‘closed systems’. Second- and third-generation ECIGs, referred to as ‘open systems’, tend to look more like pens or larger devices and have chambers that can be re-filled with e-liquids of choice, including personalized mixtures of flavors. They allow for more variety in nicotine concentrations, and most allow modification to customize the user experience with regard to mouthpieces, heating elements, atomizer and voltage. The flexibility can create a more reinforcing experience, such as greater puff volume and delivering higher nicotine levels [16,17]. However, not all users choose to modify their device. In general, smoking behavior has been associated with different components of the vaping experience, including flavors [18,19], type of device and nicotine content [20]. Furthermore, open system devices are more likely to be associated with daily vaping, being a former smoker and attempting to quit smoking in the last 12 months [20].

ECIG use patterns

Patterns of ECIG use in dual users can also vary greatly, from infrequent use to daily use with varying frequency of use within a day [4]. For example, most vapers use ECIGs a few times per month [21], yet recent quitters are more likely to vape daily [7,22]. In addition, the variability of ECIG devices increases the difficulty of comparing puff duration, velocity, count and nicotine yield among users and devices. A 2017 review [4] found that puff duration and volume are higher for vaping than for smoking, but they vary depending on the vaper’s experience (lower in naive vapers) and nicotine content (shorter with higher nicotine content). There is still much to learn about how patterns of use are related to the propensity for smoking cessation.

Psychological factors

Finally, psychological variables play a significant role in smoking cessation. Evidence shows that motivation to quit, past quit attempts and smoking expectancies are all predictors of smoking cessation [23]. Outcome expectancies represent explicit or implicit beliefs about the consequences of actions such as drug use which influence the motivation to engage in those actions [24]. Smoking-related expectancies predict the onset and maintenance of smoking [25]. Thus, expectancies about ECIGs should also predict future use of ECIGs. Among dual users, vapers tend to believe ECIGs are less harmful, less expensive and more convenient than combustible cigarettes [4,26].

The present study

Although many dual users report being motivated to quit smoking, only half quit smoking within 5 years [8]. Therefore, it would be useful to understand which characteristics of vaping are more likely to increase smokers’ motivation and ability to quit. This study is a secondary data analysis that examined the reinforcing characteristics of the vaping experience (vaping reinforcement) that may be related to the motivation to quit smoking, negative expectancies about smoking and perceived likelihood of quitting smoking, which we label smoking cessation propensity (SCP). Building upon findings with individual predictors of smoking behavior, we theorized that the unitary construct of degree of reinforcement from vaping would be positively associated with SCP among dual users. The first step was to appropriately model the latent variables of vaping reinforcement and SCP. Exploratory and confirmatory factor analyses modeled the constructs. Next, a structural

equation model (SEM) approach examined the hypothesis that vaping reinforcement would significantly predict SCP.

METHODS

Participants

Dual users (*n* = 2896) were recruited from throughout the United States, primarily via social media advertisements, as part of an ongoing surveillance and smoking cessation study described elsewhere [27] from July 2016 to October 2017. Inclusion criteria first assessed at the time of the telephone screening and confirmed by the baseline survey included: self-reported (1) smoking ≥ 1 tobacco cigarette/week and smoked for at least the past year; (2) e-cigarettes use ≥ 1/week over the past month; (3) age ≥ 18 years; (4) not currently enrolled in a face-to-face smoking cessation program; and (5) able to speak and read English. Recruitment was not limited to dual users interested in quitting smoking or seeking assistance.

Assessment and procedures

This ongoing study was reviewed and approved by the Chesapeake Institutional Review Board. Dual users (*n* = 5827) were screened via the telephone. Those meeting inclusion criteria (*n* = 3644) and agreeing to participate in the study (*n* = 3611) were sent a bound set of baseline questionnaires or an e-mail link to our survey site. Those who returned the baseline survey were enrolled into the study (*n* = 3113) and then randomized to one of three conditions (assessment only, validated smoking cessation materials or smoking cessation materials targeted for vapers) and assessed at 3-month intervals over the course of 2 years. Eighty-six per cent (*n* = 2493) of participants chose to complete the survey electronically. The secondary analyses in this report utilized only baseline data, which included the following information.

Demographics—Age, gender, socio-economic indicators (education level, household income) and marital status were assessed.

Combustible cigarette-related measures—Motivation to quit smoking combustible cigarettes was assessed (see Supporting Information, Appendix S1) with the contemplation ladder [28]; two five-point Likert items assessed overall commitment and confidence about being smoke-free in the future. Change in smoking behavior pre- to post-vaping was assessed by a single item: ‘When you began to use e-cigarettes, how did your use of tobacco cigarettes change?’, with response options for increased, decreased and stayed about the same.

Smoking expectancies were assessed using 16 items rated on a seven-point scale from ‘strongly disagree’ to ‘strongly agree’. Nine of the items were included from the original Smoking Consequences Questionnaire—Adult [29] (SCQ-A), as has been performed previously [30]. Items were selected to represent each of the nine original factors (negative affect reduction, stimulation/state enhancement, health risk, taste/sensorimotor manipulation, social facilitation, weight control, craving/addiction, negative physical

feelings and negative social impression), based on factor loadings from the original development study and their ability to be adapted for ECIGs. Additional expectancy items included ratings of the degree to which they experienced craving and withdrawal effects, and the degree to which smoking helped with stress reduction was satisfying or was addictive. Two additional questions assessed convenience and cost. Of the 16 expectancy items, the seven negative items were used for the negative expectancy scale (SCQ-N; the three craving items, cost, health risk, negative physical feelings and negative social impression) and included in analyses to reflect SCP.

ECIG-related measures—ECIG use was assessed with items from a questionnaire developed for a recent e-cigarette survey [26,28] (see Supporting Information, Appendix S2): seven items about reasons for initiating use (e.g. ‘To use them when I can’t smoke cigarettes’, ‘To help me quit smoking tobacco cigarettes’); one item about the most important reason; one item of vaping frequency in the past month (EDAYS, with five options from daily to no use in the past month); number of vaping sessions per day (with eight options from none to vaping continuously throughout the day); number of puffs per vaping session (four options from one to 10 puffs to 30+ puffs); types of modifications to their ECIG (battery, heating element, pass through which allows vaping while charging the device, personal charging case, cartridge which allows for ease of changing flavors, mixing juice, atomizer, other and no modification); strength of nicotine in their current ECIG in mg/ml; and flavors of e-liquid used, scored as either tobacco flavor (e.g. tobacco, menthol) or non-tobacco (e.g. fruit, beverage, vanilla, etc.). For modeling purposes, the numbers of flavors endorsed in each category (tobacco or non-tobacco) were counted.

Positive expectancies about ECIGs were included to reflect vaping reinforcement and assessed by a modified version of the expectancy measure previously described for cigarettes that comprised the nine positive items [26] (eSCQ-P; ‘E-cigarettes satisfy my nicotine cravings’, ‘… are satisfying’, ‘… help me deal with anxiety or worry’, ‘… taste good’, ‘… control my appetite’, ‘… help me enjoy people more’, ‘… energize me’, ‘… are good for dealing with stress’, ‘… are convenient’) on a seven-point Likert scale.

Analytical plan

Missing data—Only 1% of data were missing from the baseline measures, with 12.7% of participants missing some data. Of those, 97.8% were missing only one variable. The contemplation ladder was missing scores from 8.7% of participants, whereas 4.1% of participants did not enter a value for the nicotine dose of their e-liquid (most of these indicated that they did not know), 0.07% were missing for both puff counts and eSCQ-P and 0.04% were missing a score on commitment, times/day vaping or change in number of cigarettes per day. Table 2 includes the *n*s for each of the observed variables. Ninety-three cases (3%) were found to be multivariate outliers of all observed variables in analyses (Mahalanobis distance > 28.19) and were removed from further analyses. Missing data were considered missing at random and estimated through full information maximum likelihood in Amos version 24.0.0 [31].

As described below, the analytical plan included first conducting a confirmatory factor analysis (CFA) for the proposed subsequent two-factor (vaping reinforcement and SCP) SEM model in which vaping reinforcement predicts SCP. Failure of the CFA model to fit the data led to an exploratory factor analysis (EFA) using a random half of the sample, followed by a CFA of those findings with the remaining half of the sample. Next, an SEM was evaluated to determine the hypothesized relationships of vaping reinforcement latent variables on a SCP latent variable. Finally, age, gender and income were added to the model as potential contributors to latent variables of SCP and/or vaping. There are several advantages of using an SEM approach to the data. Given the many features of the vaping experience as well as motivation to quit smoking, a latent variable may more effectively represent a construct than an array of individual variables. Furthermore, SEM considers the latent variable with measurement error that is not solely explained by the latent variable. SPSS version 24 [32] was used for summary statistics and to conduct the EFA. SPSS Amos [31] was used for CFAs and SEM analyses.

Maximum likelihood estimation was used to estimate free parameters in CFA and SEM analyses. Model fit to the observed data was evaluated by (1) comparative fit index [33] (CFI), (2) Tucker-Lewis Index [34] (TLI); (3) root mean square error of approximation (RMSEA) [35] and the Akaike information criterion (AIC) when model comparisons are made [36]. Minimum CFIs and TLIs of 0.90 were used as indicators of acceptable models, and values of 0.95 or greater as indication of good model fit [33,37–39]. Additionally, RMSEAs of less than 0.06 were accepted as indicating a good model fit. χ^2 analysis was not used to evaluate model fit, because it is not informative with very large sample sizes [40].

RESULTS

Descriptive statistics and correlations

Summary statistics for demographics, tobacco and ECIG-related variables can be found in Table 1. The majority of the sample was aged 18–41 years, male, overwhelmingly non-Hispanic white and mostly of lower educational and financial attainment. Most participants were daily but light smokers (< 10 cigarettes per day). Approximately two-thirds of participants reported initiating vaping to help them quit smoking. Zero-order correlations (Pearson’s product-moment, point-biserial) between all measured variables are displayed in Table 2. Notably, observed variables related to nicotine/tobacco flavor were negatively correlated with indices of SCP, whereas greater frequency of vaping per day and more days vaping had higher correlations with SCP variables. Also, as expected, the highest correlations were generally found between measures within the same latent variable.

Confirmatory factor analysis

The initial proposed model included two latent variables, vaping reinforcement and SCP. The vaping reinforcement measurement model included the following variables thought to reflect enthusiasm for vaping: vaping frequency, vaping events/day, number of puffs/event, nicotine concentration, number of tobacco flavors, number of non-tobacco flavors used, number of modifications to the ECIG and positive outcome expectancies for ECIGs (eSCQ-P). SCP was indicated by variables that have been associated with smoking cessation:

contemplation ladder score, commitment and confidence items, change in smoking after the onset of vaping and negative smoking expectancies (SCQ-N). Means, standard deviations and sample size for each of these observed variables can be found in Table 3. Maximum likelihood estimates of the proposed measurement model were generated. Fit indices for this two-factor model were poor (CFI = 0.791; TLI = 0.711; RMSEA = 0.069), suggesting that a different factor structure was possible. Thus, we conducted an EFA.

Exploratory factor analysis

One half of the sample ($n = 1401$) was randomly selected for EFA using the SPSS random sample function, with the other half ($n = 1402$) reserved for a subsequent CFA. There were no significant differences between the two samples on any demographic or model observed variables (all *P*s > 0.05). The EFA comprised a principal components analysis with Varimax rotation, revealing four factors (with eigenvalues ≥ 1; scree plot analysis). The rotated factor scores are presented in Table 4 and are consistent with an independent factor structure. An SCP factor was, as expected, indicated by the five proposed variables. Vaping reinforcement was split into three factors: vaping propensity (EDAYS, vaping times/day, eSCQ-P), vaping enthusiasm (number of device modifications, number of non-tobacco flavors and puffs/vaping session) and nicotine/tobacco flavor (nicotine strength and number of tobacco flavors) [Kaiser-Meyer-Olkin (KMO) = 0.72]. The factor structure accounted for 51% of the common variance. There was no evidence of collinearity [variance inflation factor (VIF) < 5; Tolerance > 0.01]. The data were adequate for structure detection (KMO = 0.72; Bartlett's test of sphericity < 0.001).

Confirmatory factor analysis of the new model

Following the EFA, four latent variables were developed (vaping propensity, vape enthusiasm, nicotine/tobacco flavor and SCP) in the measurement model (see Fig. 1). Vaping propensity was indicated by EDAYS, times per day using ECIG and eSCQ-P. Maximum likelihood estimation was found to have adequate model fit according to two of the three indicators (CFI = 0.91, TLI = 0.88 and RMSEA = 0.046). Fit was improved by allowing the error variances of the expectancy questionnaires to covary (eSCQ-P and SCQ-N) and the error variances among SCP observed variables to covary (CFI = 0.93, TLI = 0.91, RMSEA = 0.040). This decision was made because of the probable shared method variance in the two expectancy measures. The factor loading with the highest estimate between observed and latent variable was fixed to 1 for each latent variable of the structural model. All four factors exhibited acceptable convergent validity as assessed using the Fornell-Larcker system in which average variance extracted (AVE) for each factor is considered acceptable (> 0.5) or very good (> 0.7). The composite reliability (CR) scores are considered less biased estimates of reliability than Cronbach's alpha [41]. CRs at 0.7 or above are considered acceptable (see Table 4). For discriminant validity, the AVE for each construct was greater than the squared correlations between all possible pairs of covariances between constructs.

Structural equation model

The hypothesized conceptual model fitted the data adequately (CFI = 0.93; TLI = 0.91; RMSEA = 0.040). Modification indices strongly suggested by the LaGrange Multiplier test

that the errors between the smoking and the ECIG expectancy measures were correlated. They also indicated that allowing the error variances for the observed variables of the SCP latent variable to correlate would improve model fit [42]. Each of these modifications was theoretically reasonable due to the likelihood that the two expectancy measures may share method variance, and that the observed variables for SCP may not be independent. Allowing these correlated errors resulted in slightly improved fit statistics on most indices, achieving a good fit to the data. The final model with significant standardized coefficients and fit indices is presented in Fig. 2.

Each of the vaping latent variables showed significant effects on SCP, explaining 30% of the variance in SCP ($R^2 = 0.295$). Vaping enthusiasm ($\beta = -0.158$, $P = 0.014$) and nicotine/tobacco flavor ($\beta = -0.230$, $P < 0.001$) had significant negative effects on SCP, whereas vaping propensity ($\beta = 0.509$, $P < 0.001$) had a positive effect. We then added gender, income level and age as covariates. Males are more likely to vape [43], and lower income may act as a barrier to using more expensive features of ECIGS (e.g. modifications, flavors). We theorized that age would moderate vaping characteristics as a relatively new technology adopted more completely (e.g. frequency of vaping) or more uniquely (e.g. number of modifications) by younger smokers. Covariates were added as a group in one model and individually in three additional models. The covariate was modeled to contribute to SCP and/or the three latent vaping variables. All the models were poorer fits to the data than the original model according to AIC indices (see Supporting Information, Figs S1–S5). Based on the principle of parsimony, we retain the model without covariates.

DISCUSSION

Most dual users begin vaping to quit or reduce smoking. The current cross-sectional findings help to understand qualities of the vaping experience associated with greater propensity to quit smoking. To our knowledge, this is the first study to summarize characteristics of vaping into latent variables. Although we hypothesized that vaping reinforcement would predict SCP, the findings were somewhat more complex. The vaping experience emerged as three independent factors: vaping propensity, which included positive expectancies about ECIGs, frequency of vaping days and vaping sessions per day; vaping enthusiasm, as indicated by the number of ECIG device modifications, use of non-tobacco-flavored e-liquids and number of puffs per use; and nicotine/tobacco flavor, which represented both the use of tobacco flavors and nicotine strength in e-liquids. These three factors explained the variation in SCP as indicated by motivation/commitment to being smoke-free, negative expectancies about smoking, as well as reductions in smoking as a result of vaping.

Specifically, our results indicated that vaping propensity was positively related to SCP. That is, positive beliefs about the benefits of vaping combined with more frequent vaping were linked to greater motivation and commitment to being smoke-free and initial change in cigarette use with initiation of vaping. This is consistent with recent studies finding that daily vaping was four times more common among those who quit smoking in the past year [22], and was the strongest ECIG characteristic correlate of smoking cessation [8]. Findings suggest that encouraging vapers to hold positive beliefs about vaping and to vape daily

might lead to greater smoking cessation rather than continued dependence, as some authors fear [44–46].

Vaping enthusiasm, which was negatively associated with SCP, may reduce smoking cessation propensity. This latent variable appears to indicate the degree of experimenting with vaping features and technology. Those who try more flavors, make more modifications and take more puffs per vaping event may be enjoying the experience of vaping without independent intention to use vaping to quit smoking. Alternatively, it is possible that those who are immersing themselves in the many options of the vaping experience are also still trying to find the vaping characteristics that are a satisfying replacement for cigarette smoking. If the former explanation is correct, it may be important to promote ECIG use as a means to an end (smoking cessation), rather than a form of recreation. It is unclear why frequency of vaping and puffs per event loaded on different factors with opposite associations with SCP. Perhaps frequent vaping is associated with SCP via the use of ECIGS for reduction of cigarette cravings and nicotine withdrawal. In contrast, greater puffing per event may reflect more recreational use.

Finally, aspects of the vaping experience that re-create most closely the experience of smoking, such as higher nicotine dosing and tobacco flavorings, may hinder SCP. As recommended for NRTs, there may be utility in tapering the nicotine dose of ECIGs. Indeed, recent evidence from a balanced-placebo study suggests that the nicotine content of an ECIG is less important than vapers' cognitive expectancies with respect to controlling craving to smoke [47]. It might be valuable to educate vapers about effective methods of gradually reducing nicotine dose so as to minimize nicotine withdrawal. Similarly, it may be helpful for vapers to migrate away from flavors associated with combustible tobacco use, a strategy that has been recommended by successful quitters [27].

Limitations

Whereas the final structural model was theoretically plausible and a good fit to the data, much of the variance in SCP remained unexplained. This suggests that there are unmeasured variables that may add to the understanding of these data. Classifications of dual users (e.g. mostly vape/rarely smoke versus mostly smoke/rarely vape) might reveal different pathways toward SCP. More precise measurement of the vaping experience is also needed. Additionally, new ECIG models and alternative nicotine delivery systems may contain features that emerged after this study. For example, heat-not-burn tobacco products and nicotine salt-based ECIGs (e.g. Juul) that deliver higher nicotine doses may provide very different vaping experiences.

Although the current sample is relatively large and reasonably representative, it is possible that alternative theoretically interesting models also fit the data. We used a combination of model generating and strictly confirmatory approaches to SEM [48]. This was a practical approach, because very little is currently known about features of vaping and the relationship to smoking cessation propensity However, the CFA followed by the SEM give us confidence in our EFA findings. As a greater understanding of the vaping experience of dual users is achieved, it will become more practical to test competing a priori models. Furthermore, as with all SEM results, generalizability to other samples is unknown.

Because these data are cross-sectional and rely upon retrospective reports of change in smoking behavior, we cannot address how vaping characteristics are related to SCP over time. Dual users are not a monolithic, static group, and they are likely to change their vaping ‘profile’ as their needs and motivations change. Time-varying models using longitudinal data to examine reciprocal influences between vaping reinforcement and SCP would be highly informative in understanding the role of ECIGs in smoking cessation.

Summary

Although the effectiveness of vaping on smoking reduction or cessation remains unsettled, a better understanding of the characteristics of vaping will help to sharpen the association. In this study, vaping characteristics were summarized by three factors that are associated in different ways with SCP. The strongest relationship to SCP was with the frequent use of ECIGs combined with positive expectancies about ECIGs. Conversely, using ECIGs in ways that mimic cigarettes, as well as experimenting with features and flavors of ECIGs, were related to lower SCP. One implication is that vapers who use ECIGs much like NRTs, primarily as a tool for the purpose of quitting smoking as opposed to an extension of smoking or a hobby, may be more likely to attempt and eventually succeed at smoking cessation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Declaration of interests

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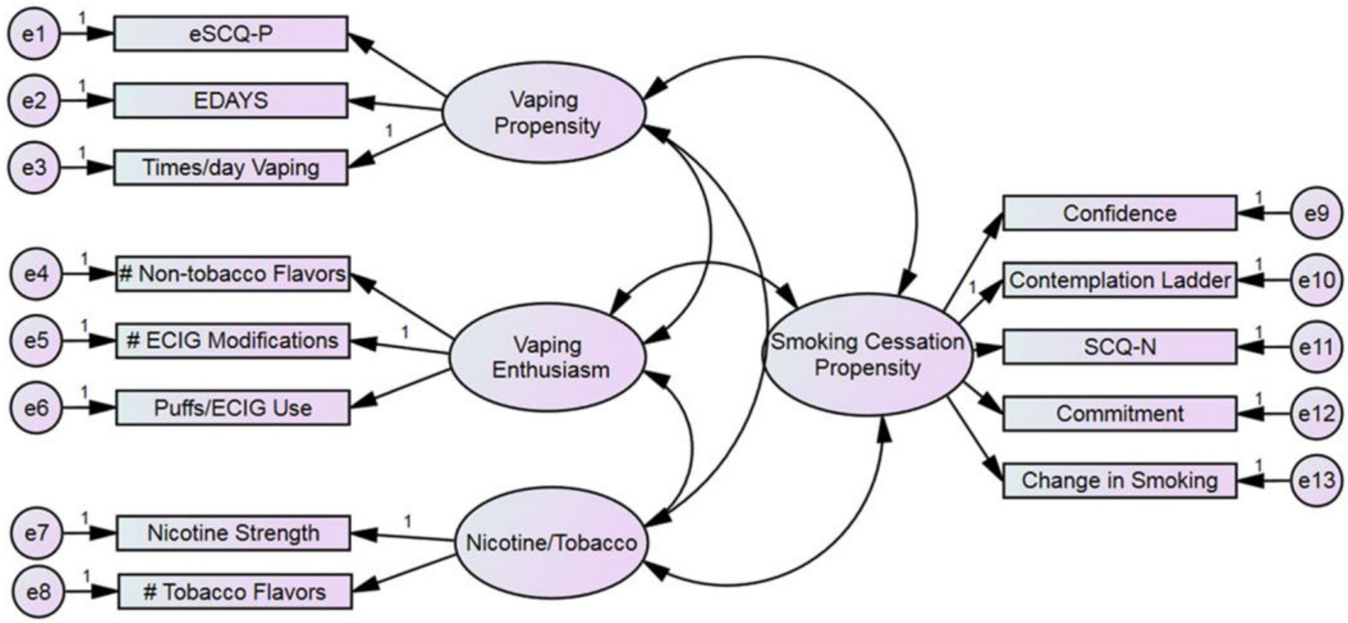

Figure 1.
Confirmatory factor model. eSCQ-P = e-cigarette Smoking Consequences Questionnaire positive scale; EDAYS = vaping day frequency in the past month; ECIG = e-cigarette; SCQ-N = Smoking Consequences Questionnaire negative scale

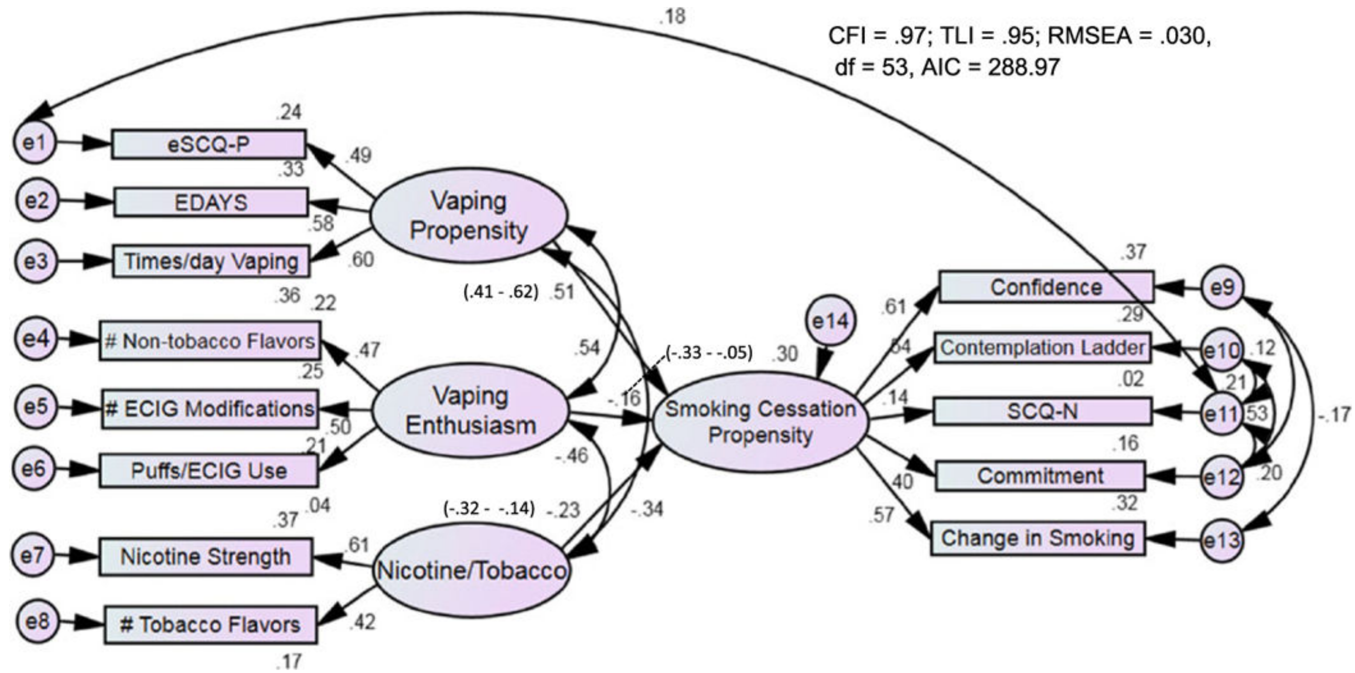

Figure 2.

Final structural model with standardized coefficients and 95% confidence intervalsAll paths significant at the $P \leq 0.05$ level. eSCQ-P =e-cigarette Smoking Consequences Questionnaire positive scale; EDAYS = vaping day frequency in the past month; ECIG = e-cigarette; SCQ-N = Smoking Consequences Questionnaire negative scale

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Table 1

Means and standard deviations or percentages of demographic, tobacco and ECIG-related variables.

Variable	Mean (SD)/%(n)	Total N
Demographics		
Age	29.97(11.23)	2803
Gender: male	63.4% (1777)	2803
Ethnicity		2803
Hispanic	8.3% (233)	
Race		2803
White	92.7% (2597)	
Black	4.6% (128)	
Education level: high school or less	46.9% (1314)	2803
Income < $30 K	56.4% (1573)	2790
Tobacco-related		
Years smoked before ECIGs	12.98 (10.75)	2789
Cigarettes/day		2801
≤ 5	29.6% (828)	
6–10	28.6% (802)	
11–15	13.4% (377)	
16–20	20.1% (564)	
21–30	5.2% (146)	
≥ 31	3.0% (84)	
Frequency of smoking		2802
1–5 times/month	0% (0)	
1–3 days/week	14.9% (417)	
4–6 days/week	25.4(712)	
7 days a week	59.7(1673)	
E-cigarette-related		
Vaping frequency		2803
1–5 times/month	4.4% (121)	
1–3 days/week	10.2% (287)	
4–6 days/week	15.6% (438)	
7 days a week	69.7% (1955)	
Began vaping		2802
< 1 month ago	1.4% (40)	
1–6 months ago	14.2% (397)	
7–12 months ago	14.6% (408)	
13–24 months ago	25.8% (722)	
> 24 months ago	44.1% (1235)	
Started vaping to help quit smoking	66.4%	2803

Variable	**Mean (SD)/%(n)**	**Total N**
Most important reason to start vaping: to quit or cut down smoking	68.8%	2777
No plans to stop using ECIGs	46.0%	2800

ECIGs = electronic cigarettes; SD = standard deviation.

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Table 2

Zero order correlations among measured variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Demographics														
1. Age														
2. Income	0.132**													
Vaping propensity														
3. eSCQ-P	−0.111**	0.062**												
4. EDAYS	0.006	0.101**	0.277**											
5. Times/day vaping	−0.148**	0.040*	0.283**	0.377**										
Vaping enthusiasm														
6. Puffs/ECIG use	−0.146**	0.068**	0.046**	0.012	0.072**									
7. No. of modifications	−0.230**	0.007	0.132**	0.107**	0.179**	0.116**								
8. No. of non-tobacco flavors	−0.190**	−0.017	0.162**	0.100**	0.184**	0.068**	0.236**							
Nicotine/tobacco flavor														
9. Nicotine strength	0.215**	−0.038*	−0.060**	−0.089**	−0.097**	−0.045*	−0.173**	−0.142**						
10. No. of tobacco flavors	0.079**	−0.039*	−0.083**	−0.134**	−0.135**	−0.029	−0.076**	−0.057*	0.232**					
Cessation propensity														
11. SCQ-N	0.115**	0.091**	0.193**	0.020	0.062**	−0.030	−0.017	0.007	−0.010	−0.031				
12. Confidence	−0.018	0.060**	0.116**	0.169**	0.158**	0.015	0.103**	0.046**	−0.136**	−0.116**	0.073**			
13. Ladder	0.161**	0.097**	0.145**	0.219**	0.143**	−0.047*	0.039	0.071**	−0.093**	−0.105**	0.233**	0.350**		
14. Committed to quit	0.223**	0.075**	0.088**	0.150**	0.075**	−0.034	0.002	0.002	−0.091**	−0.074**	0.238**	0.328**	0.616**	
15. Change in smoking	0.086**	0.100**	0.186**	0.200**	0.160**	−0.030	0.086**	0.088**	−0.057**	−0.109**	0.090**	0.242**	0.291**	0.224**

$^{*}P < 0.05$;

$^{**}P < 0.010$.

ECIG = e-cigarette; EDAYS = number of days per month using e-cigarettes; SCQ-N = Smoking Consequence Questionnaire negative scale; eSCQ-P = e-cigarette Smoking Consequences Questionnaire positive scale.

Table 3

Descriptive statistics for observed variables.

	Scale range	Mean/%	SD	N(%n)
Vaping propensity				
eSCQ-P	9–63	39.56	8.38	2801
EDAYS	0–5	4.51	0.85	2803
Times/day vaping	0–7	5.06	2.27	2802
Vaping enthusiasm				
Number of ECIG modifications	0–8	1.56	1.78	2803
Puffs per ECIG use	1–4	1.70	1.03	2801
Number of non-tobacco flavors	0–6	1.77	1.06	2803
Nicotine/tobacco flavor				
Number of tobacco flavors	0–2	0.38	0.56	2803
Nicotine strength	0–6	1.88	1.06	2689
Smoking cessation propensity				
Decreased smoking since vaping initiation		80.7%		2261
SCQ-N	9–63	15.56	3.19	2803
Confident quit for good	1–5	3.50	0.98	2803
Committed to being smoke-free	1–5	3.32	1.03	2802
Contemplation ladder	1–10	5.74	2.38	2560

ECIG = e-cigarette; EDAYS = number of days per week using e-cigarettes; SCQ-N = Smoking Consequence Questionnaire negative scale; eSCQ-P = e-cigarette Smoking Consequences Questionnaire positive scale; SD = standard deviation. For all scales, higher numbers reflect more of the construct measured.

Table 4

Rotated factor loadings for exploratory factor analysis.

Variable	Factor 1 (cessation propensity)	Factor 2 (vaping propensity)	Factor 3 (vaping enthusiasm)	Factor 4 (nicotine/ tobacco)
Commitment	0.834	0.022	−0.050	0.069
Contemplation ladder	0.833	0.073	−0.030	−0.048
Confidence	0.571	0.094	0.014	−0.174
SCQ-N	0.465	0.017	0.083	0.157
Change in smoking	0.427	0.202	−0.011	−0.079
EDAYS	0.115	0.736	0.128	0.137
Times/day vaping	0.068	0.708	0.126	−0.094
eSCQ-P	0.193	0.645	0.185	0.123
No. of ECIG modifications	−0.020	0.099	0.700	−0.121
No. of non-tobacco flavors	0.106	0.035	0.679	0.030
Puffs/ECIG use	−0.135	0.201	0.472	0.038
No. of tobacco flavors	−0.036	−0.121	0.134	0.788
Nicotine strength	−0.097	0.050	−0.115	0.695
AVE	0.626	0.696	0.617	0.745
CR	0.773	0.739	0.650	0.711

SCQ-N = Smoking Consequence Questionnaire negative scale; EDAYS = vaping day frequency in the past month; eSCQ-P = e-cigarette Smoking Consequences Questionnaire positive scale; ECIG = e-cigarette; AVE = average variance extracted; CR = composite reliability.