Original investigation

The Relationships of Expectancies With E-cigarette Use Among Hospitalized Smokers: A Prospective Longitudinal Study

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Abstract

Background: Expectancies demonstrate cross-sectional associations with e-cigarette use, but the prospective relationships between expectancies and e-cigarette use are unknown. This study examined the longitudinal associations of expectancies with e-cigarette use among hospitalized tobacco cigarette smokers.

Methods: E-cigarette expectancies (e-cigarette-specific Brief Smoking Consequences Questionnaire-Adult [BSCQ-A]), tobacco cigarette expectancies (tobacco-specific BSCQ-A), and number of days used e-cigarettes in the past 30 days were assessed at baseline hospitalization, 6-months post-hospitalization, and 12-months post-hospitalization among 978 hospitalized tobacco cigarette smokers. Expectancy difference scores (e-cigarette-specific expectancies minus tobacco-specific expectancies) were computed for each of the 10 BSCQ-A scales. Cross-lagged panel models tested the relationships between expectancy difference scores and number of days used e-cigarettes in the past 30 days for each of the 10 BSCQ-A scales.

Results: Though some models revealed partial associations between expectancies and e-cigarette use, only one yielded results consistent with hypotheses. Greater e-cigarette use at baseline predicted greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at 6 months, which then predicted greater e-cigarette use at 12 months. To a lesser degree greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at baseline predicted greater e-cigarette use at 6 months, which then predicted greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at 12 months.

Conclusions: Expectancies that e-cigarettes provide similar or more pleasant taste sensations as compared to tobacco cigarettes may be both a cause and consequence of e-cigarette use. Focusing on the taste experience may prove most effective in modifying e-cigarette use behavior.

Implications: The current study offers the first longitudinal examination of expectancies and e-cigarette use. Results suggest expectancies that e-cigarettes provide similar or more pleasant taste

sensations relative to tobacco cigarettes are both a cause and consequence of e-cigarette use. Efforts that focus on the e-cigarette taste experience may prove most effective in modifying e-cigarette use behavior.

Introduction

In the absence of effective tobacco control, smoking is projected to claim the lives of 1 billion people this century.¹ Initial evidence suggests electronic cigarettes (e-cigarettes) may represent a viable harm reduction strategy for tobacco control²⁻⁶ and facilitate smoking cessation,⁷ though they may also present problems. For instance, nicotine delivered via e-cigarettes may still pose some cardiovascular risk,⁸ and e-cigarette use may lead to the initiation of tobacco cigarette use, sustain tobacco cigarette smoking, and promote nicotine dependence.^{9,10} These issues notwithstanding, the prevalence of e-cigarette use continues to rise. In 2014, 12.6% of US adults and 11.6% of European Union adults reported ever using e-cigarettes, up from 8.5% of US adults in 2013 and 7.2% of EU adults in 2012.¹¹⁻¹³ Most adults who have used e-cigarettes are current or former tobacco cigarette smokers.¹¹

In the United States and EU, e-cigarettes were largely unregulated until recently.^{14,15} They remain legal in most jurisdictions and readily available on the Internet even where they are banned.¹⁶ Considering that smokers view e-cigarettes as viable though imperfect substitutes for tobacco cigarettes,^{17,18} it is reasonable to assume that e-cigarette use will continue to endure across the globe. Elucidating the causal mechanisms underlying e-cigarette use is therefore needed to identify who is likely to use these products and why. This information can be used to inform the development of interventions designed to modify e-cigarette use behavior, including those intended to promote e-cigarette use as a harm reduction approach or discourage use patterns that serve to maintain the addiction to tobacco cigarettes.

Expectancies, the expected consequences of substance use, are well-supported mechanisms explaining smoking motivation and behavior that may also explain e-cigarette use.¹⁹ Indeed, contemporary theory posits that expectancies serve as a final common pathway involved in the substance use decision-making process.²⁰ With regard to e-cigarettes, however, expectancy research is sparse. Pokhrel et al.²¹ found that among college students, greater e-cigarette expectancies for social enhancement, affect regulation, and positive sensory experience were associated with a greater likelihood of past 30-day e-cigarette use, whereas greater e-cigarette expectancies for negative health outcomes, negative appearance, and negative sensory experience were associated with a lower likelihood of past 30-day e-cigarette use. In a study of young adult non-daily smokers, Doran and Brikmanis²² found that greater e-cigarette expectancies for affect regulation, social facilitation, and relief of tobacco cigarette craving were associated with greater past 14-day e-cigarette use. Harrell et al.,¹⁸ reporting on the results of an online survey, found differences in expectancies for e-cigarettes as compared to tobacco cigarettes among former smoker e-cigarette users. They also found differences in e-cigarette expectancies among e-cigarette/tobacco cigarette dual users relative to former smoker e-cigarette users, with intention to quit e-cigarette use among former smoker e-cigarette users predicted by greater expectancies that e-cigarettes damage health and cause addiction, and weaker expectancies that e-cigarettes taste good.²³ Using the same online survey data, Piñeiro et al.²⁴ reported modest gender differences in e-cigarette expectancies. Finally, our research group examined expectancies for e-cigarettes versus tobacco cigarettes among hospitalized smokers and found that these individuals

held weaker expectancies for both the positive and negative outcomes of e-cigarette use as compared to tobacco cigarette use. Among the best predictors of past 30-day e-cigarette use and intention to use e-cigarettes were expectancies that e-cigarettes taste pleasant, relieve negative affect, and satisfy the desire for nicotine.¹⁷

Though informative, all prior investigations of e-cigarette expectancies have been cross-sectional in nature, which precludes strong inferences of causal relationships. Consequently, expectancy researchers have called for prospective longitudinal designs to better inform the effect of expectancies on e-cigarette use.^{17,18,22-24} In this study, we administered an e-cigarette expectancy questionnaire based on the Brief Smoking Consequences Questionnaire-Adult (BSCQ-A; 17) along with the original, tobacco-specific BSCQ-A²⁵ to a sample of hospitalized cigarette smokers at baseline hospitalization, 6-months post-hospitalization, and 12-months post-hospitalization. Given that the perceived advantages and disadvantages of e-cigarettes relative to tobacco cigarettes may drive e-cigarette use,^{17,18} we computed expectancy difference scores (e-cigarette expectancies minus tobacco cigarette expectancies) for each of the 10 BSCQ-A scales. We then tested the longitudinal and reciprocal relationships between expectancy difference scores and e-cigarette use for each of the 10 BSCQ-A scales with cross-lagged panel models. We hypothesized that: (1) stronger positive and weaker negative expectancies for e-cigarettes at baseline would predict greater e-cigarette use at 6 months, which would in turn predict stronger positive and weaker negative expectancies for e-cigarettes at 12 months; and (2) greater e-cigarette use at baseline would predict stronger positive and weaker negative expectancies for e-cigarettes at 6 months, which would in turn predict greater e-cigarette use at 12 months. Although analyses were exploratory in nature, on the basis of our previous work, we anticipated strongest effects for expectancies pertaining to taste, negative affect reduction, and satisfaction of the desire for nicotine.¹⁷

Methods

Participants and Procedure

Participants were 979 tobacco cigarette smokers admitted for overnight stay in a tertiary academic center hospital in Birmingham, AL, and recruited to participate in a longitudinal observational study. Of these, 178 were concurrently enrolled in a randomized controlled trial of a web-based smoking cessation intervention (intervention condition $n = 92$, control condition $n = 86$). Though the assessment schedule was identical for all participants, those enrolled in the randomized controlled trial completed additional assessments related to tobacco use. Moreover, those in the intervention condition were sent automated emails promoting smoking abstinence and access to a website dedicated to smoking cessation. No information on e-cigarettes was provided. Complete details and results of the randomized controlled trial are reported elsewhere.²⁶

Inclusion criteria were: (1) ≥ 19 years of age; (2) identified as a tobacco cigarette smoker by hospital admission record and reported smoking within the past 30 days; (3) fluent in English; and (4) cognitively and physically able to complete assessments.

Patients admitted to maternity wards, locked psychiatric wards, and some intensive care units were not recruited for participation. Those who provided written informed consent completed a baseline assessment between December 2012 and September 2013. All participants were provided brief smoking cessation advice by staff at this time. Follow-up assessments were completed via mail and telephone 6-months post-hospitalization between May 2013 and May 2014 (follow-up rate = 84.3%) and 12-months post-hospitalization between November 2013 and October 2014 (follow-up rate = 82.8%). We applied the maximum-likelihood-based missing data adjustment,²⁷ leaving a final sample of 978. This study was approved by the University of Alabama at Birmingham's Institutional Review Board.

Measures

Demographic Questionnaire

An author-constructed questionnaire administered at baseline assessed gender, age, race, educational attainment, and marital status.

Charlson Comorbidity Index

The widely-used Charlson Comorbidity Index²⁸ was computed from baseline hospitalization International Classification of Diseases, Ninth Edition, discharge codes. The Charlson Comorbidity Index classifies the number and seriousness of participants' comorbid disease.

Brief Smoking Consequences Questionnaire-Adult (BSCQ-A)

An e-cigarette-specific²⁵ and tobacco-specific BSCQ-A were each administered at baseline, 6-months post-hospitalization, and 12-months post-hospitalization. Development of the e-cigarette-specific BSCQ-A, including confirmation of its factor structure and reliability, is described elsewhere.¹⁷ The e-cigarette-specific BSCQ-A instructs participants to rate how likely they believe 25 consequences are to occur when they use e-cigarettes whereas the tobacco-specific BSCQ-A instructs participants to rate how likely they believe the same 25 consequences are to occur when they use tobacco cigarettes (0 = "completely unlikely" to 9 = "completely likely"). Both versions of the BSCQ-A measure expectancies on the same 10 scales: (1) Negative Affect Reduction; (2) Stimulation/State Enhancement; (3) Health Risks; (4) Taste/Sensorimotor Manipulation; (5) Social Facilitation; (6) Weight Control; (7) Craving/Addiction; (8) Negative Physical Feelings; (9) Boredom Reduction; and (10) Negative Social Impression.

E-Cigarette Use Characteristics

An author-constructed questionnaire administered at baseline, 6-months post-hospitalization, and 12-months post-hospitalization assessed whether participants had ever heard of (yes/no) or used (yes/no) e-cigarettes. Use of e-cigarettes in the past 30 days (yes/no) also was assessed, as were number of days used e-cigarettes in the past 30 days (possible range 0–30; e-cigarette use has been similarly assessed in recent national surveys [eg, ²⁹]). Among those who reported using e-cigarettes in the past 30 days, preferred e-cigarette liquid flavor was queried, with response options corresponding to tobacco, menthol, food/dessert/fruit, or a combination of flavors.

Statistical Analysis

We calculated expectancy difference scores (e-cigarette expectancies minus tobacco cigarette expectancies) for each of the 10 BSCQ-A

scales (possible range –9.0 to 9.0). Greater expectancy difference scores could represent either less negative or more positive values. We then conducted cross-lagged panel analyses of data collected at baseline hospitalization, 6-months post-hospitalization, and 12-months post-hospitalization (Figure 1) in structural equation modeling using Mplus version 7.4.³⁰ Separate models were estimated for each of the 10 expectancy difference scores. Gender, age, race (white vs. other), educational attainment (less than a high school degree vs. a high school degree or more), marital status (married vs. not married), Charlson Comorbidity Index, and study condition (intervention, control, or observation only) were included as covariates in each model. The relationships between expectancy difference scores and e-cigarette use were modeled as lag 1 relationships and all models were estimated with the robust maximum likelihood estimation (mlr) method that uses the Yuan–Bentler robust chi-square and sandwich standard errors.³¹ Path coefficients are reported as standardized estimates.

Results

Sample and Descriptive Characteristics

Sample characteristics, BSCQ-A difference scores, and e-cigarette use characteristics across assessment periods are presented in Table 1. Participants were well distributed with regard to gender and were middle-aged on average, with approximately half identifying as white. One-fifth attained less than a high school degree, one-third was married, and, as a whole, the sample demonstrated low comorbidity. E-cigarette expectancies were weaker than tobacco cigarette expectancies on average. However, expectancies for e-cigarettes increased slightly relative to expectancies for tobacco cigarettes across assessment periods, with the exception of expectancies pertaining to irritation of the mouth and throat (*Negative Physical Feelings* scale) and social stigma (*Negative Social Impression* scale). Nearly all participants had ever heard of e-cigarettes across assessment periods, approximately half had ever used e-cigarettes at baseline with this proportion rising to over 60% by 12 months, and approximately one-fifth had used e-cigarettes in the past 30 days at baseline with this proportion increasing to approximately one-third by 12 months. Number of days used e-cigarettes in the past 30 days increased four-fold from baseline to 6 months and increased slightly from 6 months to 12 months. Among those who reported using e-cigarettes in the past 30 days, tobacco or menthol were the preferred e-cigarette liquid flavors for most, though food/dessert/fruit flavors nearly doubled in popularity from baseline to 12 months.

Primary Analyses

All 10 models demonstrated adequate to good fit (root mean square error of approximation [RMSEA] range = 0.03–0.06; standardized root mean square residual [SRMR] range = 0.02–0.03; and comparative fit index [CFI] range = 0.87–0.94;³²). Cross-lagged path models using the *Negative Affect Reduction*, *Stimulation/State Enhancement*, *Health Risks*, *Social Facilitation*, *Weight Control*, *Craving/Addiction*, *Negative Physical Feelings*, *Boredom Reduction*, and *Negative Social Impression* scales are presented in Supplementary Figures 1–9. In some of these models, the hypothesized relationships between expectancies and e-cigarette use were partially supported. Specifically, stronger expectancies that e-cigarettes control weight as compared to tobacco cigarettes (*Weight Control* scale) at baseline predicted greater e-cigarette use at 6 months (path coefficient = 0.22, $p = .03$), stronger expectancies that e-cigarettes satisfy the desire for

Figure 1. Cross-lagged path model of the relations between Brief Smoking Consequences Questionnaire-Adult Taste/Sensorimotor Manipulation difference scores (e-cigarette expectancies minus tobacco cigarette expectancies) and e-cigarette use (number of days used e-cigarettes in the past 30 days). Paths are adjusted for gender, age, race, educational attainment, marital status, Charlson Comorbidity Index, and study condition. Reported statistics are standardized path coefficients. † $p < .10$, * $p < .05$, *** $p < .001$.

Table 1. Sample Characteristics, Brief Smoking Consequences Questionnaire-Adult (BSCQ-A) Difference Scores, and E-cigarette Use across Assessment Periods

Variable	Assessment Period		
	Baseline	6 months	12 months
Gender (% Male)	54.4		
Mean age (SD, range)	45.49 (12.88, 19–75)		
Race (% white)	55.5		
Educational attainment (% < high school degree)	22.2		
Marital status (% married)	30.8		
Median Charlson Comorbidity Index (range)	1.0 (0–6)		
Mean BSCQ-A difference score (SD, range)			
Negative affect reduction	−2.20 (2.57, −9.0 to 6.17)	−1.86 (3.03, −9.0 to 9.0)	−2.03 (2.81, −9.0 to 9.0)
Stimulation/State enhancement	−0.91 (2.78, −9.0 to 9.0)	−0.49 (2.74, −9.0 to 9.0)	−0.47 (2.71, −9.0 to 9.0)
Health risks	−4.55 (3.12, −9.0 to 5.5)	−4.29 (3.34, −9.0 to 9.0)	−4.09 (3.23, −9.0 to 4.75)
Taste/Sensorimotor manipulation	−1.73 (2.96, −9.0 to 9.0)	−1.16 (3.43, −9.0 to 9.0)	−0.90 (3.49, −9.0 to 9.0)
Social facilitation	−0.74 (2.29, −9.0 to 7.67)	−0.35 (2.57, −9.0 to 9.0)	−0.31 (2.45, −9.0 to 8.0)
Weight control	−1.20 (2.53, −9.0 to 9.0)	−1.01 (2.62, −9.0 to 9.0)	−0.99 (2.60, −9.0 to 8.0)
Craving/addiction	−1.87 (2.74, −9.0 to 9.0)	−1.59 (3.27, −9.0 to 9.0)	−1.57 (3.18, −9.0 to 9.0)
Negative physical feelings	−0.66 (2.95, −9.0 to 9.0)	−0.88 (3.44, −9.0 to 9.0)	−0.79 (3.41, −9.0 to 9.0)
Boredom reduction	−1.60 (2.65, −9.0 to 7.5)	−1.13 (3.02, −9.0 to 9.0)	−1.11 (2.91, −9.0 to 9.0)
Negative social impression	−1.29 (2.20, −8.33 to 6.0)	−1.53 (2.62, −9.0 to 9.0)	−1.35 (2.54, −9.0 to 8.0)
Ever heard of e-cigarettes (%)	97.9	97.6	98.2
Ever used e-cigarettes (%)	49.5	58.7	63.2
Used e-cigarettes in the past 30 days (%)	20.9	27.3	30.8
Mean e-cigarette use (SD, range)	1.79 (5.50, 0–30)	4.01 (8.73, 0–30)	4.31 (8.78, 0–30)
Preferred e-cigarette flavor (%)			
Tobacco	48.8	44.0	40.0
Menthol	34.1	39.0	35.8
Food/Dessert/Fruit	7.7	8.0	14.9
A combination of flavors	9.4	9.0	9.3

Difference scores were computed by subtracting tobacco cigarette expectancies from e-cigarette expectancies. Possible range of difference scores is −9.0 to 9.0, with greater scores representing stronger expectancies for e-cigarettes as compared to tobacco cigarettes. E-cigarette use was assessed as number of days used e-cigarettes in the past 30 days.

nicotine as compared to tobacco cigarettes (*Craving/Addiction* scale) at 6 months predicted greater e-cigarette use at 12 months (path coefficient = 0.19, $p = .04$), weaker expectancies that e-cigarettes irritate the mouth and throat as compared to tobacco cigarettes (*Negative Physical Feelings* scale) at baseline predicted more e-cigarette use at 6 months (path coefficient = −0.22, $p = .02$), and weaker expectancies that e-cigarettes irritate the mouth and throat as compared to tobacco cigarettes at 6 months predicted more e-cigarette use at 12 months (path coefficient = −0.26, $p = .001$). Moreover, greater e-cigarette use at 6 months predicted weaker expectancies

that e-cigarettes pose health risks (*Health Risks* scale; path coefficient = −0.03, $p = .01$) and that e-cigarette use is stigmatizing (*Negative Social Impression* scale; path coefficient = −0.02, $p = .01$) as compared to tobacco cigarettes at 12 months.

Only one model, however, displayed significant relationships between expectancies and e-cigarette use as hypothesized. As shown in Figure 1, greater e-cigarette use at baseline predicted greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes (*Taste/Sensorimotor Manipulation* scale) at 6 months. Greater expectancies that e-cigarettes taste pleasant as compared to

tobacco cigarettes at 6 months, in turn, predicted greater e-cigarette use at 12 months. A test of mediation using the INDIRECT command in Mplus indicated a near-significant effect (estimate = 0.01, standard error = 0.008, $p = .05$). Furthermore, though results were marginally significant, greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at baseline predicted greater e-cigarette use at 6 months, which then predicted greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at 12 months. A test of mediation failed to indicate a significant effect for these associations (estimate = 0.004, standard error = 0.003, $p = .27$).

All 10 models also were estimated with e-cigarette use classified dichotomously (any use of e-cigarettes in the past 30 days vs. no use of e-cigarettes in the past 30 days). Results were similar to original analyses with e-cigarette use classified continuously, although a number of path coefficients that were previously significant with e-cigarette use classified continuously were no longer significant in models with e-cigarette use classified dichotomously. This is likely attributable to reduced power associated with dichotomizing continuous data.³³

Exploratory Analyses

Exploratory analyses evaluated the effect of including tobacco cigarette use (number of days smoked tobacco cigarettes in the past 30 days) at baseline, 6 months, and 12 months in all 10 cross-lagged panel models. Each of these models demonstrated poor fit (RMSEA range = 0.101–0.106; SRMR range = 0.052–0.055; and CFI range = 0.52–0.64;³²), suggesting tobacco cigarette use did not impact expectancy difference scores or e-cigarette use. Of note, 100%, 90.2%, and 87.2% of those who used e-cigarettes in the past 30 days also smoked tobacco cigarettes in the past 30 days (ie, were e-cigarette/tobacco cigarette dual users) at baseline, 6 months, and 12 months, respectively. Moreover, number of days used e-cigarettes in the past 30 days was not associated with number of days smoked tobacco cigarettes in the past 30 days at baseline ($r = -0.01$, $p = .60$), and only modestly associated with number of days smoked tobacco cigarettes in the past 30 days at 6 months ($r = -0.08$, $p = .01$) and 12 months ($r = -0.08$, $p = .01$). Similar results were obtained when tobacco cigarette use was operationalized as average number of tobacco cigarettes smoked per day in the past 30 days.

Linear regression analyses also evaluated the effect of preferred e-cigarette liquid flavor (tobacco or menthol [coded as 1] vs. food/dessert/fruit or a combination of flavors [coded as 2]) on Taste/Sensorimotor Manipulation difference scores at 6 and 12 months. In unadjusted models, preferred e-cigarette liquid flavor at baseline was not associated with Taste/Sensorimotor Manipulation difference score at 6 months (standardized $\beta = 0.01$, $p = .83$), whereas those reporting a preference for food/dessert/fruit or a combination of flavors at 6 months reported greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at 12 months (standardized $\beta = 0.11$, $p = .02$). In a model adjusted for Taste/Sensorimotor Manipulation difference score at baseline, gender, age, race, educational attainment, marital status, Charlson Comorbidity Index, and study condition, preferred e-cigarette liquid flavor at baseline was not associated with Taste/Sensorimotor Manipulation difference score at 6 months (standardized $\beta = -0.07$, $p = .35$). Similarly, in a model adjusted for Taste/Sensorimotor Manipulation difference score at 6 months, gender, age, race, educational attainment, marital status, Charlson Comorbidity Index, and study condition, preferred e-cigarette liquid flavor at 6 months was not associated with Taste/

Sensorimotor Manipulation difference score at 12 months (standardized $\beta = -0.03$, $p = .49$).

Discussion

The objective of the present study was to evaluate the longitudinal and reciprocal relationships between expectancies for e-cigarettes as they compare to expectancies for tobacco cigarettes, and e-cigarette use. We accomplished this objective by assessing e-cigarette and tobacco cigarette expectancies as well as e-cigarette use among hospitalized tobacco smokers at baseline hospitalization, 6 months post-hospitalization, and 12 months post-hospitalization. We hypothesized that stronger positive and weaker negative expectancies for e-cigarettes at baseline would predict greater e-cigarette use at 6 months, which would in turn predict stronger positive and weaker negative expectancies for e-cigarette use at 12 months. We also hypothesized that greater e-cigarette use at baseline would predict stronger positive and weaker negative expectancies for e-cigarettes at 6 months, which would then predict greater e-cigarette use at 12 months.

Some results revealed partial associations linking expectancies and e-cigarette use. Greater expectancies that e-cigarettes control weight and satisfy the desire for nicotine and weaker expectancies that e-cigarettes irritate the mouth and throat as compared to tobacco cigarettes predicted greater e-cigarette use. Moreover, greater e-cigarette use predicted weaker expectancies that e-cigarettes pose health risks and that e-cigarette use is stigmatizing as compared to tobacco cigarettes. These results are consistent with prior cross-sectional investigations,^{21–23} and add to the literature by identifying those expectancies that precede e-cigarette use and those that follow it. Efforts designed to modify e-cigarette use might do well to focus on those expectancies that appear to play a causal role in the behavior (weight control, craving relief, and negative physical feelings) as opposed to those that may be a consequence of use (health risks, negative social impacts), though obviously further studies are needed to reach more definitive conclusions.

Nevertheless, only one expectancy domain—namely, expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes—yielded results consistent with hypotheses. Greater e-cigarette use at baseline predicted greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at 6 months, which then predicted greater e-cigarette use at 12 months. To a lesser extent expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at baseline predicted greater e-cigarette use at 6 months, which then predicted greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes at 12 months. These findings are consistent with leading contemporary theories of addiction motivation that underscore the importance of the drug self-administration ritual.^{34,35} According to these theories, smokers learn that the act of smoking is an effective means of regulating withdrawal via repeated pairings of cigarette use with nicotine administration (see ^{36,37}). Of course, the act of smoking comprises a number of sensorimotor characteristics including taste. In support of this view, denicotinized cigarettes have been shown to suppress withdrawal symptoms (eg, ^{38–43}) and nicotine replacement therapies only partially alleviate withdrawal symptoms even at very high doses (eg, ⁴⁴).

Because participants reported weaker expectancies for e-cigarettes relative to tobacco cigarettes on average, greater expectancy difference scores by and large reflected smaller absolute values, or e-cigarette expectancies that more closely approximated tobacco cigarette expectancies. The current results may therefore suggest that

with greater e-cigarette use, the majority of smokers may be more likely to expect e-cigarettes to produce similar taste sensations as tobacco cigarettes; and as these smokers are more likely to expect e-cigarettes to produce similar taste sensations as tobacco cigarettes, they are more likely to use e-cigarettes. Consistent with this interpretation, tobacco or menthol are the preferred e-cigarette liquid flavors among approximately 80% of e-cigarette users⁴⁵; analysis of the current data revealed similar trends (among participants who used e-cigarettes, 75.8% to 83% reported using tobacco or menthol e-cigarette liquid flavor across assessment periods). E-cigarette liquids are, however, available in an array of additional flavors that may be growing in popularity and appear to play an important role in e-cigarette use (see ^{46,47}). Indeed, a number of participants in the current study reported stronger taste expectancies for e-cigarettes as compared to tobacco cigarettes (23.1%, 24.8%, and 28.6% of participants at baseline, 6 months, and 12 months, respectively), and exploratory analyses provided some evidence that food/dessert/fruit or a combination of e-cigarette liquid flavors may be associated with greater expectancies that e-cigarettes taste pleasant as compared to tobacco cigarettes. Thus, the current findings may also point to unique effects of novel e-cigarette liquid flavors in providing pleasant taste sensations that exceed those of tobacco cigarettes.

It is not clear why other expectancy domains associated with intention to use e-cigarettes at baseline failed to yield results consistent with hypotheses in the current longitudinal analysis (eg, negative affect reduction;¹⁷). A simple explanation is that behavioral intentions are inconsistently related to actual behavioral outcomes.⁴⁸ Another explanation is that, assuming expectancies operate primarily outside of conscious awareness,⁴⁹ taste expectancies may be unique in their ability to tap associative processes not otherwise available to conscious awareness. If true, this account would further emphasize the significance of the drug self-administration ritual.

Results should be considered in light of a number of limitations. First, though hospitalized smokers may be an especially appropriate population for informing the effect of e-cigarette expectancies on e-cigarette use,¹⁷ our findings may not generalize to other populations, particularly those that are tobacco cigarette naïve. Second, although the range of expectancies relevant to tobacco cigarette use was assessed, we did not capture expectancies specific to e-cigarette use (eg, the utility of e-cigarettes in facilitating a smoking cessation attempt or allowing nicotine use where smoking is forbidden). Future investigations evaluating the impact of expectancies on e-cigarette use should include measures that assess such expectancies (eg, ²¹). Third, e-cigarette expectancies may represent “moving targets” expected to shift in response to changing population use patterns, product exposure, and engineering alterations. Whether the current results might be applicable in the years to come is unknown. This argues for continued study of expectancies and e-cigarette use. Finally, evaluating the moderating effect of e-cigarette use characteristics was beyond the scope of the present investigation. It is nonetheless possible that the relationships described here may vary depending on the type of e-cigarette, liquid nicotine concentration, or flavored liquid used. These are questions for future research.

Conclusions

The current study offers the first longitudinal examination of expectancies and e-cigarette use. Results suggest expectancies that e-cigarettes provide similar or more pleasant taste sensations relative to tobacco cigarettes are both a cause and consequence of e-cigarette

use. This information can be used to inform the development of regulations, public health campaigns, and other interventions designed to modify e-cigarette consumption. Those intended to promote e-cigarette use as a harm reduction approach could accentuate the flavored liquids available, including tobacco and menthol, and when possible provide direct experience with these flavored liquids. Those designed to discourage e-cigarette use might downplay the degree to which e-cigarette taste sensations approximate or exceed those of tobacco cigarettes, though such expectancies may be more crystallized among those with a more extensive history of e-cigarette use. In addition, regulations might restrict available flavors, and behavioral interventions might make use of aversion therapies that involve the use of unpleasant-tasting flavored liquids. These proposals aside, future studies could benefit from incorporating the current results in developing novel e-cigarette promotion and prevention strategies.

Supplementary Material

Supplementary data are available at *Nicotine & Tobacco Research* online.

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Declaration of Interests

None declared.

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