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Brief report

E-Cigarette Susceptibility as a Predictor of Youth Initiation of E-Cigarettes

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Abstract

Introduction: Identifying youth at risk for future e-cigarette use is critical for informing prevention efforts. Prior research established measures of susceptibility to conventional cigarettes, and this study aimed to examine whether items adapted for e-cigarette susceptibility predicted subsequent e-cigarette use among never e-cigarette users.

Methods: Longitudinal school-wide survey data were collected from middle and high school students in Fall 2013 (wave 1) and Spring 2014 (wave 2). Among never e-cigarette users at wave 1 (n = 1720), e-cigarette susceptibility was measured by two items assessing anticipation of experimenting with e-cigarettes in the future and willingness to use an e-cigarette if offered by a best friend. Logistic regression models examined susceptibility as a predictor of e-cigarette initiation and past 30-day use 6 months later at wave 2. Models were clustered by school and controlled for sex, age, race, SES, and other substance use (alcohol, marijuana, and other tobacco).

Results: In total, 8.9% (n = 153) of youth initiated e-cigarettes and 3.7% (n = 63) reported past 30-day use at wave 2. E-cigarette susceptibility was a significant independent predictor of subsequent initiation (OR = 4.27, 95% CI = 3.12–5.85) and past 30-day e-cigarette use (OR = 5.10, 95%CI = 3.38–7.68) 6 months later. Susceptible youth were more likely to be male, older, and have used alcohol, marijuana, or other tobacco products.

Conclusions: These findings provide initial support for adapting two susceptibility items to identify adolescents at risk for future e-cigarette use. Identifying strategies that are effective for targeting susceptible youth and preventing future e-cigarette use will be critical areas for future research.

Implications: More than a quarter of the sample who reported both a willingness to try e-cigarettes if offered by a best friend and anticipation of experimenting with e-cigarettes in the future went on to try e-cigarettes within the academic year, suggesting that targeting this group will be critical for preventing youth e-cigarette initiation. There were notable demographic differences between susceptible and non-susceptible youth, suggesting targeting e-cigarette prevention efforts to male students who have used other substances may be especially important for preventing future e-cigarette use. Research is needed to determine the most effective prevention strategies to reach susceptible youth.

Introduction

National data indicate e-cigarette use among youth has recently increased, with current (past 30-day) e-cigarette use rates escalating between 2011 and 2015 (0.6–5.3% among middle school and 1.5–16.0% among high school students).[1] E-cigarette use among youth, especially those who are not current cigarette smokers, is concerning given that little is known about the health effects of e-cigarettes

at this time.[2] The 2016 Surgeon General report on e-cigarette use among youth and young adults cites a critical need to prevent youth initiation of e-cigarettes.[3] Identifying youth susceptible to future e-cigarette use may help inform prevention efforts.

Previous research validated questions to assess future risk for trying conventional cigarettes among youth. Pierce *et al.* demonstrated that cigarette susceptibility, measured by questions: "do you think that you will try a cigarette soon?"; "do you think that you will be smoking cigarettes 1 year from now?"; and "if one of your best friends were to offer you a cigarette, would you smoke it?", was a strong independent predictor (above and beyond demographic factors such as race, sex, and SES) of cigarette initiation and established smoking behavior in a large-scale longitudinal study.[4] Currently, it is unknown whether similar questions adapted for e-cigarette susceptibility predict e-cigarette initiation.

To date, e-cigarette susceptibility has only been examined in cross-sectional studies.[5–8] These data have helped identify characteristics of never users that are associated with greater e-cigarette susceptibility, such as being younger, male, Caucasian, a current cigarette smoker, or using alcohol or other tobacco.[5,8] However, longitudinal research is needed to examine whether e-cigarette susceptibility predicts subsequent e-cigarette initiation among youth.

The current study used longitudinal school-wide survey data from middle and high schools in Connecticut to examine whether e-cigarette susceptibility predicted subsequent e-cigarette initiation 6 months later among never using youth (n = 1720). E-cigarette susceptibility was measured by two items adapted from earlier research.[3] Logistic regression models examined susceptibility items separately and combined in a composite score to identify the unique variance accounted for by each item as well as the possible additive effects of susceptibility items. Similar to analyses by Pierce *et al.*,[4] we examined whether susceptibility was a significant independent predictor of initiation above and beyond demographic factors (eg, race, sex, SES), given evidence that these factors relate to youth e-cigarette use.[4,7] In addition, we controlled for other substance use (eg, ever use of alcohol, marijuana, or other tobacco) given that youth using other products may be more likely to initiate e-cigarettes.

Methods

Study Procedures

Study procedures were approved by the Yale Institutional Review Board and participating schools. Survey responses were confidential and anonymous, and students were informed that participation was voluntary. Parents were contacted in advance of the study and could indicate if they did not want their child to participate. No parents from wave 1 (Fall 2013) and 12 parents from wave 2 (Spring 2014) declined participation for their child. Teachers distributed paper-and-pencil surveys to all students across two middle schools and three high schools (see references for detailed procedures).[5,9,10]

Responses were matched across waves using a self-generated identification code, SGIC[11,12] instead of student name, comprised of six unique indicators (eg, day value from date of birth). This procedure is helpful for preserving anonymity and encouraging accurate reporting of youth substance use. The match rate of our sample was 72.0%, representing n = 2100 students out of n = 2915 who provided data at both surveys, comparable to match rates in other anonymous longitudinal surveys.[12,13] The matched versus unmatched sample were similar except for slight differences in age (mean ± SD age, 14.4 ± 1.9 matched vs. 14.6 ± 2.0 years unmatched, t[1208.4] = 2.70, p = .007) and sex (77.7% matched female) vs. (71.0% matched male), χ^2 [n = 2822] = 16.72; p < .001); although these differences were small and unlikely to bias the observed results.

Participants

We examined a subsample of youth who had never tried e-cigarettes or cigarettes at wave 1 (n = 1720, 53.9% female, 14.6 ± 2.0 years old). Few youth who were never users of e-cigarettes reported trying conventional cigarettes (2.1%) at wave 1. Results were unchanged with and without these individuals who had previously tried conventional cigarettes, so analyses focus on youth who were naïve to either product. School socioeconomic status (SES) was determined based on District Reference Groups[14,15] (DRGs: school groupings rated A through I based on indicators of socioeconomic status, parental education, and financial need), with 49.2% of the sample from a higher SES (DRG B) and 50.8% from a lower SES area (DRG D and E).

E-Cigarette Susceptibility

Two questions at wave 1 characterized e-cigarette susceptibility: "If one of your best friends offered you an e-cigarette, would you smoke it?" and "Do you think that in the future you might experiment with e-cigarettes?" rated as "Definitely not," "Probably not," "Probably yes," or "Definitely yes". Our survey did not include a third susceptibility item assessing plans to be smoking a year from now; however, our follow-up timeline was limited to 6 months later. Following the same guidelines used by Pierce *et al.*[4,16], susceptibility was classified as any response other than "Definitely not" for each item.

E-Cigarette Use

At both surveys, we assessed e-cigarette use by asking "Have you ever tried e-cigarettes? (yes/no)" and quantified e-cigarette use with an open-response question asking "How many days out of the past 30 days did you use e-cigarettes?". Adolescents who reported never trying an e-cigarette at wave 1, who later responded "yes" to trying an e-cigarette at wave 2 were classified as *initiators*. Youth who reported at least 1 day of e-cigarette use in the past 30 days at wave 2 were classified as *current e-cigarette users*.

Other Substance Use

Ever use of other substances was assessed at wave 1 by asking students if they had ever tried the following "cigar, cigarillo, smokeless tobacco, blunt, hookah, alcohol, and marijuana". Ever use of other tobacco products, alcohol, and marijuana were added as separate covariates (yes/no).

Data Analysis

We analyzed youth who had never tried cigarettes or e-cigarettes at wave 1 (n = 1720). Logistic regression models with maximum likelihood estimation were run using MPlus software to examine whether e-cigarette susceptibility at wave 1 predicted e-cigarette status 6 months later at wave 2. All models included school as a cluster variable and controlled for covariates including age, race (white vs. other), sex, school SES (high vs. low), and ever use of alcohol, marijuana, or other tobacco products (ie, cigar, cigarillo, smokeless, hookah, blunt). There were no missing data on these predictors with the exception of age (missing for 3.8% of cases, n = 66). Where possible, age recorded at follow-up 6 months later was imputed for missing data at wave 1, resulting in complete cases for 99.4% of the sample. Outcomes were coded as e-cigarette initiation (yes = 1,

no = 0) to identify youth who tried e-cigarettes at least once, and past 30-day use (yes = 1, no = 0) to identify youth who were current users at wave 2. Separate models were run with susceptibility entered (a) as two separate items (susceptible to each item separately, yes vs. no) to examine the unique variance accounted for by each, (b) a composite score (0 = not susceptible, 1 = susceptible to either item), and (c) a scaled score (0 = not susceptible, 1 = one response indicating susceptibility, 2 = two responses indicating susceptibility) to examine possible additive effects of susceptibility items.

Results

Among youth who had never used cigarettes or e-cigarettes (n = 1720), 28.4% were susceptible, indicated by a positive response to at least one of the two e-cigarette susceptibility survey items. Comparing demographics between susceptible (n = 489) and non-susceptible (n = 1231) youth indicated susceptible youth are slightly older (14.7 ± 1.8 vs. 14.5 ± 2.0 non-susceptible, p = .02), more likely to be male (51.9 vs. 43.8% non-susceptible, p = .002) and report ever use of other tobacco products (8.2 vs. 1.9% non-susceptible, p < .001), alcohol (24.7 vs. 10.0% non-susceptible, p < .001), and marijuana (5.1 vs. 1.5% non-susceptible, p < .001). Susceptibility did not differ by race or school SES.

Six months later, 8.9% (n = 153) of youth initiated e-cigarettes and 3.7% (n = 63) reported past 30-day use of e-cigarettes. By comparison, 3.1% (n = 53) of youth initiated conventional cigarettes and 0.9% (n = 16) reported past 30-day use of cigarettes 6 months later. Results indicate significant univariate associations between e-cigarette susceptibility items and e-cigarette outcomes at follow-up (Table 1).

Multivariable logistic regression models examined e-cigarette susceptibility as a predictor of e-cigarette onset at wave 2 (Table 2). Notably, youth reporting susceptibility on either item (ie, a willingness to try e-cigarettes if offered by a best friend or an interest in experimenting with e-cigarettes in the future) had greater odds of e-cigarette use at follow-up than youth who were not susceptible. Youth indicating susceptibility on both items were more than five times as likely to initiate e-cigarettes and were more than seven times as likely to report using e-cigarettes in the past month, compared to youth who were not susceptible. E-cigarette susceptibility predicted subsequent initiation and use above and beyond other baseline predictors from wave 1.

Discussion

The current study examined e-cigarette susceptibility among youth naïve to e-cigarettes or cigarettes as a predictor of e-cigarette initiation 6 months later. The results indicated that e-cigarette susceptibility was a significant independent predictor of future initiation and past 30-day use of e-cigarettes. E-cigarette susceptibility was measured by two items assessing plans to experiment with e-cigarettes in the future and willingness to try e-cigarettes if offered by a best friend, adapted from research on conventional cigarette susceptibility.[4,16] These findings build on research indicating curiosity and peer use influence e-cigarette use and perceptions,[9,17] and indicate that youth endorsing these susceptibility items are at greater risk for future e-cigarette use.

Specifically, a composite measure of susceptibility, where youth indicated susceptibility on both items, predicted the greatest likelihood of e-cigarette initiation and current use at follow-up. More than a quarter of the sample susceptible on both items went on to try e-cigarettes within the academic year, suggesting that prevention efforts targeting this group will be critical for reducing rates of e-cigarette initiation among youth. Importantly, e-cigarette susceptibility was an independent predictor of future e-cigarette use above and beyond other demographic characteristics (age, race, sex, school SES, and other substance use, including use of alcohol, marijuana, or other tobacco products).

While the results provide new information about e-cigarette susceptibility and have potentially important clinical implications, the following limitations should be considered. First, analyses examined e-cigarette initiation among youth naïve to both e-cigarettes and cigarettes. However, results were consistent with or without ever cigarette users. Only 2.1% of youth naïve to e-cigarettes reported

Table 1. Never Smokers' Rates of First Trying and Currently Using E-cigarettes by E-cigarette Susceptibility Score

		E-cigarette use status, wave 2	
Susceptibility responses, wave 1	*N*	Initiation	Current use (past 30 days)
If one of your best friends offered you an e-cigarette, would you smoke it?			
Yes	376	23.4%	10.9%
No	1344	4.8%	1.6%
p value		p < .001	p < .001
Do you think that in the future you might experiment with e-cigarettes?			
Yes	424	20.5%	10.4%
No	1296	5.1%	1.5%
p value		p < .001	p < .001
Composite E-cig susceptibility, susceptible to either			
Yes	489	19.6%	9.2%
No	1231	4.6%	1.5%
p value		p < .001	p < .001
Scaled susceptibility score			
0	1231	4.6%	1.5%
1	178	9.6%	2.8%
2	311	25.4%	12.9%
p value		p < .001	p < .001

p-values reflect Pearson chi-square tests. Composite susceptibility, susceptible to either item = yes, susceptible to neither item = no. Scaled susceptibility, 0 = not susceptible, 1 = one response indicating susceptibility, 2 = two responses indicating susceptibility.

Table 2. Never Smokers' E-cigarette Susceptibility Score as a Predictor of First Trying and Currently Using E-cigarettes Over Time ($N = 1720$)

	E-cigarette use status, wave 2	
	Initiation	Current use (past 30 days)
Variable	OR [95% CI]	OR [95% CI]
Model 1: separate susceptibility items		
Best friend offered	**3.20 [2.17–4.70]**	**2.18 [1.38–3.44]**
Try in future	**1.80 [1.36–2.37]**	**3.49 [2.67–4.56]**
Covariates		
Age	1.12 [0.94–1.35]	1.08 [0.90–1.29]
Female (vs. male)	**1.17 [1.03–1.33]**	1.30 [0.99–1.72]
White (vs. other)	0.72 [0.51–1.03]	0.70 [0.42–1.18]
Alcohol ever (vs. no)	1.92 [0.96–3.86]	**2.68 [1.12–6.43]**
Marijuana ever (vs. no)	1.18 [0.86–1.64]	0.78 [0.46–1.33]
Other tobacco ever (vs. no)	**3.52 [2.20–5.62]**	**4.00 [1.90–8.42]**
School SES low (vs. high)	1.77 [0.93–3.37]	1.33 [0.46–3.82]
Model 2: composite susceptibility		
Not susceptible	1.00	1.00
Any yes response	**4.27 [3.12–5.85]**	**5.10 [3.38–7.68]**
Covariates		
Age	1.14 [0.94–1.38]	1.08 [0.89–1.32]
Female (vs. male)	**1.14 [1.01–1.30]**	**1.27 [1.01–1.61]**
White (vs. other)	**0.72 [0.52–0.98]**	0.66 [0.38–1.16]
Alcohol ever (vs. no)	1.94 [0.91–4.14]	**2.72 [1.04–7.06]**
Marijuana ever (vs. no)	1.18 [0.90–1.54]	0.79 [0.50–1.26]
Other tobacco ever (vs. no)	**3.54 [2.18–5.73]**	**4.07 [1.98–8.40]**
School SES low (vs. high)	1.78 [0.92–3.46]	1.35 [0.46–3.98]
Model 3: scaled susceptibility		
Not susceptible	1.00	1.00
Susceptible level 1	**1.94 [1.19–3.15]**	1.49 [0.44–5.04]
Susceptible level 2	**5.73 [3.83–8.58]**	**7.20 [4.27–12.15]**
Covariates		
Age	1.12 [0.93–1.36]	1.06 [0.88–1.28]
Female (vs. male)	**1.18 [1.02–1.36]**	1.30 [0.98–1.72]
White (vs. other)	0.74 [0.53–1.03]	0.69 [0.42–1.16]
Alcohol ever (vs. no)	1.96 [0.96–4.02]	**2.78 [1.11–6.96]**
Marijuana ever (vs. no)	1.18 [0.86–1.61]	0.78 [0.43–1.39]
Other tobacco ever (vs. no)	**3.56 [2.28–5.56]**	**4.19 [1.76–9.92]**
School SES low (vs. high)	1.77 [0.94–3.35]	1.32 [0.46–3.80]

OR = odds ratio, adjusted for all the variables in each model and clustered by school. 95%CI = 95% confidence interval. Bold values indicate significant estimates where confidence intervals do not overlap 1.00 ($p < .05$). Composite susceptibility = yes response to either susceptibility item. Scaled susceptibility level 1 = one response indicating susceptibility; level 2 = two responses indicating susceptibility. School SES was characterized by district reference groups (DRGs: school groupings rated A through I based on indicators of socioeconomic status, parental education, and financial need).

ever trying cigarettes, so we are unable to examine differences in e-cigarette initiation by cigarette status. Future longitudinal work should consider possible bidirectional effects of susceptibility and initiation of cigarettes and e-cigarettes. Second, we surveyed a relatively diverse area including multiple schools; however, our results may not generalize to other geographic locations. Furthermore, we examined e-cigarette initiation over a 6-month interval, and did not include the susceptibility item assessing plans to be smoking 1 year from now. Future work should examine this additional item and evaluate how susceptibility relates to initiation and escalation to more consistent use over longer intervals. Lastly, we sought to examine the utility of these two e-cigarette susceptibility items as predictors of initiation. Other factors may influence susceptibility to e-cigarettes (eg, parental influence, marketing/advertisement exposure, community smoking norms), and additional longitudinal research is needed to determine the most influential risk factors of future use to inform prevention efforts. However, earlier work indicated susceptibility predicted conventional cigarette initiation above and beyond other influences (eg, school performance, parent education, income, exposure to family and friends who are smokers),[4] suggesting susceptibility is an important independent predictor of future initiation.

The current study is one of the first to longitudinally validate e-cigarette susceptibility as a predictor of e-cigarette initiation among youth. The robust relationship between e-cigarette susceptibility and future use suggests these items can predict which adolescents are at risk for trying e-cigarettes in the future. Identifying strategies that are effective for targeting susceptible youth and preventing future e-cigarette use will be critical areas for future research.

Declaration of Interests

None declared.

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