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Impulsivity-related personality traits as predictors of e-cigarette use among young adults over time

Ankita Mittal[1,#],

Ashley Du[1,#],

William Merz[1,#],

Mark G. Myers[2,4],

Laura E. Crotty Alexander[3,1],

Neal Doran[2,4]

[1]Division of Pulmonary, Critical Care and Sleep Medicine, Department of Medicine

[2]Department of Psychiatry, University of California San Diego, La Jolla, CA, United States

[3]Section of Pulmonary and Critical Care Medicine, La Jolla, CA, United States

[4]Psychology Service, Veterans Affairs San Diego Healthcare System, La Jolla, CA, United States

Abstract

Introduction: There has been rising concern about e-cigarette usage among teenagers and young adults. As knowledge about the adverse health effects of e-cigarettes accumulates, it is critical to identify factors that may increase risk of vaping initiation and frequency of use. One potential risk factor known to increase risk for other substance use is impulsivity. This study tested the hypothesis that impulsivity prospectively predicts vaping over time.

Methods: Active e-cigarette users (n=137; 51.8% male; Mean age 20 years at baseline) completed 8 waves of assessment over 21 months (2017–2020). The S-UPPS-P impulse behavior scale was used at baseline to measure impulsivity, and frequency of e-cigarette, cigarette, marijuana and alcohol use was calculated at each wave thereafter.

Results: Vaping frequency declined over time [Incidence Rate Ratio (IRR) = 0.92]. There were significant, stable, positive associations between e-cigarette use and lack of premeditation (IRR=1.06) and sensation seeking (IRR=1.09). Vaping frequency was inversely associated with negative urgency (IRR=0.95). Positive urgency and lack of perseverance were not associated with frequency of vaping.

Conclusion: These findings suggest that young adults who have higher impulsivity of certain types may use e-cigarettes more frequently. Thus, vaping interventions for young adults should address these factors to ensure the greatest impact on public health.

Corresponding author: Neal Doran, MC 116B, 3350 La Jolla Village Drive, San Diego, CA 92161, nmdoran@health.ucsd.edu, Telephone number: 858-201-1998.
[#]Authors contributed equally

Disclosure of interest: The authors declare no conflict of interest.

Keywords

E-cigarette; Impulsivity; Nicotine; UPPS-P model; Vaping

Introduction

Use of electronic cigarettes (e-cigarettes) has exploded over the past decade in the U.S. young adult population (Dai & Leventhal, 2019). Monitoring the Future data suggest prevalence of past 30-day use increased from 6% of 19–30 year-olds in 2017 to 14% of the same group in 2019 and 2020 (Schulenberg et al., 2021). E-cigarettes are viewed and marketed as a safer, more socially acceptable alternative to combustible cigarettes (Collins et al., 2019). However, evidence of e-cigarette aerosols causing cardiopulmonary disease and increasing health risks has been growing (Masso-Silva et al., 2021; Sharma et al., 2021; Ween et al., 2021; Bozier et al., 2020; Tsai et al., 2020). While key chemicals within e-cigarette solutions (propylene glycol and glycerol) are approved for consumption in food products, little information exists regarding the effects of inhaling these substances chronically. Atomizers from e-cigarettes can release traces of metals such as lead, cadmium, nickel, chromium, or tin into these aerosols (Mikheev et al., 2016). These metals can cause oxidative stress and damage different organs and organ systems (Tegin et al., 2018). Another concern regarding e-cigarette use in youth and young adults is the possibility that it could increase the likelihood of conventional cigarette smoking. E-cigarette use has been be associated with future cigarette use among adolescent never-smokers (Bold et al., 2018; Leventhal et al., 2015), and escalating cigarette use among young adult light smokers (Doran et al., 2017).

Given the risks of e-cigarette use, it is essential to identify factors that may contribute to initiation of vaping. One potential risk factor is impulsivity (Bold et al., 2017; Reff & Baschnagel, 2021), which refers to a tendency toward premature or reckless action. The UPPS-P model conceptualizes impulsivity as comprised of five distinct but related characteristics, each reflecting a tendency toward rash action under specific circumstances. Positive and negative urgency are defined by proneness to impulsive action in response to strong positive and negative moods, respectively; sensation seeking is defined by pursuit of novel, exciting experiences; lack of premeditation is a tendency to act without considering the consequences; and lack of perseverance is difficulty remaining focused on a task (Cyders & Smith, 2007; Lynam et al., 2006).

Impulsivity is increasingly recognized as a multifaceted construct implicated in substance use, especially in adolescents and young adults (Kaiser et al., 2016; Birkley & Smith, 2011; VanderVeen et al., 2016), and has been associated with cigarette smoking and nicotine dependence (Doran et al., 2009; Mitchell 1999; Kale et al., 2018). In terms of the UPPS-P model, positive and negative urgency have been associated with higher nicotine dependence in adult smokers (Pang et al., 2014), and negative urgency appears to be a strong predictor of daily vs. non-daily cigarette smoking in young adults (Lee et al., 2015). Some work has also indicated a link between impulsivity and e-cigarette consumption. In cross-sectional studies, impulsivity has been associated with younger age of e-cigarette initiation and increased

e-cigarette susceptibility and use (Bold et al., 2017; Conner et al., 2019; Grant et al., 2019, Reff & Baschnagel, 2021). Preliminary studies suggest young adult e-cigarette users tend to score higher on positive and negative urgency, sensation seeking, and lack of premeditation (Doran & Tully, 2018; Lanza et al., 2020).

Given the prevalence of e-cigarette use, better understanding of the role of predictors such as impulsivity in patterns of vaping is needed to better inform interventions. The goal of the present study was to evaluate impulsivity as a prospective predictor of e-cigarette use in young adult users over time. We predicted that participants with higher baseline positive urgency, negative urgency, sensation seeking, and lack of premeditation would higher levels of e-cigarette use over time.

Methods

Participants

Young adult e-cigarette users (n = 137; Mean age at baseline = 20.0, SD = 1.6, 51.8% male) were recruited for this cohort study. In terms of racial/ethnic background, 73% identified as White, 5.1% as Black, 5.8% as Asian American, 9.5% as Latinx, and 6.6% as having multiple racial or ethnic backgrounds. Inclusion criteria included use of e-cigarettes at least monthly for the past 6 months or longer, and aged 18–24 years at enrollment. Individuals who reported current or past use of conventional cigarettes or other combustible tobacco products at least monthly for any 6-month period in their lifetime were excluded.

Procedure

Participants were recruited from across the US using boosted Facebook posts, and paid $20–40 per wave to complete 8 waves of online assessment administered at 3-month intervals. All subjects underwent informed consent. Each wave consisted of a single assessment. Items utilized in the present study were identical across waves, and the number of items in the full assessment was consistent across waves. Data were collected from July 2017-March 2020. This study was approved by the University of California San Diego Institutional Review Board in accordance with the provisions of the Declaration of Helsinki.

Measures

Demographic characteristics were assessed at baseline, including age, gender, race/ethnicity, student status, work status, education, age at e-cigarette initiation, number of e-cigarette users in the household, and whether the participants' significant others used e-cigarettes. We estimated years of e-cigarette use at baseline by subtracting age of e-cigarette initiation from age at baseline. Substance use was measured at each wave using an adaptation of the Timeline Followback (Sobell & Sobell, 1992), which has good reliability and validity in online use (Pedersen et al., 2012). At each wave, this approach was used to evaluate whether or not participants had used e-cigarettes, cigarettes, alcohol and marijuana on each of the previous 14 days. The instruction set defined e-cigarettes as products that included only nicotine, and marijuana as including vape products containing THC. These responses were consolidated into count variables reflecting the number of days in the past 2 weeks with any

use of each product (i.e., e-cigarette frequency, cigarette frequency, alcohol frequency and marijuana frequency).

Impulsivity was measured at baseline using the S-UPPS-P (Cyders et al., 2014), a 20-item measure that includes 4 items evaluating each of the 5 impulsivity components: lack of perseverance, lack of premeditation, sensation seeking, positive urgency and negative urgency. This short form is psychometrically comparable to the original UPPS scale (Whiteside & Lynam, 2001). Each subscale was coded so that higher values reflected greater impulsivity. Internal consistency for the subscales in this sample ranged from 0.72–0.81.

Analytic Plan

Bivariate analyses evaluated relationships between demographics, other substance use, impulsivity, and outcome variables to identify covariates to be included in hypothesis tests. Years of e-cigarette use was included as a covariate to account for the possibility that more prolonged users would be more likely to be nicotine dependent and thus vape more frequently. Hypotheses were tested using a longitudinal negative binomial regression model after comparisons indicated this distribution fit the data better than alternatives. The model was implemented using the *xtnbreg* module in Intercooled Stata 15.01 (StataCorp LP, College Station, TX). E-cigarette days in the past 2 weeks at each wave was the time-varying outcome. The model included time and $time^2$ as well as all 5 impulsivity subscale scores as predictors. The initial model also included terms for all possible time*impulsivity and $time^2$*impulsivity interactions, to evaluate whether associations between impulsivity and e-cigarette frequency changed over time. Non-significant interaction terms were removed and the model re-fit. For all analyses, alpha was set to 0.05. Missing data were not imputed; models used all available data from all enrolled participants to calculate parameter estimates.

Results

Demographics and Baseline Data

Baseline demographic and clinical characteristics are shown in Table 1. At baseline, participants reported vaping on an average of 6.96 (SD=4.53) of the past 14 days, compared to 2.74 days (SD=4.58) for marijuana and 0.17 days (SD=0.95) for cigarettes. Bivariate analyses showed that, across all study waves, e-cigarette frequency was positively associated with marijuana ($p<0.001$) and cigarette frequency ($p=0.013$), but not alcohol frequency. E-cigarette frequency was higher among male participants ($p<0.001$) and those who reported having a significant other who vaped ($p=0.007$). E-cigarette frequency was unrelated to alcohol frequency, race/ethnicity, presence of other e-cigarette users in the household, highest level of education, and student and employment statuses. Consequently, marijuana frequency, cigarette frequency, gender and significant other e-cigarette status were included as covariates in hypothesis tests. Most participants had never used cigarettes at baseline, and of those who had tried cigarettes, the majority had only done so after initial e-cigarette use. In terms of missing data, all participants provided complete data at baseline. At the 7 subsequent waves, data were available for 80–92% of participants. Proportion of missing data was not significantly associated with demographic, impulsivity, or substance use variables.

Predictors of E-Cigarette Frequency

The final model is shown in Table 2. None of the impulsivity*time terms were significant, indicating that associations between baseline impulsivity scores and e-cigarette use were stable over the 8 waves of the study. E-cigarette frequency was significantly associated with lack of premeditation, such that each 1-point increase in lack of premeditation predicted 6% more e-cigarette days. A 1-standard deviation increase in lack of premeditation was associated with 19% more e-cigarette days. Similarly, e-cigarette frequency was positively associated with sensation seeking, with each 1-point and 1-standard deviation increase in sensation seeking predicting 9% and 25% more e-cigarette days, respectively. Lack of perseverance, positive urgency, and negative urgency were not significant predictors of e-cigarette use.

E-cigarette use was also inversely associated with time, with each additional wave predicting a 9% decline in frequency. Figure 1 shows the average number of e-cigarette days at each wave, which declined from a high of 7.1 of the past 14 days 3 months after baseline, to a low of 5.1 of the past 14 days at the final wave. For illustrative purposes, figure 1 also shows the proportion of the sample with the reported current use (i.e., any nicotine vaping in the past 14 days) at each wave. Similarly, this declined from 92.0% at baseline to 62.0% at 21 months. E-cigarette frequency was associated with marijuana use, with each additional day of marijuana use predicting a 3% increase in e-cigarette days, but was not associated with combustible cigarette use. Having a significant other who used e-cigarettes was associated with 44% more e-cigarette days compared to a significant other who did not use e-cigarettes. E-cigarette frequency did not differ between those whose significant others were non-users and those who were single, and was unrelated to years of e-cigarette use. Finally, identifying as female predicted 23% fewer e-cigarette days.

Discussion

The aim of this study was to test the hypothesis that facets of impulsivity (positive urgency, negative urgency, sensation seeking, and lack of premeditation) would prospectively predict e-cigarette use over time in a sample of young adult users. Some findings were consistent with our expectations: participants with higher sensation seeking and lack of premeditation at baseline consistently used e-cigarettes more frequently across all 8 waves of assessment. Unexpectedly, e-cigarette use was unrelated to positive and negative urgency. Additionally, there was a modest decline in e-cigarette frequency and prevalence over time.

These longitudinal results further support our previous findings in an independent sample of young adult cigarette smokers. In that study, we found e-cigarette use was positively associated with sensation seeking and lack of premeditation; positive and negative urgency predicted cigarette but not e-cigarette use (Doran & Tully, 2018). Another recent cross-sectional study among European adults suggested urgency measures may be more closely related to use of cigarettes than e-cigarettes (Kale et al., 2020). Overall, the pattern of results suggests that, at least among emerging adults who are not yet daily users, e-cigarette use may be driven by the pursuit of positive reinforcement without concern for consequences, and not in response to acute affective states. This contrasts with evidence regarding combustible cigarette use among emerging adults, which appears to be strongly related

to negative urgency in particular (Doran & Tully, 2018; Doran et al., 2013; Spillane et al., 2010), and suggests differences in motivation for use. One potential explanation for these differences is that the greater social acceptability of e-cigarette use (Lee et al., 2017) may yield a broader pool of users, with greater likelihood of being motivated by an interest in experimenting with new, purportedly rewarding behaviors. Another potential explanation is the availability of nontraditional flavors in e-cigarettes making them more appealing and leading to increased frequency of vaping (Landry et al., 2019; Leventhal et al., 2019).

While not a primary focus of this study, the positive association between e-cigarette and marijuana frequency is notable. This is consistent with previous studies of emerging adults (Cohn et al., 2019) and potentially important given trends toward reduced restrictions on marijuana use. For example, Doran et al. (2021) recently reported that the association between e-cigarette and marijuana frequency grew stronger following legalization of recreational marijuana sales in California, perhaps as a result of perceptions that both products are safe (Roditis et al., 2015). This consistent finding suggests that interventions designed to reduce vaping will likely need to address concurrent marijuana use.

Since the participants in our study were young adults, the findings may not be generalized to older population of e-cigarette users. Another limitation of the study is that all participants were current e-cigarette users who did not use combustible cigarettes at the time of enrollment, and most of whom were non-daily e-cigarette users. Thus, we may not be able to extrapolate our findings to daily e-cigarette users, or dual users of e-cigarettes and combustible cigarettes, though frequency of e-cigarette use (35–50% of days) was comparable to other surveys (e.g., Morean et al., 2018; Vogel et al., 2018). Data were provided via online surveys and may be subject to bias, though the same is true of self-report measures collected in controlled settings (Kraut et al., 2004). Data were collected at a time of decreasing restrictions on marijuana use in many jurisdictions, raising the possibility that reported marijuana prevalence reflects a reduction in bias against reporting use. Finally, because there are no validated measures by which to quantify e-cigarette consumption, we focused on frequency of use, potentially obscuring differences in use patterns.

In sum, these findings are helpful in identifying individuals who are vulnerable to e-cigarette use, and potentially paving the way for interventions to help them to stop vaping. Data suggest that emerging adults who are prone to seeking out novel stimuli and who tend to act rashly without considering the consequences may be particularly vulnerable to e-cigarette use over time. These young adults may thus be the highest priority targets for nicotine and tobacco intervention and prevention programs.

Role of Funding Sources:

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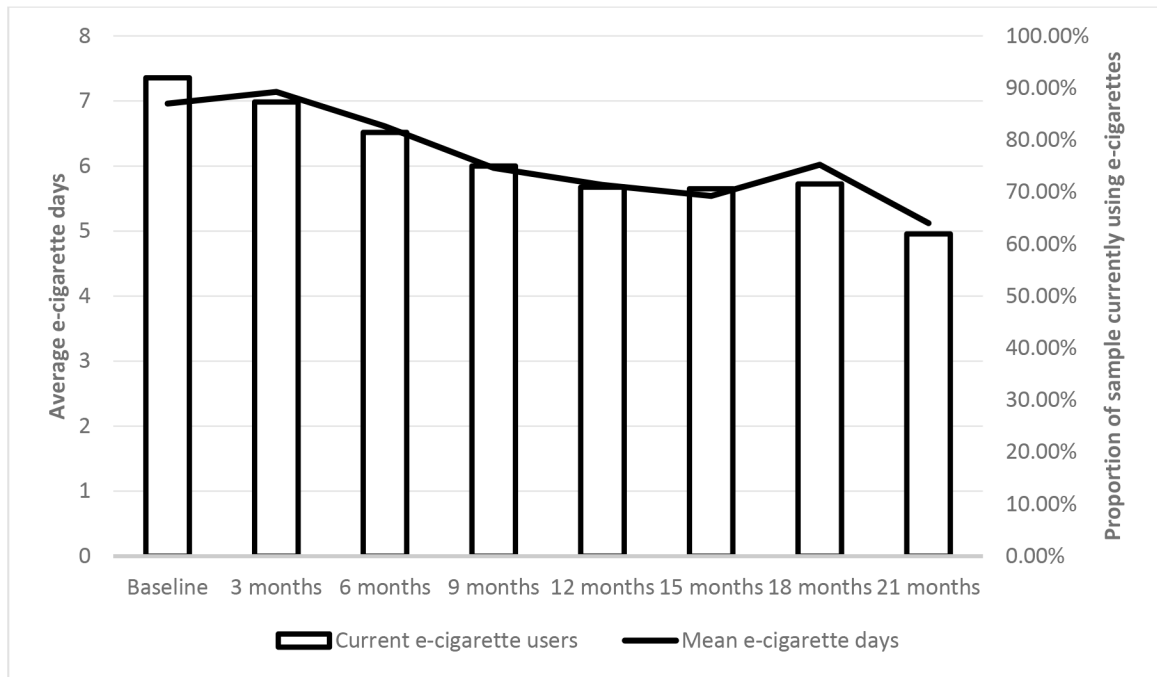**Figure 1. Frequency of e-cigarette use over time.**
This represents the relationship between the current e-cigarette users (orange bars) with their average number of e-cigarette days of the past 14 days (blue solid line) at each wave of assessment.

Table 1.

Baseline demographic and clinical characteristics

	Mean (SD), R or %
Age (years)	20.0 (1.6)
Age at first e-cigarette use (years)	17.4 (1.6)
Years of e-cigarette use	2.6 (1.5), 0.8–9.1
Race/Ethnicity	
White	73.0%
Latinx	9.5%
Multiple	6.6%
Asian American	5.8%
Black	5.1%
Gender	
Male	51.8%
Female	46%
Student status	
Full-time student	55.5%
Part-time student	14.6%
Employment	
Full-time position	16.1%
Part-time position	41.6%
Significant other e-cigarette use	
Non-user	32.1%
User	24.8%
Currently single	43.1%
Order of nicotine product initial use	
Cigarettes before e-cigs	20.4%
E-cigs before cigarettes	24.8%
Never tried cigarettes	54.7%
Impulsivity Subscale Scores	
Negative urgency	9.74 (3.10)
Positive urgency	8.65 (3.28)
Lack of perseverance	8.04 (2.93)
Lack of premeditation	8.03 (3.02)
Sensation seeking	11.32 (3.00)

Table 2.

Longitudinal regression model of e-cigarette frequency over time

Predictor	Coefficient	Std. Err.	IRR	95% CI
Intercept	0.99	0.13	2.70	2.08, 3.50
Time	−0.09	0.01	0.92	0.90, 0.94
Years of e-cigarette use		0.04	1.04	0.97, 1.11
Marijuana frequency	0.03	0.01	1.03	1.01, 1.04
Cigarette frequency	0.02	0.02	1.02	0.98, 1.05
Significant other e-cigarette use				
E-cigarette user	0.35	0.21	1.43	1.06, 1.92
Currently single	−0.15	0.11	0.86	0.67, 1.11
Gender identity				
Female	−0.27	0.08	0.76	0.61, 0.94
Impulsivity Traits				
Lack of premeditation	0.06	0.02	1.06	1.01, 1.11
Lack of perseverance	−0.03	0.02	0.96	0.93, 1.01
Sensation seeking	0.08	0.02	1.09	1.04, 1.14
Positive urgency	0.02	0.02	1.01	0.97, 1.06
Negative urgency	−0.04	0.02	0.96	0.93, 1.00

Std. Err. = Standard Error; IRR = incidence rate ratio; CI = confidence interval. For significant others' e-cigarette use, "non-user" was the reference category. For gender, "male" was the reference category. Impulsivity scores were mean-centered at 0 and coded so that higher scores reflected greater levels of impulsivity.