



Perceived Stress as a Predictor of E-Cigarette Dependence among University Students: A Cross-Sectional Study

Mannat Wadhwa

M.A. Applied Clinical Psychology Student, Lovely Professional University, Punjab,

Email: mannatwadhwa082944@gmail.com

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ABSTRACT

Despite the ban on e-cigarettes in India, e-cigarette use by university students continues through unregulated routes. Psychological stress is known to be a correlate of nicotine usage however, its independent role in predicting e-cigarette dependence severity needs to be investigated in South Asia university settings. Cross-sectional survey was conducted on 250 participants who used e-cigarettes and were selected using multistage stratified sampling from six universities in Punjab, India. Perceived stress was measured by using the Perceived Stress Scale-10 (PSS-10), whereas the severity of dependence was measured by using a 10-item E-Cigarette Dependence Scale. Hierarchical multiple regression analysis was used to determine the independent contribution of psychological stress in predicting e-cigarette dependence, controlling for sociodemographics and use history. The mean age of the sample was 22.1 years (SD = 2.4). Perceived stress showed a positive correlation with dependence ($r = .46, p < .001$). In the final model, perceived stress independently predicted dependence ($\beta = .38, p < .001, 95\% \text{ CI } [0.24, 0.52]$). Perceived stress contributed to 13% of variance in predicting dependence over and above all other predictors ($\Delta R^2 = .13$). In total, the model explained 27% of variance in predicting dependence ($R^2 = .27$,

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$F(8, 241) = 14.62, p < .001$). Psychological stress predicts e-cigarette dependence among university students in Punjab, India. Future campus-based health interventions need to have stress management elements incorporated in them.

1. Introduction

The use of electronic cigarettes or e-cigarettes has increased dramatically among college students in the past decade. In India, the Prohibition of Electronic Cigarettes Act (PECA), 2019 makes the production, sale, importation, and distribution of vaping devices a crime. However, cross-border trade through e-commerce, social media, and transits in countries with prohibitive regulatory structures continue to enable access by young adults. College students in the emerging adulthood stage engage in self-exploration, academic rivalry, and emotional turbulence that encourage drug experimentation and persistent nicotine consumption.

In the context of the etiology of addictions, psychological stress plays an essential role in etiology. According to the transactional model of stress, individuals assess environmental demands in light of available coping mechanisms. Whenever environmental demands exceed the coping mechanisms available, stress becomes pervasive and encourages the formation of maladaptive coping mechanisms such as substance abuse. In line with the self medication theory, nicotine is expected to have acute anxiety reducing and mood stabilization effects through its influence on nicotinic acetylcholine receptors, hence initiating a cycle of negative reinforcement whereby stress triggers substance use and use temporarily reduces stress. Perceived stress is known to predict both initiation and maintenance of combustible cigarette smoking.

Nevertheless, compared to combustible tobacco, e-cigarettes have unique pharmacological and experiential properties. For instance, higher nicotine salts levels, variety of flavors, and lack of sensory unpleasantness might make them particularly appealing to stressed students who seek quick affective management. Despite all these considerations, the relationship between perceived stress and e-cigarette dependence, as opposed to simple use or past month use, has not been empirically investigated in South Asian higher education settings, where academic pressures, economic challenges, and poor mental health facilities lead to higher levels of stress.

This study aims at investigating the association between perceived stress and dependence severity on e-cigarettes among stratified sampling of e-cigarette using college students in Punjab universities. We expect perceived stress to predict dependence severity of e-cigarettes after controlling for age, sex, living arrangements, academic discipline, period of use, vaping frequency, and type of device used.

2. Methods

2.1 Design and Setting

A cross-sectional survey design was adopted between October 2025 and February 2026. Six institutions of higher learning in Punjab, India, were purposefully sampled for maximal diversity of institutions, three being public and the other three private, with considerations of geographic spread (Chandigarh, Amritsar, Ludhiana, Phagwara, Mohali, and Patiala districts) and enrollment size.

2.2 Participants and Sampling

Criteria for inclusion in the study were: (i) being a currently enrolled undergraduate or postgraduate student, (ii) aged 18-30 years, (iii) having used e-cigarettes within the last month on at least weekly basis, and (iv) fluency in English and/or Punjabi language. Criteria for exclusion were: (i) use of oral nicotine pouches only and/or use of heated tobacco products, and (ii) being a part of substance-use treatment program.

Sample size of 166 was calculated using G*Power 3.1.9.7 for medium effect size ($f^2 = .10$) with nine predictors, $\alpha = .05$, and power = .95. Taking into consideration anticipated 15% incomplete data and 20% listwise deletion due to missingness, sample size of $N = 250$ was targeted. Multistage stratified random sampling procedure was utilized. In the first stage, four main faculties were randomly selected in each of the six institutions (Arts & Humanities, Natural Sciences, Engineering & Technology, and Business & Management). In the second stage, departmental lists were acquired and every third individual was approached for pre-screening. Out of 1,840 students screened, 312 reported having used e-cigarettes in the past month. Among those who met the eligibility criteria, 290 signed the informed consent form and 250 filled all questionnaires without any missing data (overall data integrity rate = 86.2%).

2.3 Instruments

Sociodemographic and Use History Proforma. Information regarding age, biological sex, faculty of study, year of enrolment, monthly disposable income (in Indian Rupees), parental education level, residence (on-campus hostel, off-campus with parents, off-campus individually or in shared premises), age at which they started using e-cigarettes, duration of regular use in months, primary device used, and frequency of vaping were sought through a structured proforma.

Perceived Stress Scale-10 (PSS-10). The PSS-10 is a well-established 10-item self-report measure of perceived stress, measuring how much respondents have appraised their lives as unpredictable, uncontrollable, and overloaded during the last month. The measure consists of 10 items scored on 5-point

Likert-type scale (from 0 = never to 4 = very often). The score can vary from 0 to 40, with higher scores indicating higher perceived stress. The measure has shown acceptable psychometric properties in university students from South Asia. Cronbach's alpha in our sample was adequate (.84).

E-Cigarette Dependence Scale-10 (ECDS-10). Dependence was measured using a 10-item measure developed based on research on e-cigarette dependence and withdrawal symptoms. These items measure aspects such as compulsive use, anticipation of withdrawal, tolerance, and functional impairment (e.g., "I find it difficult to keep from vaping when I am stressed"; "I vape more than I intend to"). The responses are rated from 0 (not at all true) to 3 (very true), resulting in total score that can be from 0 to 30. Cutoffs were applied according to previously published cut-offs for mild (> 8), moderate (> 14), and severe (> 20) dependence. Cronbach's alpha was .88.

2.4 Statistical Analysis

IBM SPSS Statistics, Version 29.0 was used for data analysis. Descriptive statistics (frequencies, percentages, means, standard deviations) were computed for describing participants' characteristics. Bivariate associations between continuous variables were determined using Pearson correlations. Central hypothesis of the study was tested by hierarchical multiple linear regression, where the total score on ECDS-10 served as dependent variable. Sociodemographic variables (age, biological sex, living arrangement [off-campus = 1 vs. on-campus = 0], and academic discipline [STEM = 1 vs. non-STEM = 0]) entered into Block 1. Block 2 consisted of use-related variables (duration of regular use, vaping frequency, and device type [non-disposable = 1 vs. disposable = 0]). Perceived stress (total PSS-10 score) was added in Block 3. Multicollinearity was checked using tolerance and variance inflation factors (VIF). Residual analysis indicated no gross violation of assumptions of linearity, homoscedasticity, or independence (Durbin-Watson = 1.89). Statistical significance was set at $p < .05$ (two-tailed).

3. Results

3.1 Participant Characteristics

The final analytic sample comprised 250 present-day electronic cigarette users. The age range was 18 to 28 years ($M = 22.10$, $SD = 2.40$). The sample had an overwhelming percentage of men ($n = 146$, 58.4%) and the vast majority of participants were pursuing bachelor's degrees ($n = 168$, 67.2%), living away from campus ($n = 185$, 74.0%). Close to half of the sample was studying STEM ($n = 120$, 48.0%). The vast



majority of participants used their devices on a daily basis ($n = 92$, 36.8%) or almost every day ($n = 70$, 28.0%) and they preferred disposable devices ($n = 118$, 47.2%). The mean age of starting to vape was 19.40 years ($SD = 1.80$), while the mean duration of regular use was 15.20 months ($SD = 9.10$).

Table 1. Sociodemographic and Use-Related Characteristics of the Sample ($N = 250$)

Characteristic	n	% / M (SD)
Sociodemographic		
Age (years)	250	2.10 (2.40)
Biological Sex		
Male	146	58.4
Female	104	41.6
Academic Program		
Undergraduate	168	67.2
Postgraduate	82	32.8
Academic Discipline		
STEM (Science, Engineering, Agriculture)	120	48.0
Non-STEM (Arts, Humanities, Business, Law)	130	52.0
Residential Arrangement		
On-campus hostel	65	26.0
Off-campus (family, independent, or shared)	185	74.0
Use-Related Variables		
Age of initiation (years)	250	19.40 (1.80)
Duration of regular use (months)	250	15.20 (9.10)
Vaping frequency (past month)		
Daily	92	36.8
3-6 days per week	70	28.0
1-2 days per week	55	22.0

Weekly (≤ 4 times/month)	33	13.2
Device type most often used		
Disposable	118	47.2
Refillable pod or mod system	95	38.0
Advanced box mod	37	14.8

STEM = Science, Technology, Engineering, and Mathematics. Unless otherwise noted, percentage values indicate valid column percentages. M = mean; SD = standard deviation.

3.2 Descriptive Statistics and Bivariate Correlations

Descriptive statistics and Pearson's correlations between continuous variables are summarized in Table 2. Perceived stress scores were found in the range between 10 and 40 ($M = 24.20$, $SD = 6.10$), suggesting moderate-to-high perceived stress compared to international norms for college students (Cohen & Williamson, 1988). E-cigarette dependence scores were distributed from 2 to 28 ($M = 12.80$, $SD = 4.70$). The distribution was normally distributed (absolute skewness < 0.60 ; absolute kurtosis < 0.80).

In terms of bivariate relations, the perceived stress score positively correlated with the e-cigarette dependence score ($r = .46$, $p < .001$). There was a significant correlation between dependence and the length of regular use of e-cigarettes ($r = .24$, $p < .001$) and the frequency of vaping ($r = .29$, $p < .001$), but no significant relationship with age ($r = .09$, $p = .16$). The perceived stress score weakly but significantly correlated with vaping frequency ($r = .17$, $p = .008$) but not age ($r = -.04$, $p = .54$).

Table 2. Descriptive Statistics and Pearson Correlations Among Continuous Variables ($N = 250$)

Variable	M	SD	1	2	3	4
1. Age	22.10	2.40	-			
2. Duration of use (months)	15.20	9.10	.14*	-		
3. Vaping frequency score	2.12	0.94	.06	.32***	-	
4. Perceived Stress (PSS-10)	24.20	6.10	-.04	.11	.17*	-
5. E-Cigarette Dependence (ECDS-10)	12.80	4.70	.09	.24***	.29***	.46***

Vaping frequency coded ordinally: 1 = weekly ($\leq 4x/month$), 2 = 1-2 days/week, 3 = 3-6 days/week, 4 = daily. * $p < .05$. *** $p < .001$.

3.3 Hierarchical Multiple Regression Analysis

Hierarchical multiple regression analysis was performed to examine the independent contribution of perceived stress in predicting e-cigarette dependence controlling for sociodemographic characteristics and use-related variables. The outcome variable was the ECDS-10 total score. No major violations of any assumptions were found. Tolerance scores ranged between 0.54 and 0.91. Variance inflation factor (VIF) ranged between 1.10 and 1.85. Durbin Watson statistic value equaled 1.89, indicating independence of residuals. Table 3 displays the standardized regression coefficients, delta R², and goodness of fit statistics.

Block 1: Sociodemographic Covariates. The introduction of age, biological sex, living situation, and field of studies accounted for a statistically significant amount of variance in dependence, $\Delta R^2 = .06$, $F(4, 245) = 3.91$, $p = .004$. None of the sociodemographic factors was identified as individual significant predictors ($p > .10$), except for STEM field of studies, showing a tendency towards statistical significance ($\beta = .13$, $p = .06$).

Block 2: Use-Related Variables. Incorporating duration of regular use, vaping frequency, and device type accounted for an additional and statistically significant proportion of variance, $\Delta R^2 = .08$, $F_{change}(3, 242) = 7.28$, $p < .001$. Both longer use duration ($\beta = .22$, $p < .001$) and high vaping frequency ($\beta = .18$, $p = .009$) significantly correlated with greater severity of dependence. Device type (non-disposable vs. disposable devices) did not constitute an important predictor ($\beta = .11$, $p = .10$).

Block 3: Perceived Stress. Once adjusting for all covariates in Blocks 1 and 2, the inclusion of perceived stress proved itself as the most psychologically important predictor of dependence. Total score in the PSS-10 questionnaire was positively correlated with dependence severity ($\beta = .38$, $p < .001$, 95%CI [.24, .52]). Including perceived stress increased the total amount of variance by 13%, $\Delta R^2 = .13$, $F_{change}(1, 241) = 42.35$, $p < .001$.

The final regression model accounted for 27 percent of the variance observed in e-cigarette addiction ($R^2 = .27$; $adj-R^2 = .25$), based on an F-test value of $F(8, 241) = 14.62$ with $p < .001$. None of the sociodemographic covariates reached statistical significance ($p > .10$). The inclusion of variables from Blocks 1 and 2 did not affect their beta coefficients or directions substantially.

Table 3. Hierarchical Multiple Linear Regression Predicting E-Cigarette Dependence ($N = 250$)

Predictor	beta	p	beta	p	beta	p
Block 1:						
Sociodemographics						

Age	-.06	.36	-.08	.21	-.05	.42
Biological sex (Male = 1)	.12	.08	.10	.14	.08	.22
Residential arrangement (Off-campus = 1)	.09	.18	.07	.27	.06	.31
Academic discipline (STEM = 1)	.13	.06	.10	.11	.09	.14
Block 2: Use-Related Variables						
Duration of use (months)			.22	< .001	.20	< .001
Vaping frequency			.18	.009	.16	.014
Device type (Non-disposable = 1)			.11	.10	.10	.12
Block 3: Psychological Predictor						
Perceived Stress (PSS-10)					.38	< .001
R-squared	.06		.14		.27	
Adjusted R-squared	.05		.13		.25	
Delta R-squared			.08		.13	
F for change	3.91**		7.28***		42.35***	

beta = standardized regression coefficient. R-squared = proportion of variance explained. ** $p < .01$. *** $p < .001$. 95% CI for perceived stress beta in Model 3: [0.24, 0.52].

4. Discussion

These preliminary results indicate that perceived stress serves as a very strong independent predictor of dependence on e-cigarettes amongst university students in Punjab, India. Controlling for sociodemographic factors and objective indicators of use history, perceived stress turned out to be the strongest psychological factor that accounted for 13% of unique variance in dependence scores. The size of zero-order correlation ($r = .46$) matches and even surpasses the correlations between stress and tobacco use found in studies of Western smokers.

The obtained data are consistent with the transactional model of stress and self-medication hypotheses that assume that nicotine is used for reducing negative affect and restoring balance under conditions of high demand and low perceived control. Indian university students have to undergo high stakes academic



examinations, face familial achievement pressure and do not have adequate mental health facilities in universities, which may lead to chronic depletion of self-regulatory capacity and increased motivational value of anxiolytic effects of nicotine.

It should be emphasized that standard sociodemographic factors such as biological sex were not predictors of dependence once history of vaping was controlled for. Although global literature sometimes notes higher prevalence of vaping in men, the present results suggest that severity of dependence, once it is formed, may be equally dependent on psychological factors regardless of demographic category. Such a finding has practical importance campus screening programs aimed at identifying dependent users may neglect female users that develop dependence as a reaction to psychosocial stress through vaping.

The contribution of duration and frequency in Block 2 is consistent with behavioural theories of tolerance and conditioned reinforcement. However, the prominent contribution of perceived stress in Block 3 means that dependence cannot only be sustained through pharmacological exposure duration, but is dynamically maintained through negative reinforcement. Students experiencing high levels of stress may engage in "emergency vaping" that takes place outside regular schedule and may increase the speed of transition from experiment to compulsion.

These results have two important implications for public health. On one hand, they show that continued availability of e-cigarettes in universities in India despite PECA 2019 indicates that restrictive measures may not be enough to reduce vaping prevalence without addressing the drivers of demand. On the other hand, university counselling centres should include nicotine-specific psychoeducation and harm reduction into their stress management interventions (such as mindfulness-based relapse prevention) rather than address vaping cessation independently. Screening programs should identify students coming to counselling centres with stress complaints and conduct short evaluation of their vaping use.

4.1 Limitations

First, the cross-sectional design does not allow for causal inference; the relationship might be bi-directional in nature with early dependence on nicotine possibly sensitizing the stress response systems of neuroendocrine in individuals and hence increasing their levels of perceived stress. Secondly, use of self report measures increases risk of social desirability and recall bias since there is uncertainty in legal status of possession of e-cigarettes in India. Thirdly, the sample included six universities in one North Indian state only, which limits its generalizability across different socio linguistic settings. Fourthly, there were no biochemical tests conducted to confirm presence of nicotine and no evaluation of comorbid conditions of



anxiety and depressive disorders that could interfere with stress and dependence relationship. Lastly, no time to event measure (e.g., time taken to first vape after waking up) was considered that is a clinical characteristic of dependence syndrome. Longitudinal designs are needed to tease out situational stress events from trait perceived stress as proximate triggers of vaping.

5. Conclusion

Perceived stress was found to be the most influential psychological predictor of e-cigarette addiction of university students of Punjab, explaining a significant amount of variation independent of demographic and behavioural variables. This research shows how critical it is to adopt a two pronged strategy in universities to deal with nicotine addiction as well as dysregulated stress. The regulatory policies have to go beyond banning the provision and include demand side mental health infrastructure in universities.

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