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Perceived Stress and Poly-Tobacco Product Use Across Adolescence: Patterns of Association and Gender Differences

Adam M. Leventhal, Ph.D.^{a,b,*}, Robert Urman, Ph.D.^a, Jessica L. Barrington-Trimis, Ph.D.^a, Nicholas I. Goldenson, B.A.^a, Katia Gallegos, Ph.D.^a, Chih Ping Chou, Ph.D.^a, Kejia Wang, MS^a, Kiros Berhane, Ph.D.^a, Tess Boley Cruz, Ph.D.^a, Mary Ann Pentz, Ph.D.^a, Jennifer Unger, Ph.D.^a, and Rob S. McConnell, M.D.^a

^aDepartment of Preventive Medicine, University of Southern California Keck School of Medicine, Los Angeles, CA

^bDepartment of Psychology, University of Southern California, Los Angeles, CA

Abstract

Perceived stress—an endophenotype indicative of the tendency to appraise stress as frequent, unpredictable and unmanageable—is associated with adolescent cigarette smoking. It is unclear whether this association: (1) extends to alternative tobacco products, like electronic cigarettes and hookah (tobacco water pipe), which are increasingly popular among youth, and (2) differs by gender. In this report, data were drawn from a population-based longitudinal cohort of youth in Southern California. Perceived stress was assessed at baseline (7th or 8th grade; 2010). Electronic cigarette, hookah, combustible cigarette, and cigar use were assessed at a 4-year follow-up (11th or 12th grade; 2014). After adjusting for confounders, polytomous logistic regressions showed that a standardized baseline perceived stress score ($M=0$, $SD=1$) predicted electronic cigarette, hookah, combustible cigarette, and cigar use and a poly-tobacco use index at the 4-year follow-up in the overall sample. Interactions between perceived stress and gender were also observed (Interaction $P<.05$), which demonstrated that the association of perceived stress with tobacco product use and poly-use were stronger in females (ORs for current use range: 1.47 to 1.72) than males (ORs range: 0.93 to 1.31). Adjusting for baseline perceived stress, the change in perceived stress from baseline to follow-up was also positively associated with use and poly-use of most tobacco products in females and in males to some extent. In the current era in which teen use of alternative tobacco products is increasingly common, adolescent tobacco use and poly-use research and prevention strategies should address gender-specific origins of tobacco product use risk and consider perceived stress and other emotional endophenotypes in such risk pathways.

*Corresponding author: Adam Leventhal, Address: 2001 N. Soto Street, 302-C, Los Angeles, CA 90089, adam.leventhal@usc.edu, Phone: 323-442-2598, Fax: 323-865-0103.

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Keywords

Perceived Stress; Tobacco; e-Cigarette; Poly-tobacco; Hookah; Endophenotype

INTRODUCTION

The association between mental health and increased risk of combustible cigarette smoking among adolescents is complex and extends across diverse forms of psychopathology (Kandel et al., 1997; Patton et al., 1998; Minichino et al., 2013; Hockenberry et al., 2011). Perceived stress (Cohen et al., 1983)—a heritable tendency (Federenko et al., 2006) to appraise negative events and resultant stress in one's life as frequent, unpredictable and uncontrollable along with a lack of resources to cope with negative events—is a putative endophenotype of several psychiatric syndromes implicated in cigarette smoking, including anhedonic depression (Pizzagalli, 2014), anxious dysthymia (Niculescu III and Akiskal, 2001), psychosis (Myin-Germeys and van Os, 2007), posttraumatic stress (Connor et al., 2007), and various personality disorders (Trull et al., 2010). Adverse environments (Cohen et al., 1993), genetically determined neurobiological stress system dysregulation (Bogdan et al., 2013), and the interaction of these two factors (Otte et al., 2007) are presumed to underlie perceived stress. Consequently, perceived stress could demarcate a broad array of etiological sources and mental health problems relevant to smoking. As brief preventive psychosocial interventions can effectively reduce perceived stress among youth (Deckro et al., 2002), perceived stress may be a useful marker of protracted risk for smoking and a fruitful target for tobacco use prevention.

The empirical association between perceived stress and smoking among adolescents has been consistent across various populations (Fields et al., 2009; Kim and Park, 2016; Lorenzo-Blanco and Unger, 2015) and robust after controlling for confounding influences (Finkelstein et al., 2006; Siqueira, L. et al., 2000; Sussman et al., 1998). A potential explanation for this association is that adolescents with high perceived stress may turn to tobacco use as a pharmacological means of coping with sources of distress that are otherwise unmanageable. Given that perceived stress could be derived from core difficulties in behavioral and emotional regulation, uptake of tobacco use as a maladaptive means of coping with distress may be disproportionately likely in youth with high levels of perceived stress. That is, behavioral and emotional regulation disturbances could be a common underlying vulnerability for perceived stress, tobacco use, and other emotional-behavioral conditions. Consistent with this notion, adolescents with higher levels of perceived stress are more likely to cite tension reduction as a motive for smoking (Bonilha et al., 2013).

Despite well-documented evidence that perceived stress may increase risk of adolescent smoking, associations between perceived stress and the use of increasingly popular alternative tobacco products, such as electronic cigarettes (e-cigarettes), hookah (tobacco water pipe) and cigars, have not yet been widely investigated (c.f., see Brikmanis et al., 2016 for one such study in young adults). This is an important gap in the literature, given that conventional cigarette use has steadily declined while in 2015 an estimated 16%, 7%, and 9% of US high school students used e-cigarettes, hookah, and cigars, respectively, within the

past 30 days (Singh, 2016). Accordingly, we chose to study four tobacco products (i.e., e-cigarettes, cigarettes, cigars and hookah) that are the most commonly used by youth and together account for 84.2% of all tobacco product use (Singh, 2016).

Another gap is the dearth of data on gender differences in the association of perceived stress with tobacco use. Poor mental health and stress have been shown to be a stronger risk factor for smoking uptake among females as compared to males (Byrne and Mazanov, 2003; Audrain-McGovern et al., 2015; Yue et al., 2015). Thus, research examining whether the association between perceived stress and smoking extends to new and emerging alternative tobacco products should also consider the role of gender/sex. Evaluating whether gender modifies the extent to which perceived stress confers risk for alternative tobacco product use can inform gender-specific multi-product tobacco prevention strategies.

To address these questions, perceived stress was examined as a predictor of later tobacco product use in a population-based cohort of southern California adolescents. We hypothesized that youth with higher levels of perceived stress in early adolescence (i.e., 12–14 years old) would be more likely to report ever use and past 30-day use of conventional cigarettes, e-cigarettes, hookah and cigars and poly-users of multiple tobacco products four years later (i.e., 16–18 years old). We also tested the hypothesis that the association between perceived stress and subsequent tobacco product use would be stronger in females than in males. Some evidence suggests that in addition to static levels of perceived stress prospectively increasing risk of smoking, trajectories of increasing perceived stress may also predict combustible cigarette use (Cohen and Lichtenstein, 1990). Thus, a supplemental aim was to examine the association of changes in perceived stress from baseline to follow up with tobacco product use at follow-up.

MATERIALS AND METHODS

Sample and Procedures

Participants were initially recruited into the Southern California Children's Health Study (CHS) in 2003—a longitudinal study involving schools in 12 communities across southern California (for additional details see McConnell et al., 2006). Perceived stress was originally measured when participants were in 7th or 8th grade (Spring 2010; i.e., baseline time point in the current report). Tobacco product use and perceived stress were assessed four years later when participants were in 11th or 12th grade (Spring 2014; follow-up). At both assessments participants completed questionnaires in school classrooms under the supervision of study staff. Of the 3212 participants who were surveyed at baseline, 1914 (60%) completed the 4-year follow-up. Participants who completed both waves of assessment but did not provide data on perceived stress or at least one tobacco product use outcome (N=63) were excluded from this report, leaving a total of 1,851 participants included in the analyses of this report (see Supplementary text and Supplementary Table 1 for an attrition analysis). Because there were intermittent missing responses across each outcome, each analysis was restricted to participants for whom data were available on that respective outcome (Ns ranged from 1842–1849, see Table 2). The study protocol was approved by the University of Southern California Institutional Review Board.

Measures

Perceived stress—The 4-item version of the Perceived Stress Scale (PSS; Warrtig et al., 2013), an extensively validated measure of perceived stress appropriate for use in adolescent populations (Martin et al., 1995), was the primary predictor in this study. The PSS instructs respondents to report on experiences in the past month with the following questions: How often have you felt: 1) That you were unable to control the important things in your life?; 2) Confident about your ability to handle your personal problems?; 3) That things were going your way?; and 4) That difficulties were piling up so high that you could not overcome them? Participants selected the following response options (“Never” = 0; “Almost never” = 1; “Sometimes” = 2; “Fairly often” = 3; and “Very often” = 4). After reverse scoring questions two and three, an overall composite stress score was calculated as the sum of the four questions (ranging from 0–16). For the primary analyses the baseline raw sum score was standardized (*Mean* = 0; *Standard Deviation* = 1) to facilitate interpretation of risk estimates by presenting the results on a common effect size metric comparable to other studies that may use measures with different quantitative scaling properties. Change in stress was calculated by subtracting the raw perceived stress composite score at baseline from the score at follow-up; this change score was standardized in the same fashion.

Tobacco product use—Questionnaires assessed the use of traditional and alternative tobacco products at follow-up, including combustible cigarettes, e-cigarettes, hookah, and cigars (Barrington-Trimis et al., 2015). Participants were asked whether they had ever used each product and, if so, the number of days they used each product in the past 30 days. Responses to these two questions were used to classify participants into one of three use categories for each product. Participants who reported having “never tried” a specific product (i.e., not “even one or two puffs”) were classified as “never users.” Participants who had used a product but not in the last 30 days were classified as “prior users.” Participants who had used a product during the past 30 days were classified as “current (past 30-day) users” of that product. We also computed two poly-tobacco product use outcomes: (a) the total number of different tobacco products a participant had ever used, ranging from 0 to 4, and (b) the total number of different tobacco products a participant had used in the past 30 days (0 vs. 1 vs. 2 vs. 3 or 4).

Covariates—Self-administered questionnaires completed by the parents of participants at study enrollment assessed gender and ethnicity (Hispanic White, Non-Hispanic White, Other) of participants, highest level of parental education (<12th grade, high school diploma or GED, some college, college degree, some graduate school or higher), and whether anyone living at home smoked tobacco (either cigarettes, cigars, or pipes; yes/no). These factors were included as a priori covariates as prior literature implicates them as correlates of perceived stress and tobacco use (i.e., potential confounders or moderators; Heslop et al., 2001; Ng and Jeffery, 2003; Todd, 2004; Ward et al., 1997). Study design factors were also included as covariates (month of questionnaire administration, grade level [7th vs. 8th], and community that the participant’s school was in). Ever use of cigarettes by participants was assessed at baseline in a subset of the sample (N=1024).

Statistical Analysis

Polytomous (multinomial) logistic regression models were used to evaluate the association between baseline standardized perceived stress score (assessed in 7th or 8th grade) and each tobacco product use outcome at four-year follow-up. For the single-product use outcomes, four separate models were tested – one model for each product (e-cigarettes, hookah, cigarettes, a cigars). These models used tri-level multinomial outcomes (never use, prior use, and current [past 30-day] use) that produced two odds ratio (OR) estimates both involving never use as the referent category: (1) current vs. never use; and (2) prior vs. never use.

For the poly-product use analyses, two polytomous logistic regression models were tested, one for each poly-product use index. One model was tested for the five-level ordinal ever-use poly-product outcome (0=no products, 1=one product, 2=two products, 3=three products, or 4=use of all four products), yielding four ORs with ever use of 0 products as the referent category (1 vs. 0, 2 vs. 0, 3 vs. 0, and 4 vs. 0 products). Another model was tested for the current (past 30-day) poly-product composite. For this outcome, use of three or four products were collapsed into a single category due to small frequencies of adolescents who were current users of 3 products at follow-up, resulting in a 4-level ordinal variable yielding three ORs with current use of 0 products as the referent category (3 or 4 vs. 0, 2 vs. 0, and 1 vs. 0 products).

An additional set of single-product and poly-product models paralleling those above were calculated to test the interactive effects of gender and perceived stress on each outcome. To do this, a multiplicative interaction term between gender and stress was added to each model. The interaction term for the single-product polytomous models provided an omnibus p-value effect, which could be interpreted as evidence that all ORs yielded from the respective polytomous model in females were not equivalent to each corresponding OR yielded among the subsample of males.

All models were adjusted for covariates listed above. A missing indicator strategy was used to address intermittent missing data for covariates, which dummy codes an additional missing category for each covariate to prevent loss of data due to list-wise deletion from missing covariate data (see supplementary materials for further description of this approach). Supplementary logistic regression models paralleling those described above that included the change in perceived stress score from baseline to follow-up after adjusting for baseline perceived stress were conducted to determine the incremental effect of time-varying perceived stress on tobacco product use at follow-up. Additional sensitivity analyses involving adjustment for baseline cigarette use for the subsample for which cigarette use was assessed at baseline and other results are briefly noted below and detailed in the supplementary materials. ORs and 95% confidence intervals (CIs) are reported with α 0.05 (two-sided). Analyses were performed using SAS 9.4.

RESULTS

Descriptive Analyses

Participants were on average 13.5 ($SD = 0.6$) years of age at baseline. The unstandardized raw mean perceived stress sum score in the sample was 5.6 and the SD was 3.0, which are similar to distributions reported from other general population samples and lower than what has been reported in psychiatric patient samples (Warttig et al., 2013; Williams et al., 2017; Martin et al., 1995; Hewitt et al., 1992). On average, females reported higher stress than males (5.9 vs. 5.3; $p < 0.01$), as did Non-Hispanic Whites compared to Hispanic Whites and those of other ethnic backgrounds ($p < 0.01$). Lower levels of parental education and the presence (vs. absence) of exposure to smoking by others in the home were also associated with higher perceived stress ($p < 0.01$ for all tests; Table 1).

At follow-up, participants were on average 17.3 ($SD = 0.6$) years of age and reported a mean raw perceived stress score of 6.1 ($SD = 3.3$). Prevalence of tobacco product use ranged from 4% – 11% across all products for current (past 30-day) use estimates and 10% – 17% for prior use estimates (Table 2). Of note, 37% of the participants had ever used at least one product, and nearly half of these lifetime ever-users used at least one tobacco product in the past 30 days at follow-up.

Prospective Associations of Baseline Perceived Stress with Tobacco Product Use at 4-Year Follow-Up

In the overall sample, polytomous logistic regression models adjusted for covariates revealed that each one SD unit increase in levels of perceived stress at baseline was associated with a 20% and 25% increase in the odds of being a prior (OR: 1.20; 95% CI: 1.04, 1.37) and past 30-day (OR: 1.25; 95% CI: 1.07, 1.47) user (vs. never user) of e-cigarettes, respectively, at the 4-year follow-up (Table 2). Relative to never-users of each respective tobacco product, higher level of baseline perceived stress was also associated with higher odds of past 30-day use of hookah (OR: 1.26; 95% CI: 1.08, 1.47), combustible cigarettes (OR: 1.32; 95% CI: 1.08, 1.61), and cigars (OR: 1.36; 95% CI: 1.06, 1.75). For the poly-product ever-use composite score, higher perceived stress scores were associated with an increase in odds of ever using 1 (OR: 1.16; 95% CI: 1.00, 1.34), 3 (OR: 1.32; 95% CI: 1.10, 1.58), or 4 (OR: 1.29; 95% CI: 1.07, 1.55) products relative to never use of any tobacco product. Similar associations were found with the past 30-day poly-product use outcome (Table 2).

Gender Differences in the Association of Baseline Perceived Stress with Tobacco Product Use

Associations between perceived stress and each of the individual tobacco product outcomes significantly or marginally differed by gender (P s $\leq .06$ for interaction tests; Table 2). Among females, associations between perceived stress and each of the four tobacco use outcomes and the poly-tobacco use indexes were stronger than the corresponding associations among males, which were not statistically significant for any outcome in males. For example, each one SD unit increase in baseline perceived stress was associated with a 29% increase in the odds of being a prior (vs. never) user of combustible cigarettes (OR: 1.29; 95% CI: 1.05, 1.59) and a 72% increase in the odds of being a past 30-day cigarette

smoker vs. never smoker (OR: 1.72; 95% CI: 1.29, 2.29) at follow-up, whereas among males baseline perceived stress was not associated with prior (OR: 1.07; 95% CI: 0.87, 1.31) or past 30-day (OR: 1.02; 95% CI: 0.76, 1.38) use (vs. never use) of cigarette smoking at follow-up. Similar patterns were found with the other tobacco product use outcomes (Table 2).

Association of Changes in Perceived Stress from Baseline to Follow-Up with Tobacco Product Use at Follow-Up

As depicted in Table 3, youth with greater increases in perceived stress from baseline to follow-up were more likely to report use and poly-use (vs. never use) of each tobacco product at follow-up after adjusting for covariates and baseline perceived stress in the overall sample. Gender stratified analyses revealed that the positive association of changes in stress and tobacco product use status was significant for most outcomes in females and for several outcomes in males. Apart from cigar use, the association of changes in perceived stress and tobacco product use did not significantly differ by gender. The gender x changes in perceived stress interaction effect on cigar use was significant and can be attributed to a stronger association with current (vs. never) cigar use in girls (OR = 3.96) than in boys (OR = 1.63).

Additional sensitivity analyses of the impact of attrition, baseline combustible cigarette use, and baseline attention problems are detailed in the online supplementary materials.

DISCUSSION

Previous results have consistently linked perceived stress with risk of combustible cigarette use (Fields et al., 2009; Finkelstein et al., 2006; Kim and Park, 2016; Lorenzo-Blanco and Unger, 2015; Siqueira, Lorena et al., 2000). The current study provides new evidence demonstrating that the association of perceived stress with tobacco use generalizes to use and poly-use of four different tobacco products in the current milieu. The association extended to both prior use (i.e., ever use but not in the past 30 days) and current use (i.e., use in the past 30 days) classifications for most tobacco product outcomes. Those who meet the definition of prior use may fall into one of two use trajectories: (1) youth who temporarily used a product and are unlikely to ultimately become regular users; or (2) youth at the beginning of the use uptake continuum, which, in some adolescents, begins with very irregular use (e.g., once every few months) and then accelerates over a multi-year period to intermittent use (e.g., 1–2 days per month), weekly use, and eventually daily use (McGovern et al., 2004). Given that adolescents who are current combustible cigarette smokers are substantially more likely to become nicotine dependent during adulthood (Riggs et al., 2007), the present findings raise concern that youth with higher levels of perceived stress may ultimately be at increased risk of becoming nicotine-dependent in adulthood and perhaps developing dependence on multiple tobacco products.

While causal inferences cannot be definitively drawn on the basis of this observational study, it is plausible that perceived stress confers vulnerability to tobacco product use in adolescence by amplifying known biological, psychological, and social risk pathways to nicotine and tobacco product use. These pathways may be particularly robust in female (vs.

male) adolescents for several reasons. 1) The preclinical evidence indicates that the female adolescent brain is more susceptible than the male brain to the rewarding effects of nicotine, possibly because of innervations between ovarian hormone changes and the reward system during pubertal development (Torres et al., 2009). Dysregulation of stress, reward, and executive control circuitry associated with perceived stress phenotypes could exacerbate neurobiological vulnerability to initiation and progression of any product containing nicotine in female adolescents. 2) Youth with high perceived stress may have poorer social skill development than their counterparts without heightened perceived stress due to increased sensitivity to rejection and social withdrawal (Bijstra et al., 1994; Segrin, 1993). Because females have been shown to be more susceptible to social influences on risk behavior than males (Mrug and McCay, 2013), females with high perceived stress may be more likely to socially conform with peers who use one or multiple tobacco products to avoid social rejection. 3) Youth with greater perceived stress who find it difficult to manage distress may particularly value nicotine's acute mood-altering pharmacological effects and therefore be more likely to persist, rather than discontinue, tobacco product use following initial experimentation. Such youth may also be more likely to progress to poly-product use patterns because use of multiple tobacco products is likely to engender greater nicotine delivery than single-product use patterns. Female smokers report stronger cognitive expectations that tobacco use alleviates negative affect than males (Pang et al., 2014; Piñeiro et al., 2016), raising the possibility that the salience of mood-regulation motives could explain why associations of perceived stress with past 30 day tobacco product use was stronger in female adolescents. Thus, both biological sex differences and psychosocial gender differences may contribute to differences between adolescent boys and girls in this study.

The current findings advance a nascent literature on the association between alternative tobacco product use and emotional and behavioral functioning in adolescents. A previous cross-sectional study in a non-clinical general adolescent community sample demonstrated that while mental health syndromes and transdiagnostic endophenotypes, such as major depression, panic disorder, and negative urgency are higher in teens who had used e-cigarettes in comparison to those who had not used any tobacco products; these forms of emotional distress were incrementally higher in users of cigarettes vs. e-cigarettes only (Leventhal et al., 2016). Some have suggested that e-cigarettes and hookah may be drawing in new 'lower-risk' teens with fewer mental health or behavioral problems because these products are considered to be more socially acceptable and less harmful to health than conventional cigarettes (Barrington-Trimis et al., 2015; Leventhal et al., 2016; Wills et al., 2015). Consequently, the more socially-stigmatized and harmful product—combustible cigarettes—are suspected to be overrepresented amongst high risk youth who may overlook the negative consequences of such products. Our results suggest that female teens with elevated perceived stress are not preferentially at risk for combustible tobacco products, but rather all products, including poly-tobacco product use. Two other recent longitudinal studies have also shown that depressive symptoms predict future e-cigarette use in general community samples of adolescents and college students (Bandiera et al., 2017; Lechner et al., 2017). Thus, emotional functioning may be associated with use of alternative tobacco products, particularly when studied longitudinally.

The current findings may have implications for tobacco use and poly-use prevention. Perceived stress, which is a cross-cutting emotional endophenotype with wide inter-individual variability in the population, may be a useful addition to prognosticative screening batteries that identify high risk youth who could be targeted for tobacco prevention programs. In a single 4-item questionnaire the perceived stress scale may efficiently integrate risk across a wide variety of mental health conditions that determine vulnerability to initiation and maintenance of numerous tobacco products during high school. Importantly, it could identify females who may be vulnerable to the use and poly-use of tobacco products during high school, even if screening is administered during middle school when the baseline assessment took place in this study. Evidence in this study that changes in perceived stress from baseline to follow-up predicted outcomes suggest that interventions that ameliorate (or prevent exacerbations in) perceived stress during mid adolescence warrant consideration in poly-tobacco product use prevention.

This study is limited in several respects. The survey lacked clinical assessments. It would be of value to determine the extent to which perceived stress accounts for risk of tobacco product use attributable to psychiatric disorders and whether perceived stress is a risk factor that is independent of various psychopathologies, including externalizing problems. Perceived stress and objective stressful life events are distinct constructs (Cohen, 1988; Cohen et al., 1983). An investigation of young adults found that stressful life events were associated with hookah use but perceived stress was not (Brikmanis et al., 2016), highlighting potential differences between the two constructs, which we could not address here. There was sizeable attrition from baseline to follow-up (40%) and differences in the demographic characteristics of youth who were vs. were not retained for the follow-up, which may impact study generalizability. Finally, baseline data on tobacco use was incomplete or missing for certain products, which should be considered when interpreting the findings. Adjustment of baseline cigarette smoking for whom such data were available and a re-test of analyses yielded results largely consistent with results produced in the overarching sample (see supplemental Table 2). Thus, baseline cigarette use likely did not play a substantive role in the associations of perceived stress and tobacco product use at follow-up reported here. The first assessment of perceived stress in this study occurred in 2010, and thus almost certainly preceded the initiation of e-cigarettes, which were not widely available at that time. Although data on whether youth had used hookah or other tobacco products at baseline were not available in this sample, national prevalence of hookah and cigar use was lower than use of cigarettes in adolescents in 2011 (Singh et al, 2016). On the whole, it is certainly possible that baseline tobacco use may have impacted the findings, but the plausibility that baseline use had a substantive impact on study results is low.

CONCLUSION

Perceived stress was associated with increased likelihood of subsequent use and poly-use of the four currently popular tobacco products over a key 4-year period of adolescence in southern California female youth. Future investigation of the mediators of this association may help establish the causality of this association and contribute to the development of tobacco product use risk screening and prevention strategies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Perceived stress predicted use and poly use of e-cigarettes, hookah, cigarettes, and cigars in adolescence
- Associations were largely stronger in females than in males
- Perceived stress warrants consideration in youth tobacco product prevention

Table 1Sample descriptive statistics and $M(SD)$ of perceived stress score by sociodemographic factors

	Freq (%) ^a (N=1851)	Perceived Stress Score ^b by Sociodemographic strata Mean (SD)	P-value ^c
<i>Gender</i>			
Female	937 (50.6)	5.85 (3.04)	0.0002
Male	914 (49.4)	5.32 (2.96)	
<i>Race/ethnicity</i>			
Non-Hispanic White	930 (50.2)	5.95 (2.95) ¹	<0.0001
Hispanic White	671 (36.3)	5.10 (3.07) ¹	
Other	250 (13.5)	5.55 (2.89)	
<i>Education (highest parental)</i>			
<12th grade	348 (20.4)	6.14 (2.82) ^{1,2}	<0.0001
12th grade	254 (14.9)	5.99 (2.99) ³	
Some college	646 (37.8)	5.42 (3.03) ²	
College degree	235 (13.7)	5.51 (3.33)	
Some graduate school	227 (13.3)	4.76 (2.89) ^{1,3}	
<i>Grade (2010)</i>			
7 th grade	1036 (56.0)	5.53 (2.99)	0.37
8 th grade	815 (44.0)	5.66 (3.04)	
<i>Month of tobacco questionnaire (2014)</i>			
January–February	611 (33.0)	5.57 (3.00)	0.62
March–April	1008 (54.5)	5.55 (3.00)	
May–June	232 (12.5)	5.77 (3.12)	
<i>Smokers at home (2010)</i>			
No	1714 (92.8)	5.49 (2.99)	<0.0001
Yes	132 (7.2)	6.70 (3.05)	

^a May not add up to the total due to missing responses^b The stress score, derived from the Perceived Stress Scale, is comprised of four questions used to assess perceived stress experienced in the past month. The score for each question ranged from 0 to 4 and were summed to get a cumulative raw score that ranged from 0 to 16 reported here.^c ANOVA used to determine significant differences in mean perceived stress across levels for each variable. For tests of 3 groups, pair-wise post hoc Scheffe tests were used. Groups sharing numerical superscripts reflect those that are significantly different in pairwise tests.

Descriptive statistics and associations of baseline perceived stress with tobacco product use outcomes at follow-up in overall sample and by gender

Table 2

	All subjects (N=1851)			Gender x Stress Interaction	
	Tobacco Product Use at Follow-Up N (%) ^a	Baseline Perceived Stress Score Mean (SD) ^b	OR (95%CI) ^c	Males (N=914)	Females (N=937)
<i>E-cigarette use</i>			(N=1847)	(N=914)	(N=933)
Never	1408 (76.2)	5.45 (2.98)	Ref	Ref	Ref
Prior	260 (14.1)	5.97 (3.19)	1.20 (1.04, 1.37) [*]	0.99 (0.82, 1.21)	1.44 (1.18, 1.77) ^{***}
Past 30-day	179 (9.7)	6.11 (2.95)	1.25 (1.07, 1.47) ^{**}	1.14 (0.92, 1.41)	1.47 (1.14, 1.89) ^{***}
<i>Hookah use</i>			(N=1849)	(N=914)	(N=935)
Never	1334 (72.1)	5.49 (3.02)	Ref	Ref	Ref
Prior	317 (17.1)	5.64 (2.82)	1.06 (0.93, 1.21)	0.98 (0.81, 1.19)	1.13 (0.94, 1.35)
Past 30-day	198 (10.7)	6.14 (3.20)	1.26 (1.08, 1.47) ^{***}	0.93 (0.74, 1.18)	1.64 (1.32, 2.05) ^{***}
<i>Combustible cigarette use</i>			(N=1849)	(N=912)	(N=937)
Never	1511 (81.7)	5.46 (2.99)	Ref	Ref	Ref
Prior	233 (12.6)	6.05 (2.89)	1.17 (1.01, 1.35) [*]	1.07 (0.87, 1.31)	1.29 (1.05, 1.59) [*]
Past 30-day	105 (5.7)	6.41 (3.30)	1.32 (1.08, 1.61) ^{**}	1.02 (0.76, 1.38)	1.72 (1.29, 2.29) ^{***}
<i>Cigar use</i>			(N=1848)	(N=914)	(N=934)
Never	1603 (86.7)	5.53 (3.00)	Ref	Ref	Ref
Prior	179 (9.7)	5.87 (3.20)	1.17 (1.00, 1.38) [*]	0.97 (0.79, 1.20)	1.51 (1.17, 1.94) ^{***}
Past 30-day	66 (3.6)	6.17 (2.83)	1.36 (1.06, 1.75) [*]	1.31 (0.98, 1.76)	1.63 (0.93, 2.87)
<i>Ever Poly tobacco product use</i>			(N=1842)	(N=912)	(N=930)
None	1161 (63.0)	5.39 (2.98)	Ref	Ref	Ref
1 product	245 (13.3)	5.80 (3.01)	1.16 (1.00, 1.34) [*]	1.03 (0.82, 1.28)	1.29 (1.06, 1.57) ^{**}
2 products	167 (9.1)	5.74 (3.10)	1.11 (0.94, 1.32)	0.92 (0.72, 1.18)	1.35 (1.05, 1.73) [*]
3 products	134 (7.3)	6.21 (3.22)	1.32 (1.10, 1.58) ^{***}	1.09 (0.83, 1.41)	1.61 (1.24, 2.10) ^{***}

	All subjects (N=1851)			Gender x Stress Interaction	
	Tobacco Product Use at Follow-Up N (%) ^a	Baseline Perceived Stress Score Mean (SD) ^b	OR (95%CI) ^c	Males (N=914)	Females (N=937)
				OR (95%CI) ^c	OR (95%CI) ^c
4 products	135 (7.3)	6.08 (2.89)	1.29 (1.07,1.55) **	1.07 (0.84,1.36)	1.72 (1.26,2.35) ***
<i>Past 30-day poly tobacco product use</i>					
None	1513 (82.1)	5.46 (2.96)	Ref (N=1842)	Ref (N=912)	Ref (N=930)
1 product	188 (10.2)	6.04 (3.28)	1.20 (1.03,1.41) *	0.90 (0.71,1.14)	1.56 (1.25,1.93) ***
2 products	85 (4.6)	6.31 (3.10)	1.32 (1.06,1.64) *	1.07 (0.77,1.49)	1.62 (1.20,2.20) ***
3+ products ^e	56 (3.0)	6.36 (2.95)	1.40 (1.07,1.85) *	1.23 (0.89,1.70)	1.96 (1.10,3.49) *

* p<0.05;

**

p<0.01;

p<0.005

^aMay not add up to the total due to missing responses.^bThe stress score, derived from the Perceived Stress Scale, is comprised of four questions used to assess perceived stress experienced in the past month. The score for each question ranged from 0 to 4 and were summed to get a cumulative raw score that ranged from 0 to 16 reported here.^cAssociation of perceived stress score as regressor and tobacco product use status as outcome variable djusted for gender, ethnicity, highest parental education, grade level at baseline, month of questionnaire at follow-up, presence of smokers at home at baseline, and community. Odds ratios are for a 1 standard deviation difference in baseline perceived stress; SD = 3.0 raw score units.^dComputed by including an interaction term between gender and perceived stress in the adjusted model among all subjects.^e41 had used 3 products, while 15 had used all 4 products.

Associations of change in perceived stress from baseline to follow-up with tobacco product use outcomes at follow-up in overall sample and by gender

Table 3

	All subjects (N=1842)		Males (N=910)		Females (N=932)		Gender x Stress Interaction
	OR (95%CI) ^a		OR (95%CI) ^b		OR (95%CI) ^b		
<i>E-cigarette use</i>	(N=1838)	(N=910)	(N=928)				
Never	Ref	Ref	Ref		Ref		0.83
Prior	1.37 (1.15,1.63) ***	1.30 (1.02,1.66) *	1.47 (1.14,1.89) ***				
Past 30-day	1.43 (1.17,1.75) ***	1.41 (1.09,1.84) **	1.48 (1.09,2.02) *				
<i>Hookah use</i>	(N=1840)	(N=910)	(N=930)				
Never	Ref	Ref	Ref				0.88
Prior	1.35 (1.15,1.58) ***	1.41 (1.11,1.79) ***	1.30 (1.04,1.62) *				
Past 30-day	1.34 (1.11,1.63) ***	1.32 (0.99,1.76)	1.37 (1.05,1.78) *				
<i>Combustible cigarette use</i>	(N=1840)	(N=908)	(N=932)				
Never	Ref	Ref	Ref				0.82
Prior	1.42 (1.19,1.69) ***	1.38 (1.07,1.78) *	1.49 (1.16,1.92) ***				
Past 30-day	1.55 (1.20,1.99) ***	1.68 (1.17,2.41) ***	1.51 (1.05,2.19) *				
<i>Cigar use</i>	(N=1839)	(N=910)	(N=929)				
Never	Ref	Ref	Ref				0.04
Prior	1.36 (1.11,1.66) ***	1.38 (1.07,1.78) *	1.29 (0.94,1.79)				
Past 30-day	1.87 (1.36,2.58) ***	1.63 (1.14,2.34) **	3.96 (1.76,8.91) ***				
<i>Ever Poly tobacco product use</i>	(N=1833)	(N=908)	(N=925)				
None	Ref	Ref	Ref				0.68
1 product	1.30 (1.09,1.55) ***	1.21 (0.91,1.60)	1.34 (1.07,1.69) *				
2 products	1.18 (0.96,1.46)	1.04 (0.76,1.42)	1.36 (1.01,1.83) *				
3 products	1.52 (1.20,1.91) ***	1.53 (1.11,2.12) **	1.48 (1.06,2.05) *				
4 products	1.81 (1.43,2.30) ***	1.72 (1.27,2.33) ***	2.03 (1.37,3.02) ***				
<i>Past 30-day poly tobacco product use</i>	(N=1833)	(N=908)	(N=925)				
None	Ref	Ref	Ref				0.34

	All subjects (N=1842)		Males (N=910)		Females (N=932)		Gender x Stress Interaction
	OR (95%CI) ^a		OR (95%CI) ^b		OR (95%CI) ^b		
1 product	1.23 (1.01,1.49) *		1.13 (0.85,1.51)		1.33 (1.02,1.73) *		p-value ^b
2 products	1.40 (1.07,1.84) *		1.46 (0.97,2.19)		1.37 (0.94,1.99)		
3+ products	1.80 (1.27,2.55) ***		1.63 (1.09,2.44) *		3.03 (1.42,6.44) ***		

* p<0.05;
** p<0.01;
*** p<0.005

^a Adjusted for gender, ethnicity, highest parental education, grade level at baseline, month of questionnaire at follow-up, presence of smokers at home at baseline, baseline perceived stress, and community. Odds ratios are for a 1 standard deviation increase in the change in perceived stress (3.75).

^b Gender specific models and the interaction model were adjusted for gender, ethnicity, highest parental education, grade level at baseline, month of questionnaire at follow-up, baseline perceived stress, and community. Presence of smokers at home at baseline was not included due to model saturation and imposed by this covariate in the gender stratified analysis. Odds ratios are for a 1 standard deviation increase in the change in perceived stress; SD = 3.75 raw score units.