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Bi-directional associations of electronic and combustible cigarette use onset patterns with depressive symptoms in adolescents

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ABSTRACT

Whether well-documented patterns of mental health comorbidity with adolescent combustible cigarette use extend to e-cigarette use is unclear. Demonstrating associations between e-cigarette and combustible cigarette use with mental health symptomatology across adolescence may be important for promoting accurate perceptions of populations at risk for and potential consequences of tobacco product use. Adolescents (N = 2460; mean age at baseline = 14.1; 53.4% female; 44.1% Hispanic) who had never previously used combustible or e-cigarettes were assessed at baseline, and 6- and 12-month follow-ups in Los Angeles, CA (2013–2014). Logistic regression was used to examine associations between baseline depressive symptoms and onset of e-cigarette and cigarette single product and dual use at follow-ups. Latent growth modeling was used to examine associations between sustained use of either product (vs. non-use) and changes in depressive symptoms over 12-months. Higher baseline depressive symptoms predicted subsequent onset of cigarette (OR = 1.024, 95% C.I. = 1.009–1.055), e-cigarette (OR = 1.015, C.I. = 1.003–1.023), and dual use of both products (OR = 1.021, C.I. = 1.003–1.043). Sustained use of e-cigarettes over the 12-month observation (vs. non-use) was associated with a greater rate of increase in depressive symptoms over time (b = 1.272, SE = 0.513, p = 0.01). Among those who sustained use of e-cigarettes, higher frequency of use was associated with higher depressive symptoms at the final follow-up (B = 1.611, p = 0.04). A bi-directional association of depressive symptoms with e-cigarette use onset across mid adolescence was observed. Further research on the causal nature, etiological underpinnings, and intervention implications of mental health and tobacco product use comorbidity is warranted.

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1. Introduction

The association between (combustible) cigarette smoking and depressive symptoms has been well documented in adolescent populations and appears to be bi-directional. Depressive symptoms predict onset and escalation of smoking, and smoking predicts increasing levels of depressive symptoms over time (Brown et al., 1996; Chaiton et al., 2009; Wang et al., 1996; Windle and Windle, 2001). The recent emergence of e-cigarettes as a dominant form of tobacco product use in adolescent populations (Leventhal et al., 2015; Johnston et al., 2015a; Corey et al., 2013) raises questions regarding whether associations with depressive symptoms extend to e-cigarette use. The extent to which the bi-directional association of depressive symptoms with e-cigarette use parallels with or departs from the well-studied association of depressive symptoms and cigarette smoking has implications for understanding whether: (a) e-cigarette use is confined to vulnerable subpopulations

with risk factors, such as depressive symptoms, or has appeal to a wider cross-section of the adolescent population including those with no or low levels of depressive symptoms; and (b) if poor mental health is a potential consequence of adolescent e-cigarette use. Given recent reports indicating that e-cigarettes may have a lower risk-profile in terms of acute physical harm (Hajek et al., 2014; Goniewicz et al., 2014; Polosa et al., 2014), documenting associations between prolonged e-cigarette use and negative associations with mental health may be particularly important in creating an accurate perception of the overall harm associated with these products.

Adolescents with higher depressive symptoms have been shown to be at greater risk of smoking due to heightened motivation to derive nicotine's rewarding (Audrain-McGovern et al., 2012) or negatively reinforcing effects (Audrain-McGovern et al., 2009; Laje et al., 2001) and greater association with peers who smoke (Audrain-McGovern et al., 2009) or engage in other deviant or risky behaviors. Prolonged nicotine exposure can cause abnormal cerebral dopamine transmission (Rademacher et al., 2016), dysregulate neural pathways underlying emotional processing (Parrott, 2015), amplify stress sensitivity (Kassel et al., 2003; Sinha, 2007), and interfere with the development of

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adaptive coping strategies that buffer against the onset of depressive symptoms (Leventhal and Zvolensky, 2015), particularly during adolescence when the developing brain is more vulnerable to nicotine-induced neurobiological insults (Holliday and Gould, 2016).

Some but not all of these aforementioned mechanisms underlying the link between cigarette smoking and depressive symptoms may extend to a possible coupling of depressive symptoms with e-cigarette use. Greater social acceptability (Kong et al., 2015) and ubiquitous use of e-cigarettes in comparison to conventional cigarettes in adolescent populations (Johnston et al., 2016), may result in e-cigarette use being less confined to peer groups saturated with high-risk youth with vulnerabilities such as depression. Or, e-cigarettes may be seen as less risky products (Wills et al., 2015) and thus initiated by adolescents with less mental health vulnerability who may normally be deterred from initiating riskier products, like combustible cigarettes. Some adolescents report using e-cigarettes without nicotine (Miech et al., 2016). Additionally, nicotine absorption and effects may differ based on the type and generation of e-cigarette used (Farsalinos et al., 2014a; Lechner et al., 2015), thus effects of nicotine on the neural circuitry underlying depressive symptoms may be more variable as compared to cigarettes which may deliver nicotine more reliably.

Research on the association of depressive symptoms and e-cigarette use in adolescents is scant and entirely cross-sectional. One such study of psychiatric comorbidity among adolescent ever cigarette smokers, ever e-cigarette users, dual users of both products, and never users of either product found that e-cigarette users had a level of depressive symptoms midway between adolescents who had not used either product and adolescents who had smoked or were dual users (Leventhal et al., 2016). Thus, while the association of depressive symptoms with e-cigarette use is present and may be less pronounced than the corresponding relation with combustible cigarettes, whether such relationships extend to longitudinal designs and follow bi-directional patterns is unknown.

To provide the first longitudinal evidence on the association of e-cigarette use and depressive symptoms in adolescents, this study examined bi-directional associations of depressive symptoms with onset and sustained use of e-cigarettes over a 12-month period in adolescent's who had never used cigarettes or e-cigarettes at baseline. We hypothesized that elevated baseline depressive symptoms would predict onset of e-cigarette use over the follow-up period. We also hypothesized that teens who onset and then sustained use of e-cigarettes during the 12-month follow-up period (as compared to non-users of either tobacco product) would report higher concurrent increases in depressive symptoms across the 12 months. Furthermore, given the data reviewed above indicating that e-cigarette users may have less pronounced risk factors than combustible cigarette users, we also examined the bi-directional associations of depressive symptoms with combustible cigarette, and dual use. Examining these relationships will provide information on mental health risk factors for e-cigarette use and aid in understanding the overall harm associated with these products.

2. Method

2.1. Participants and procedure

Data were drawn from a longitudinal study (baseline [wave 1], 6-month follow-up [wave 2], and 12 month follow-up [wave 3]) of substance use and mental health among high school students in the Los Angeles, CA metropolitan area between 2013 and 2014. At each wave students completed surveys in their classrooms; those absent during data collection completed phone or web surveys. All procedures were approved by the University of Southern California Institutional Review Board.

The first wave of data collection commenced when participants were enrolled in ninth-grade coursework; all English-speaking students not in special education were eligible to participate (N = 4100). Of the assenting students (N = 3874; 94.5%), 3396 (87.7%) returned parental consent, from whom data was collected for 3383 (99.6%), 3293 (97.0%), and 3282 (96.6%) participants, at baseline and 6- and 12-month follow-ups, respectively. The sample for the current report included 2460 adolescents who completed measures within the current analyses for all 3 waves, and reported never using combustible or electronic cigarettes, in their lifetime, at the baseline assessment. The analytic sample had a baseline mean age = 14.1 (SD = 0.41) and was ethnically heterogeneous (53.4% female, 44.1% Hispanic, 19.0% Asian, 16.2% White, 5.6% Bi-ethnic or Bi-racial, 4.8% African-American, 4.1% Native-American/Pacific-Islander, 5.5% other); 71.5% of students' parents attained a level of education of high school diploma or higher.

2.2. Measures

2.2.1. E-cigarette and cigarette use

Using items derived from the Youth Behavior Risk Surveillance (Eaton et al., 2010) and Monitoring the Future Surveys (Johnston et al., 2015b), lifetime and past 6-month use of e-cigarettes (described as "electronic cigarettes, personal vaporizers") and combustible cigarettes were measured at each wave (yes/no). Frequency of e-cigarette use and cigarette use within the last 30 days (scored as a 6-level variable: $0 = 0$ days, $1 = 1$–2 days, $2 = 3$–5 days, $3 = 6$–9 days, $4 = 10$–14 days, $5 = 30$ days) was assessed only at wave 3. For analyses of the association of baseline depression with the onset of tobacco product use, we defined four mutually exclusive groups: (1) tobacco non-users (no-use of either tobacco product across waves); (2) onset of only combustible cigarette use at wave 2 or 3 (any onset within 12 months of baseline); (3) onset of only e-cigarette use at wave 2 or 3; (4) onset of dual use of both products at wave 2 or 3. For analyses of the trajectories of depressive symptoms associated with tobacco product use over time, e-cigarette use and combustible cigarette use were separately categorized as non-use (no use at wave 2 or 3), non-sustained use (use at wave 2 or 3 but not both), or sustained use (use at both wave 2 and wave 3). We did not model onset of dual use as a separate classification for these analyses due to small cell sizes.

2.2.2. Depressive symptoms

The 20-item Center for Epidemiologic Studies – Depression Scale (CES-D) was used to obtain self-reports of recent depressive symptom level. Questions are phrased as self-statements (e.g., "I felt sad", "I had crying spells"). Sum past week frequency rating was utilized for the current analysis (score range for each item: 0 [rarely or none of the time; 0–1 day] to 3 [most or all of the time; 5–7 days]). The CES-D has been shown to have good internal consistency and adequate psychometric properties in adolescent populations (Garrison et al., 1991).

2.2.3. Covariates: demographics, other tobacco use, alcohol use

Variables peripheral to a putative pathway by which tobacco product use may be directly associated with depressive symptoms were selected a priori as covariates based on the previous literature. Sociodemographic characteristics including age, gender, ethnicity/race, and highest parental education were assessed using self-report responses to investigator-selected forced choice items. Family living environment was measured with the item, "Who do you live with most of the time?" (both biological parents vs. other) (Covey and Tam, 1990). Other tobacco and alcohol use was measured at each wave, using items based on the YRBS (Eaton et al., 2010) and MTF (Johnston et al., 2015b) assessing lifetime and past 6-month use (yes/no) of full-size cigars, little cigars/cigarillos, hookah water pipe, blunts ("marijuana rolled in a tobacco leaf or cigar casing"), and frequency alcohol use in the past 30 days.