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E-cigarette Use and Perceptions among Adolescents with Attention-Deficit/Hyperactivity

Disorder: The Role of Parental Messages about Tobacco

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science
at Virginia Commonwealth University

by

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Bachelor of Arts

University of Virginia, May 2017

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Abstract

E-CIGARETTE USE AND PERCEPTIONS AMONG ADOLESCENTS WITH ATTENTION-DEFICIT/HYPERACTIVITY DISORDER: THE ROLE OF PARENTAL MESSAGES ABOUT TOBACCO

By Mayra Sabina Ramos, B.A.

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University

Virginia Commonwealth University, 2021

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Adolescents with attention-deficit/hyperactivity disorder (ADHD) are at increased risk of using e-cigarettes compared to their neurotypical peers. Parent-adolescent communication about tobacco use and number of ADHD symptoms can influence adolescents' perceptions of e-cigarettes and their e-cigarette use. Adolescents with ADHD ($n = 80$) completed questionnaires assessing parental messages about tobacco use; e-cigarette harm perceptions; susceptibility to use e-cigarettes; and e-cigarette use. Parents reported on messages about tobacco use, adolescent's ADHD symptomatology, and completed demographic questionnaires. Twenty-percent of adolescents reported e-cigarette ever use. Adolescent girls were significantly more likely to report higher e-cigarette harm perceptions than boys. Parents reported providing messages about tobacco use more frequently than adolescents reported receiving. E-cigarette harm perceptions did not mediate the association between parent-reported messages and adolescent's e-cigarette use. Further, the ADHD symptom severity did not moderate the associations between parental messages of tobacco use and adolescents' e-cigarette outcomes.

Results highlight the similarities in e-cigarette outcomes for adolescents with ADHD and their peers without ADHD. Suggestions for future research are provided.

E-Cigarette Use and Perceptions among Adolescents with Attention-Deficit/Hyperactivity Disorder: The Role of Parental Messages about Tobacco

Smoking among adolescents with attention-deficit/hyperactive disorder (ADHD) is a public health priority. Adolescents with ADHD are more likely than their peers without ADHD to smoke traditional cigarettes and initiate smoking at an earlier age (14 vs 15 years) (Howard et al., 2020; Molina et al., 2018; Rhodes et al., 2016; Sibley et al., 2014). Adolescents with ADHD also progress from smoking initiation to daily smoking more quickly than adolescents without ADHD (Mitchell et al., 2019). This increased risk of smoking and fast progression to heavier use likely contributes to the comorbidity between tobacco use and ADHD in adulthood. In the Multimodal Treatment Study that surveyed 529 children with ADHD over time, young adults with ADHD were more likely to be daily smokers (38.4%) than adolescents who did not have ADHD (19.2%) (Mitchell et al., 2019).

Over the past few years, traditional cigarette smoking among adolescents has declined (Miech et al., 2019; Wang et al., 2018) and the use of e-cigarettes has increased (Amrock et al., 2015; Gentzke et al., 2019; Huang et al., 2016; Levy et al., 2019). Similar trends have been found for adolescents with ADHD. For instance, Dvorsky and Langberg (2019) reported that past 30-day e-cigarette use increased from 13.3% to 20.9% during the transition from high school to college in a sample of adolescents with ADHD. Goldenson et al. (2018) found that 3.9% of 9th grade students with ADHD reported past 30-day use of cigarettes, 9.0% e-cigarettes, and 3.4% hookah. They also found that total number of ADHD symptoms were associated with initiating e-cigarette but not hookah or traditional cigarette smoking. Finally, some studies have demonstrated that older adolescents with ADHD are more likely than their neurotypical peers to use e-cigarettes (Xu et al., 2021). Accordingly, identifying factors that may be associated with

increased e-cigarette use among adolescents with ADHD can aid in the development of prevention programs for adolescents with ADHD.

Adolescents' Perceptions of E-Cigarettes

Adolescent's misperceptions of the harm and addictiveness of e-cigarettes are risk factors for increased susceptibility to use e-cigarettes and e-cigarette experimentation (Ebrahimi Kalan et al., 2020). A common misperception about e-cigarettes is that smoking e-cigarettes carries a lesser degree of harm than smoking traditional cigarettes (Pearson et al., 2012; Rohde et al., 2018; Owotomo et al., 2018). In fact, almost a third of 24,658 adolescents considered e-cigarettes to be less harmful than traditional cigarettes (Ambrose et al., 2014). Park et al. (2019) found that adolescents described e-cigarettes as a healthier alternative compared to traditional cigarettes. Specifically, adolescent e-cigarette users held a strong belief that inhaling e-cigarette vapor was "much better" for their health than traditional cigarette smoke. Studies have also found that adolescents' reduced harm perceptions of e-cigarettes, in comparison to traditional cigarettes, are associated with adolescent's e-cigarette use (Ambrose et al., 2014; Bernat et al., 2018; Chaffee et al., 2015; Cooper et al., 2016). For instance, Amrock et al. (2015) found that adolescent's misperception of e-cigarette harmfulness compared to traditional cigarettes was associated with a 1.6-point increase in e-cigarette use. In a nationally representative sample of middle and high school students who smoked e-cigarettes, Tsai et al. (2018) found one of the most commonly selected reasons for use was the perception that e-cigarettes were less harmful than other forms of tobacco. These misperceptions are concerning because the nicotine and other chemicals in e-cigarettes are harmful to adolescent development (Coke, 2020; Goriounova & Mansvelter, 2012; Peterson & Hecht, 2017; Rubinstein et al., 2018; Yuan et al., 2015).

E-cigarettes have been advertised as devices that can be used to reduce and ultimately

help people quit smoking traditional cigarettes (Pepper et al., 2014). Gorukanti et al. (2017) found that approximately 40% of 9th and 12th grade students believed that e-cigarettes help people quit smoking traditional cigarettes. These types of messages and beliefs may be associated with adolescents' misperceptions about the addictiveness of e-cigarettes compared to traditional cigarettes (Amrock et al., 2015; Roditis et al., 2016). For instance, Alexander et al. (2019) found that adolescents knew that nicotine was an additive in e-cigarettes and they expressed future expectations of quitting e-cigarette use once available research on the damaging effects was available. Still, the adolescents failed to recognize that continued use and exposure to nicotine would make it far more difficult to quit smoking.

Relatively few studies have examined the perceptions of e-cigarettes held by adolescents with ADHD. Yet, there is some literature suggesting that symptoms of ADHD may exacerbate their misperceptions about e-cigarettes, which may then increase e-cigarette use (Dvorsky & Langberg, 2019). Specifically, Dvorsky and Langberg (2019) found the number of ADHD symptoms in high school predicted increased maladaptive social perceptions about traditional cigarettes and e-cigarettes during the transition to college, and across the first year of college. While Dvorsky and Langberg (2019) explored social perceptions associated with e-cigarette use (e.g., social acceptability, tolerance, and desirability of e-cigarette use), perceptions about harm and risk of e-cigarette use were not specifically addressed. Further, Corona et al. (2020) found that maladaptive perceptions about e-cigarettes decreased after adolescents with ADHD participated in an intervention that focused on academic and tobacco prevention skills. In summary, few studies have focused on perceptions about e-cigarette harmfulness among adolescents with ADHD, yet perceptions are modifiable and associated with e-cigarette and traditional cigarette smoking.

Parental Messages about Tobacco and E-cigarette Use

Oetting, Donnermeyer, and Deffenbacher's (1988) primary socialization theory proposes that drug use is a social behavior that can be strengthened or weakened through social factors (i.e., family, school, and peers). Parents are an ongoing influence on their child's behaviors. For instance, parent-adolescent prevention communication about substance use is positively associated with adolescent's anti-substance use norms (Kam & Yang, 2014; Shin & Miller-Day, 2017) and substance use behaviors (Brittner et al., 2018; Choi et al., 2017; Miller-Day, 2002; Salas-Wright et al., 2019). In a review of the literature, Carver et al. (2017) found that conversations surrounding tobacco use should include high quality explanations about the health implications associated with tobacco use to be most protective against adolescent's tobacco use. Similarly, Engels and Willemsen (2004) found anti-smoking communication was associated with smoking related cognitions (i.e., negative attitudes towards smoking, lower intentions to start smoking, and higher self-efficacy). Parental anti-smoking socialization aims to prevent smoking onset by providing messages that communicate the negative health effects resulting from substance use, reasons why people start smoking and rules designed to deter adolescents from engaging in tobacco use (Corona et al., 2015; de Leeuw et al., 2008; Nasim & Corona, 2010). This literature base suggests that parents may also play a critical role as socialization figures that can aid in e-cigarette prevention programming for their adolescents through frequent and effective communication (Trucco et al., 2021).

Parental messages about tobacco may vary in impact depending on the frequency adolescents perceive receiving such messaging. Guilamo-Ramos et al. (2006) found weak correlations between adolescent and parent reports of the frequency with which the adolescent had spoken to their mothers about smoking cigarettes. They found that adolescent reports of

parent-adolescent communication of risky behaviors (i.e., smoking cigarettes) were more predictive of adolescent smoking than parent reports about communication (Guilamo-Ramos et al., 2006). Similarly, de Leeuw et al. (2010) found adolescent's report of the frequency of anti-smoking communication was, on average, lower than the parent report. While parents may report all communication attempts made to prevent their adolescents from smoking, adolescent's may not register every statement made by the parent. Kodl and Mermelstein (2004) highlight the importance of including the parent and adolescents' perspectives when assessing the associations between parental anti-smoking communication and youth smoking behavior.

Prior research examining parent communication and adolescents with ADHD's tobacco use primarily focuses on the quality of the communication. For example, Burke et al. (2001) assessed the quality of parent-child communication and found that poor communication was associated with a 2.9 times greater risk for adolescents with ADHD's tobacco use. Further, parent-child communication about tobacco use is modifiable and can be improved through intervention (Beatty et al., 2008; Gordon et al., 2008; Guilamo-Ramos et al., 2010; Mahabee-Gittens et al., 2007). Schoenfelder and Kollins (2016) suggest teaching parents to improve communication with their teens with ADHD in order to help prevent teen health risk factors, such as substance use. Interventions including elements that target parent-child communication may also help reduce maladaptive perceptions of tobacco use across youth with ADHD. Adolescents with ADHD who had participated in a tobacco prevention program that targeted parenting and family relationship factors, including communication about tobacco's harm, reported reduced maladaptive social normative beliefs about smoking, amongst other tobacco risk prevention outcomes, during intervention and at follow-up (Corona et al., 2020).

The Potential Mediating Role of Perceptions of Harm

Anti-smoking parenting practices, such as parental communication, have been found to be associated with adolescent's perceptions of tobacco use (Engels & Willemsen, 2004; Huver et al., 2007; van Zundert et al., 2007). The perceptions adolescents hold about tobacco use may influence their own use by increasing or decreasing their susceptibility. In a study by Hiemstra et al. (2012), it was found that frequent anti-smoking communication was associated with lower pro-smoking attitudes in a sample of pre-adolescents. As such, perceptions of the harmfulness of tobacco products may explain the relationship between parental communication and adolescent's tobacco use through an indirect pathway. Indeed, Avenevoli and Merikangas (2003) suggest that parenting practices often indirectly affect adolescent smoking outcomes.

Few studies have explored the mediational mechanisms of perceptions of tobacco products between parental communication and adolescent smoking outcomes. One study by Huver et al. (2006) found adolescent's cognitions of smoking mediated the relationship between anti-smoking parenting practices, such as rules and content of communication about smoking, and adolescent's smoking behaviors. Specifically, they found that communication about the health risks and the addictive qualities of smoking was associated with reduced adolescent smoking. Further, Otten et al. (2007) found that parental practices, such as communication about the harm associated with smoking, can prevent children from smoking by shifting their cognitions about tobacco use. Smoking cognitions, including perceptions of the tobacco product's harmfulness, can indirectly influence use of tobacco. The perceptions that adolescents hold about tobacco products and smoking may serve as a critical component in tobacco use prevention and intervention programs across adolescence.

Underlying mediating mechanisms promoting or deterring adolescent with ADHD's e-cigarette use are less understood. The literature has yet to explore if perceptions of e-cigarette

harmfulness can mediate the relationship between anti-smoking parenting practices and e-cigarette use. Present literature contends that perceptions are a risk factor behind adolescent e-cigarette use (Amrock et al., 2015; Park et al., 2019; Tsai et al., 2018). As such, it is possible that messages provided by parents are also able to influence the use of this new tobacco product.

The Moderating Role of ADHD Symptoms

Not all adolescents with ADHD are equally susceptible to smoking cigarettes. Variability in ADHD symptom severity may place some adolescents with ADHD at greater risk than others. For instance, adolescents with greater ADHD symptom severity are at a heightened smoking risk (Gudjonsson et al., 2012). Kollins et al. (2005) followed a nationally representative sample of 15,197 adolescents with ADHD into young adulthood and found that adolescent's risk of becoming a regular smoker was linearly related to the number of reported retrospective hyperactive/impulsive and inattentive ADHD symptoms. Moreover, Mitchell et al. (2019) found total number of ADHD symptoms one standard deviation above average predicted a 47% chance of daily smoking while one standard deviation below the average only predicted a 25% chance. Heightened ADHD symptom severity is also associated with greater nicotine dependence (Fuemmeler et al., 2007).

Recent studies have also captured trends between ADHD symptom severity and e-cigarette perceptions and use. In a longitudinal survey by Goldenson et al. (2018) that included 3,383 high school students, adolescents with ADHD were 23% more likely to initiate in e-cigarette use with one standard deviation increase in total number of ADHD symptoms. Similarly, Vogel et al. (2020) found 12th grade students' e-cigarette dependence was significantly associated with an increase in total number of ADHD symptoms at a 6-month follow up. Additionally, Dvorsky and Langberg (2019) found that the total number of ADHD

symptoms in high school was predictive of increased e-cigarette use during the first year of college. Moreover, greater total number of symptoms were associated with increased maladaptive social perceptions (e.g., e-cigarettes are safer) of e-cigarette and traditional cigarette use. This provided novel evidence of the reciprocal influence between ADHD symptomatology and maladaptive social perceptions about e-cigarette use across time. They postulated that ADHD symptoms, such as impulsivity and poor self-regulation, were more closely related to e-cigarette use through the heightening of maladaptive perceptions.

Current Study

E-cigarette use among adolescents with ADHD is increasing (Dvorsky & Langberg, 2019; Goldenson et al., 2018). Further, some studies have found differential relationships between factors that predict e-cigarette and traditional cigarette use (Goldenson et al., 2018). The current study contributes to the literature in three ways: (1) The present study will describe adolescents with ADHD's e-cigarette harm perceptions, susceptibility to use e-cigarettes, and e-cigarette use. To date, most studies have primarily focused on e-cigarette use with less attention paid to factors such as perceptions that could affect use. (2) Further, relatively few studies have examined the relationship between parental messages about tobacco use and e-cigarette use in families of adolescents with ADHD. (3) This study also seeks to identify a moderator (i.e., ADHD symptom severity) and mediator (i.e., e-cigarette harm perceptions) of the association between parent-adolescent communication about tobacco and adolescents' e-cigarette use outcomes.

Study Aims and Hypotheses

Aim 1.

The first aim of the study is to describe e-cigarette harm perceptions, susceptibility to use

e-cigarettes, and e-cigarette use in a sample of adolescents with ADHD. It is expected that adolescents with a greater ADHD symptom severity will report that e-cigarettes are less harmful than traditional cigarettes. This aim will also characterize parent- and adolescent-reported messages about tobacco use. It is hypothesized that parents will report more messages about tobacco use than adolescents report receiving.

Aim 2.

The second aim of the study explores whether adolescent's low harm perceptions mediate the association between parent- and adolescent-reported parental messages about tobacco use and adolescents with ADHD's e-cigarette use. It is expected that adolescent's e-cigarette harm perceptions will indirectly explain the associations between parent- and adolescent-reported parental messages and adolescent's e-cigarette use.

Aim 3.

The third aim of the study examines whether ADHD symptom severity moderates the associations between parent- and adolescent-reported parental messages about tobacco use and adolescent's low harm perceptions, susceptibility to use e-cigarettes, and e-cigarette use. It is expected that parent- and adolescent-reported parental messages about tobacco use will be negatively associated with low harm perceptions and e-cigarette use and positively associated with susceptibility to use e-cigarettes. It is hypothesized that adolescents with greater ADHD symptom severity will have lower harm perceptions. It is also hypothesized that adolescents with greater ADHD symptom severity will have higher susceptibility to use e-cigarettes and will endorse e-cigarette use.

Method

Overview

The present study is a secondary analysis of data collected as part of a pilot randomized-controlled trial (see Corona et al., 2020 for information about the parent study). Adolescents with ADHD and their caregivers completed baseline measures, participated in an evidence-based intervention targeting academic difficulties often experienced by adolescents with ADHD, and then completed follow-up measures. Analyses in the present study were conducted using baseline data.

Participants

Participants included 80 adolescents (58 boys, 22 girls) with ADHD and their caregivers. Adolescents ranged in age from 13 to 17 years ($M = 14.9$, $SD = 1.1$). The majority of adolescents (91.1%) attended public school with the remaining adolescents attending charter (6.4%) and private (2.5%) schools. Eighty percent of adolescents were in high school and 12.5% were in middle school. Nearly three-fourths (71.3%) of adolescents were non-Hispanic/Latinx White, 17.7% were non-Hispanic/Latinx Black or African American, 8.8% were Biracial/Multiracial, 1.3% were Native Hawaiian/Pacific Islander, 5% were Latinx, and 1.3% chose not to answer. Eighty-four percent of adolescents presented with ADHD Predominantly Inattentive (ADHD-IA), and 16.2% presented with ADHD Combined (ADHD-C) presentation. ADHD presentation type was not reported for two adolescents (2.5%). Slightly over half of the caregivers reported their adolescents (53.8%) were taking medication for ADHD.

The majority of the caregivers were biological mothers (85%) with the remaining caregivers identifying as biological fathers (7.5%) and other (2.5%). Four caregivers chose not to answer. Caregivers ranged in age from 34 to 59 years ($M = 46.8$, $SD = 6.0$). Four caregivers did not provide their birthdate. Family annual income ranged from less than \$10,000 to more than \$200,000: less than \$49,999 (11.3%), between \$50,000 and \$74,999 (22.3%), between \$75,000

and \$99,999 (16.3%), between \$100,000 and \$149,999 (23.8%), greater than \$150,000 (23.8%), and three participants chose not to answer (3.8%). Caregivers' highest level of education is as follows: high school diploma/G.E.D. (6.3%), partial college or associate's degree (11.3%), bachelor's degree (37.5%), and advanced degree (38.8%). Five caregivers chose not to report their highest degree earned. Characteristics of the sample are shown in Table 1.

Table 1.

Demographics

<i>Demographic variable</i>	<i>N (%)</i>
Age (years), mean (SD)	
Adolescent	14.9 (1.1)
Caregiver	46.8 (6)
Adolescent Gender	
Boys	58 (72.5)
Girls	22 (27.5)
Adolescent Ethnicity	
Hispanic/Latinx	4 (5)
Not Hispanic/Latinx	56 (70)
Not Reported	20 (25)
Adolescent Race	
White	57 (71.3)
Black or African American	14 (17.5)
Biracial/ Multiracial	7 (8.8)
Native Hawaiian/Pacific Islander	1 (1.3)
Not Reported	1 (1.3)
Adolescent Grade	
8	10 (12.5)
9	31 (38.8)
10	16 (20)
11	13 (16.3)
12	3 (3.8)
Not Reported	7 (8.8)
Adolescent Medication Status	
Medicated	43 (53.8)
Not Medicated	35 (43.8)
Not Reported	2 (2.5)

Caregivers' Education

High School Diploma/G.E.D.	5 (6.3)
Some College/Associate's Degree	9 (11.3)
Bachelor's Degree	30 (37.5)
Advanced Degrees	31 (38.8)
Not Reported	5 (6.3)

Family Income

Less than \$49,999	9 (11.3)
\$50,000 to \$74,999	17 (22.3)
\$75,000 to \$99,999	13 (16.3)
\$100,000 to \$149,999	19 (23.8)
\$150,000 or more	19 (23.8)
Not Reported	3 (3.8)

Procedures

Participants were recruited from local middle and high schools in the central Virginia region through flyers sent home and referrals from school counselors. The recruitment flyers indicated that families had the opportunity to receive a free diagnostic assessment for the adolescent, and if adolescents met eligibility criteria, families could receive an intervention that focuses on academic impairments frequently exhibited by adolescents with ADHD. Interested families completed a phone screener with research staff. Parents who endorsed that their child was currently exhibiting at least four of nine DSM-5 ADHD symptoms of inattention were invited to participate in a full eligibility evaluation.

Eligibility evaluations were administered by clinical psychology doctoral students who were observed multiple times before the evaluations were administered independently. This information was reviewed by a licensed clinical psychologist to determine eligibility and diagnoses. Adolescents were eligible to participate in the study if they: (a) were between 13 and 17 years of age; (b) met DSM-5 diagnostic criteria for ADHD based on the Parent Children's Interview for Psychiatric Syndromes (P-ChIPS; Weller et al., 2000); (c) demonstrated an IQ of

80 or above as measured by the Wechsler Abbreviated Scale of Intelligence Scale for Children (WASI; Wechsler, 1999); and (d) did not meet diagnostic criteria for a pervasive developmental disorder, bipolar disorder, or psychosis. Adolescents were also administered four subtests from the Wechsler Individual Achievement Test, Third Edition (WIAT-III; Wechsler, 2009) to evaluate academic achievement abilities. The four subtests measured word reading, pseudoword decoding, math problem solving, and numerical operations.

Because the intervention was developed to prevent initiation and further progression of tobacco use, adolescents who were currently using or had previously used tobacco, but who did not meet criteria for a Substance Use Disorder ($n=16$) participated in the study. Adolescents who met criteria for, or had been diagnosed with, a Substance Use Disorder were excluded from the study ($n=1$). Baseline measures were completed at the time of the eligibility evaluations and before the intervention started. After completing the baseline assessment, adolescents were randomly assigned to the intervention and control groups and participated in the group interventions. Participants completed measures at baseline, post-intervention and 3- and 9-month post-intervention. Families received \$50 for completing the baseline and post measures, and \$75 for the 3- and 9-month assessments.

Measures

Demographic Information. Adolescents were asked to report their date of birth, gender, race, ethnicity, and their grade in school. Caregivers reported on their date of birth, gender, race, ethnicity, adolescent's ADHD medication status, and the family's estimated household yearly income.

Parental Messages about Tobacco Use. Parents and adolescents responded to eight items that evaluated the frequency of messages parents conveyed to their adolescent about

tobacco use over the last six months (Ennett et al., 2001). Example items included “How to resist peer pressure to using tobacco” and “Encouragement of not using tobacco.” Responses for the items ranged from 0 (*0 times*) to 3 (*3 or more times*). Items were summed so that higher scores indicated greater frequency of parental messages about tobacco use. Reliability coefficients for this measure were $\alpha = .95$ for parent-report of parental messages and $\alpha = .94$ for adolescent-report of parental messages.

ADHD Symptom Severity. The Vanderbilt ADHD Diagnostic Rating Scale (VADRS) is a DSM-IV-based scale that contains 18 DSM-IV symptoms of ADHD. Parents were asked to report on their adolescent’s behavior in the past six months. Some of the items in this measure were, “Does not pay attention to details or makes careless mistakes, with, for example, homework,” and “Is easily distracted by noises or other stimuli.” Caregivers rated how frequently each symptom occurred on a 4-point scale ranging from 1 (*never*) to 4 (*very often*). This measure provided an Inattentive symptom score (sum of the nine inattention items) and a Hyperactivity/Impulsivity symptom score (sum of the nine hyperactive/impulsive items). For the present study, ADHD symptom severity was computed by summing all 18-items (see American Academy of Pediatrics and National Initiative for Children’s Healthcare Quality, 2002). Higher values suggested greater ADHD symptom severity. The VADRS has good psychometric properties with the DSM-IV criteria for ADHD (Wolraich et al., 2003). In the current sample, internal reliability was $\alpha = .91$.

Adolescent Low E-cigarette Harm Perceptions. Adolescents responded to five items about their perceptions of e-cigarette harmfulness (Adkison et al., 2013; Choi & Forster, 2013). Example items were: “E-cigarettes are less harmful than regular cigarettes” and “E-cigarettes are less addictive than regular cigarettes.” Participants indicated their level of agreement using a 5-

point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The five items were summed to create a total score with higher scores indicating lower e-cigarette harm perceptions (Pokhrel et al., 2015). Internal consistency in the current sample was $\alpha = .80$.

Adolescent Susceptibility to Use E-cigarettes. Adolescents responded to five items that assessed their awareness and willingness to use e-cigarettes (Pepper et al., 2013). Example items included “Do you think that in the future you might experiment with e-cigarettes” and “If one of your best friends were to offer you an e-cigarette, would you try it?” Responses ranged from 1 (*definitely yes*) to 4 (*definitely not*). All five items were summed to create a total score with lower scores indicating greater susceptibility to use e-cigarettes (see Dunbar et al., 2019 for similar scoring). The reliability coefficient for this measure was $\alpha = .92$.

Parental Tobacco Use. Parents responded to 17 items that assessed their lifetime and past 30-day use of several types of tobacco products (i.e., cigarettes, cigars, cigarillos, snuff, chewing tobacco, e-cigarettes, and any “other” tobacco product). Parents were asked if they had ever used or had used any of the mentioned tobacco products in the past 30 days. Responses for the items were 0 (*no*) to 1 (*yes*). For the present study, parents were categorized as a “past 30 day smoker” or “ever smoker” if they responded “yes” to ever using any of the mentioned tobacco products in each respective question.

Adolescent E-cigarette Use. Adolescents responded to two items that asked about their ever-use and past 30 day use of electronic vapor products. Specifically, adolescents were asked about their use of products such as blue, NJOY, Starbuzz, e-cigarettes, e-cigars, e-pipes, vaping pens, e-hookahs, and hookah pens. Adolescent responses ranged from 0 (*no*) to 1 (*yes*) for the ever use item and ranged from 1 (*I did not use an electronic vapor product during the past 30 days*) and 7 (*More than 20 times per day*) for the past 30 day use item. To categorize past 30 day

users, any response other than “I did not use an electronic vapor product during the past 30 days” was scored as a “past 30 day user.”

Data Analytic Plan

Missing Data. Little’s MCAR test for randomness of missing data was conducted at the scale for all variables. Minimal proportions of data were missing for parent-reported messages (2.5%), medication status (2.5%), and ADHD symptom severity (2.5%). Little’s MCAR test demonstrated the three variables were missing completely at random, $\chi^2(10) = 9.68, p = .469$. All other variables had no missing data.

Power Analysis. Given that this was a secondary data analysis, a post hoc power analysis was conducted using G* Power software (Faul et al., 2009) to provide an estimate of power with the current sample size of 80 participants. With 80% power ($1 - \beta$), the sample of 80 participants generated enough power to uncover a medium-sized effect ($\geq f^2 = .19$) for the hypotheses.

Descriptive Statistics. Assumptions of normality were met for all variables with all skewness and kurtosis values ± 1.5 (Tabachnick & Fidell, 2013). No univariate nor multivariate outliers were found. Multicollinearity was not observed across the independent variables. Assumptions for linearity, normality, and homoscedasticity were evaluated in each moderation and mediation model. Means, standard deviations, and ranges for continuous criterion and outcome variables were calculated. Prior to conducting the primary analyses, bivariate correlation coefficients (demographic variables and study variables) were computed to identify covariates.

Specific Aim Analyses. Aim 1 characterized the prevalence and nature of e-cigarette outcomes. Descriptive statistics were used to capture the responses of the adolescents and the frequency of responses as reported by gender. Frequency of parent- and adolescent-reported

parental messages of tobacco use was also reported to characterize differences in perceived receipt of messages. To address Aim 2, two mediation models were tested using PROCESS macro (Model 4) in SPSS version 26. The mediation models explored if adolescents' low harm perceptions mediated the association between parent- and adolescent-reported parental messages and adolescents' e-cigarette use. The confidence interval for this analysis was 95% to correspond with the proposed α level ($\alpha = .05$). If the confidence interval did not include 0, this indicated that the mediation effect was significant. Adolescent age, gender, and medication status were included as covariates. Finally, Aim 3 examined whether ADHD symptom severity moderated the associations between parental messages about tobacco (parent- and adolescent-report) and adolescent's e-cigarette outcomes (i.e., low harm perceptions, susceptibility to use e-cigarettes, and e-cigarette use). Six moderation models were run using PROCESS macro (Model 1) in SPSS version 26. The discrete predictor and moderating variables (i.e., parent- and adolescent-reported parental messages and ADHD symptom severity) were mean-centered to reduce nonessential multicollinearity. The moderation effects were tested by using a bootstrap estimation approach with 5,000 samples to allow for greater precision in estimating the effect of the moderator variable (i.e., ADHD symptom severity). The Hayes PROCESS Macro software computed the interaction term of the predictor and centered moderator variable. If the interaction term was significant, the association was plotted. Adolescent age, gender, and medication status were included as covariates in all analyses.

Results

E-cigarette Outcomes among Adolescents with ADHD

One-fifth of the adolescents with ADHD (20%) reported ever using an e-cigarette. The majority of the adolescents (92.5%) reported no e-cigarette use in the past 30 days. Thirty-nine

percent of caregivers reported ever using tobacco products. Specifically, caregivers reported ever use of the following products: 30 caregivers reported cigarette use, 8 reported cigar use, 5 reported cigarillo use, 3 reported snuff use, 5 reported chewing tobacco use, and 4 reported e-cigarette use. Regarding caregiver past 30 day use, 11.3% reported using a tobacco product, specifically seven reported cigarette use and two reported e-cigarette use. Caregivers did not report past 30 day use for cigars, cigarillos, snuff, and chewing tobacco. As seen in Table 2, the majority of adolescents believed that e-cigarettes can help people quit or reduce cigarette smoking, and that e-cigarettes are less harmful than regular cigarettes. Relatively few adolescents believed that e-cigarettes are less addictive than regular cigarettes or that they could be used in non-smoking environments. The majority of the adolescents reported that they would “definitely not” smoke e-cigarettes soon (82.5%), in the future (63.7%), and in the next year (76.3%). Similarly, most responded “definitely not” to the items that asked whether they would try an e-cigarette if their best friends offered it to them.

With respect to parental messages about tobacco use, there were differences in parent- and adolescent report about parental messages about tobacco use. Specifically, parents ($M = 7.0$) reported a greater frequency of parental messages about tobacco use than their adolescents ($M = 2.5$) reported, $t(77) = 4.51, p < .001$ (see Table 5). There was only one item that adolescents endorsed at a higher percentage than parents and it was focused on discipline if adolescents used tobacco (see Table 3). Also, adolescents and parents endorsed the messages of encouragement to choose friends who do not use tobacco at a similar percentage.

As observed in Table 4, there was one significant difference in e-cigarette outcome by gender. There was a significant difference in report of low harm perceptions, $t(78) = -2.01, p =$

.046, with boys reporting more low harm perceptions than girls. There were no other significant differences by gender across susceptibility to use e-cigarettes nor e-cigarette use.

Table 5 displays the bivariate correlations between all variables (i.e., age, gender, medication status, total number of ADHD symptoms, adolescents' low harm perceptions, susceptibility to use e-cigarettes, and e-cigarette use). The means and standard deviations of each variable are also found in Table 5. Bivariate correlations revealed several significant associations. The demographic variables (i.e., adolescent age, gender, and medication status) were significantly associated with several other variables. Adolescent age was significantly positively associated with low harm perceptions ($r = .42, p < .001$) and adolescents' e-cigarette use ($r = .25, p = .013$), and negatively associated with ADHD symptom severity ($r = -.25, p = .015$). Gender was positively associated with adolescents' low harm perceptions ($r = .20, p = .042$) and negatively associated with medication status ($r = -.34, p = .001$). Medication status was positively associated with adolescents' susceptibility to use e-cigarettes ($r = .23, p = .021$) and negatively associated with e-cigarette use ($r = -.31, p = .003$). Given these results, adolescent age, gender, and medication status were included in analyses as covariates.

Parent- and adolescent-reported parental messages were not significantly associated with each other. Parent-reported parental messages were significantly negatively associated with adolescent's low harm perceptions ($r = -.22, p = .028$). Parent-reported parental messages were not associated with susceptibility nor e-cigarette use. Adolescent-reported parental messages were not significantly associated with any e-cigarette outcomes. ADHD symptom severity was negatively associated with e-cigarette use ($r = -.22, p = .026$). Adolescent's low harm perceptions were negatively associated with susceptibility to use e-cigarettes, ($r = -.41, p < .001$),

and positively associated with e-cigarette use ($r = .29, p = .005$). Adolescent susceptibility to use e-cigarettes was negatively associated with e-cigarette use ($r = -.66, p < .001$).

Table 2.*Adolescent E-cigarette Outcome Frequencies*

Item	<i>M (SD)</i>	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		n (%)	n (%)	n (%)	n (%)	n (%)
E-cigarette Harm Perceptions						
E-cigarettes can help quit regular cigarette use	3.26 (1.18)	9 (11.3)	10 (12.5)	22 (27.5)	29 (36.3)	10 (12.5)
E-cigarettes are less harmful than regular cigarettes	3.09 (1.22)	13 (6.3)	7 (8.8)	28 (35.0)	22 (27.5)	9 (11.3)
E-cigarettes can help reduce regular cigarette use	3.45 (1.11)	8 (10.0)	5 (6.3)	20 (25.0)	37 (46.3)	10 (12.5)
E-cigarettes can be used in non-smoking environments	2.33 (1.24)	26 (32.5)	23 (28.7)	15 (18.8)	11 (13.8)	5 (6.3)
E-cigarettes are less addictive than regular cigarettes	2.42 (1.05)	18 (22.5)	23 (28.7)	29 (36.3)	7 (8.8)	3 (3.8)

Item	<i>M (SD)</i>	Definitely Not	Probably Not	Probably Yes	Definitely Yes
		n (%)	n (%)	n (%)	n (%)
Susceptibility to Use E-cigarettes					
Do you think that you will smoke an e-cigarette soon?	3.74 (.63)	66 (82.5)	8 (10.0)	5 (6.3)	1 (1.3)
Do you think that in the future you might experiment with e-cigarettes?	3.45 (.81)	51 (63.7)	15 (18.8)	13 (16.3)	1 (1.3)
Do you think you will smoke an e-cigarette in the next year?	3.68 (.65)	61 (76.3)	13 (16.3)	5 (6.3)	1 (1.3)
If one of your best friends were to offer you an e-cigarette, would you try it? ^a	3.64 (.64)	58 (72.5)		15 (18.8)	7 (8.8)
If one of your best friends were to offer you a flavored e-cigarette (chocolate, mint, apple, etc.), would you try it? ^a	3.52 (.73)	53 (66.3)		16 (20.0)	11 (13.8)

^a Response scale for the item omitted the option "Probably Not"

Table 3.

Descriptive Statistics for Parent- and Adolescent-Reported Parental Messages about Tobacco Use

Item	Parent	Adolescent
	<i>n</i> (%)	<i>n</i> (%)
Negative Consequences	47 (58.8)	32 (40)
Resisting Peer Pressure	30 (37.5)	23 (28.7)
Encouragement to Choose Friends Who Do Not Use Tobacco	31 (38.8)	28 (35)
Media Portrayal of Tobacco Use	27 (36.3)	15 (18.8)
Encouragement to Not Use Tobacco	45 (56.3)	29 (36.3)
Telling Adolescent Not to Use Tobacco	38 (47.5)	30 (37.5)
Rules About Tobacco Use	23 (28.8)	18 (22.5)
Discipline if Adolescent Uses Tobacco	16 (20)	24 (30)

Note. N = 78 for Parent Report, N = 80 for Adolescent Report; No. and percentage represent a message was given at least 1 time

Table 4.

Descriptive Statistics of E-cigarette Outcomes by Gender

Variable of Interest	Range	Total		Boys		Girls		<i>t</i> (78)	<i>p</i>
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Low Harm Perceptions	5 - 24	14.51	4.31	15.10	4.20	12.95	4.28	-2.03	.046*
Susceptibility to Use E-cigarettes	9 - 20	18.03	3.04	17.83	3.14	18.55	2.74	.944	.348
E-cigarette Use	0 - 1	0.2	0.4	0.21	0.41	0.18	0.39	-.247	.805

Note. Perceptions of E-cigarette Harmfulness and Susceptibility to Use E-cigarettes variables were total scores. E-cigarette

Use was a binary variable.

* $p < .05$.

Table 5.

Correlations Between Variables of Interest

Variable	<i>M</i>	<i>SD</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Adolescent Age	14.9	1.1	–								
2. Gender	.7	.5	.01	–							
3. Medication Status	.6	.5	-.16	-.34**	–						
4. Parent-Reported Parental Messages	7.0	8.2	-.05	-.12	.09	–					
5. Adolescent-Reported Parental Messages	2.5	3.0	-.16	-.03	-.06	-.01	–				
6. ADHD Symptom Severity	13.1	3.2	-.25*	.13	.15	.001	.03	–			
7. Low Harm Perceptions	18.6	4.4	.42***	.20*	-.06	-.22*	.01	.04	–		
8. Susceptibility of E-cigarette Use	18.0	3.0	-.10	-.11	.23*	.07	-.17	.11	-.41***	–	
9. E-cigarette Use	.2	.4	.25*	.03	-.31**	-.05	.10	-.22*	.29**	-.66***	–

Note. * $p < .05$, one-tailed, ** $p < .01$, one-tailed, *** $p < .001$, one-tailed

Gender: 1 = boy; Medication Status: 1 = medicated

Do Harm Perceptions Mediate the Association between Parental Messages about Tobacco and Adolescents' E-cigarette Outcomes?

Parent-reported messages: As shown in Figure 1, the direct effect of parent-reported parental messages on whether adolescents had ever used e-cigarettes was not significant ($c: b = .03, SE = .05, p = .603, 95\% CI [-.07, .12]$). The standardized regression coefficient between parent-reported messages and adolescent low harm perceptions was statistically significant, as was the standardized regression coefficient between adolescent low harm perceptions and adolescent e-cigarette ever use. Contrary to our hypothesis, the indirect effect was not significant ($ab: b = -.03, SE = .22, 95\% CI [-.11, .01]$), as evidenced by the bootstrapped 95% confidence interval that was not entirely above zero. This indicated that adolescent's low harm perceptions were not a significant mediator of the association between parent-reported parental messages and adolescent's e-cigarette use.

Adolescent-reported messages: As shown in Figure 2, the direct effect of adolescent reported messages on whether adolescents had ever used e-cigarettes was not significant, ($c: b = .13, SE = .11, p = .23, 95\% CI [-.08, .35]$). In contrast to what was predicted, the indirect effect was not significant ($ab: b = .03, SE = .06, 95\% CI [-.07, .15]$), as evidenced by the bootstrapped 95% confidence interval that was not entirely above zero. This indicated that adolescent's low harm perceptions were not a significant mediator of the association between adolescent-reported parental messages and adolescent's e-cigarette use.

Figure 1.

Mediation Analysis Results with Parent-reported Parental Messages as Predictor

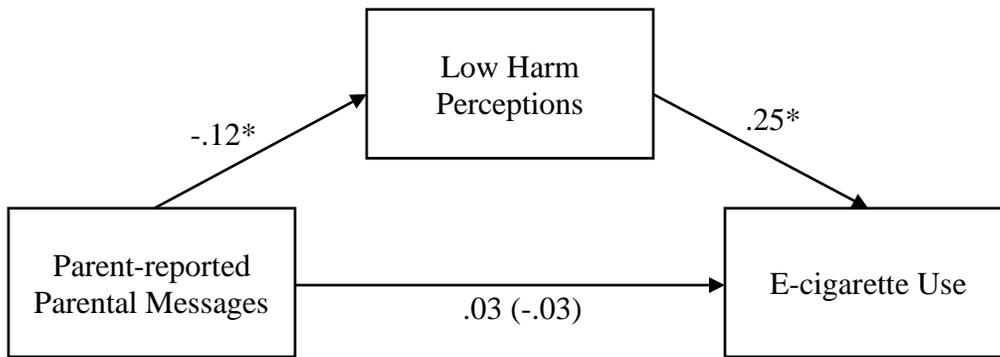
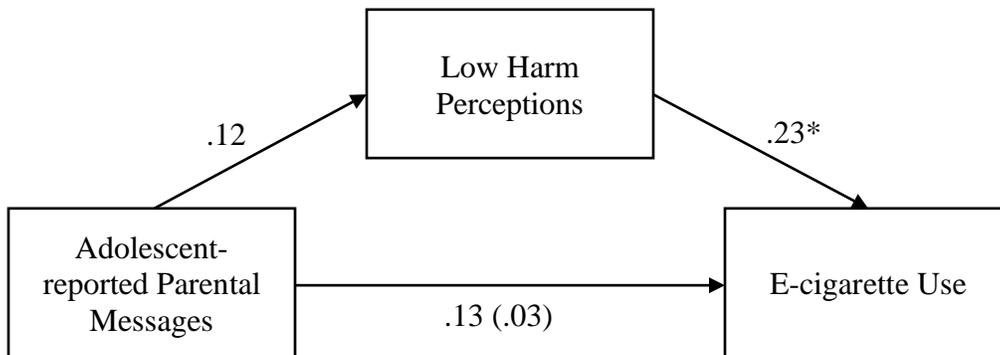


Figure 2.

Mediation Analysis Results with Adolescent-reported Parental Messages as Predictor



ADHD Symptom Severity as a Moderator between Parent-reported Parental Messages and Adolescents’ E-cigarette Outcomes

The results of the moderation analyses exploring whether ADHD symptom severity moderated the association between parent-reported parental messages and adolescent e-cigarette outcomes are presented in Tables 6, 7, and 8. In the first model, parent-reported parental messages were significantly associated with adolescent’s low harm perceptions ($b = -.14$, 95% CI [-.26, -.03], $p = .017$), such that less parent-reported parental messages were associated with

lower harm perceptions. However, ADHD symptom severity was not associated with adolescent's low harm perceptions ($b = .11$, 95% CI [-.19, .42], $p = .452$) nor did it significantly moderate the association between parent-reported parental messages and adolescent's low harm perceptions ($b = -.03$, 95% CI [-.06, .01], $\Delta R^2 = .02$, $\Delta F(1, 67) = 2.22$, $p = .141$).

There were no significant associations between parent-reported parental messages ($b = -.01$, 95% CI [-.08, .11], $p = .805$) nor ADHD symptom severity ($b = .05$, 95% CI [-.19, .30], $p = .668$) and adolescents' susceptibility to use e-cigarettes. ADHD symptom severity did not moderate the association between parent-reported parental messages and susceptibility to use e-cigarettes, ($b = .01$, 95% CI [-.02, .04], $\Delta R^2 = .01$, $\Delta F(1, 67) = .55$, $p = .462$).

Finally, neither parent-reported parental messages ($b = -.09$, 95% CI [-.24, .06], $p = .257$) nor ADHD symptom severity ($b = -.18$, 95% CI [-.46, .11], $p = .219$) were associated with adolescent's e-cigarette use. Similarly, ADHD symptom severity did not moderate the association between parent-reported messages and adolescent's e-cigarette use ($b = -.03$, 95% CI [-.08, .01], $\chi^2(1, 74) = 3.59$, $p = .058$).

Table 6.

Moderation Analyses Results for Adolescent E-cigarette Harm Perceptions with Parent-Reported Parental Messages as Predictor

Variable	<i>b</i>	<i>SE</i>	95% CI		<i>p</i>
			<i>LL</i>	<i>UL</i>	
Age	1.74	.43	.88	2.60	<.001***
Gender	1.53	1.11	-.67	3.74	.170
Medication Status	.73	.98	-1.22	2.69	.457
Constant	-12.80	6.61	-25.99	.40	.057
Parent-Reported Parental Messages	-.14	.06	-.26	-.03	.017*
ADHD Symptom Severity	.11	.15	-.19	.42	.452
Parent-Reported Parental Messages x ADHD Symptom Severity	-.03	.02	-.06	.01	.141

Note. Predictor = Parent-Reported Parental Messages, Moderator = ADHD Symptom Severity, Covariates = Age, Gender, Medication Status; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

p* < .05. *p* < .01. ****p* < .001

Table 7.

Moderation Analyses Results for Adolescent Susceptibility with Parent-Reported Parental Messages as Predictor

Variable	<i>b</i>	<i>SE</i>	95% CI		<i>p</i>
			<i>LL</i>	<i>UL</i>	
Age	-.23	.35	-.93	.47	.510
Gender	-.21	.90	-.2.01	1.59	.817
Medication Status	1.08	.80	-.52	2.67	.183
Constant	20.97	5.38	10.22	31.72	.002**
Parent-Reported Parental Messages	.01	.05	-.08	.11	0.805
ADHD Symptom Severity	.05	.12	-.19	.30	0.668
Parent-Reported Parental Messages x ADHD Symptom Severity	.01	.01	-.02	.04	0.462

Note. Predictor = Parent-Reported Parental Messages, Moderator = ADHD Symptom Severity, Covariates = Age, Gender, Medication Status; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

p* < .05. *p* < .01. ****p* < .001

Table 8.

Moderation Analyses Results for Adolescent E-cigarette Use with Parent-Reported Parental Messages as Predictor

Variable	<i>b</i>	<i>SE</i>	95% CI		<i>p</i>
			<i>LL</i>	<i>UL</i>	
Age	.59	.34	-.08	1.27	.084
Gender	-.67	.95	-2.54	1.20	.481

Medication Status	-1.96	.88	-3.68	-.23	.026*
Constant	-9.44	5.37	-19.98	1.09	0.079
Parent-Reported Parental Messages	-.09	.08	-.24	.06	0.257
ADHD Symptom Severity	-.18	.14	-.46	.11	0.219
Parent-Reported Parental Messages x ADHD Symptom Severity	-.03	.02	-.08	.01	0.058

Note. Predictor = Parent-Reported Parental Messages, Moderator = ADHD Symptom Severity,

Covariates = Age, Gender, Medication Status; CI = confidence interval; *LL* = lower limit; *UL*

= upper limit.

* $p < .05$. ** $p < .01$. *** $p < .001$.

ADHD Symptom Severity as a Moderator between Adolescent-reported Parental Messages and Adolescents' E-cigarette Outcomes

The results of the moderation analyses exploring whether ADHD symptom severity moderated the association between adolescent-reported parental messages and adolescent e-cigarette outcomes are presented in Tables 9, 10, and 11. The moderation analyses indicated that adolescent-reported parental messages ($b = .16$, 95% CI [-.14, .47], $p = .292$) and ADHD symptom severity ($b = .07$, 95% CI [-.25, .38], $p = .680$) were not significantly associated with adolescent's perceptions of e-cigarette harmfulness. ADHD symptom severity did not significantly moderate the association between adolescent-reported parental messages and perceptions of e-cigarette harmfulness, ($b = .03$, 95% CI [-.14, .47], $\Delta R^2 = .01$, $\Delta F(1, 69) = .47$, $p = .497$).

Adolescent-reported parental messages ($b = -.19$, 95% CI [-.43, .04], $p = .108$) was not associated with adolescent susceptibility to use e-cigarettes. Similarly, ADHD symptom severity was not associated with susceptibility to use e-cigarettes, ($b = .08$, 95% CI [-.16, .33], $p = .491$).

ADHD symptom severity did not significantly moderate the association between adolescent-

reported parental messages and susceptibility to use e-cigarette, ($b = -.02$, 95% CI [-.09, .05], $\Delta R^2 = .004$, $\Delta F(1, 69) = .32$, $p = .575$).

Finally, there were no significant associations between adolescent-reported parental messages ($b = .15$, 95% CI [-.06, .37], $p = .163$) or ADHD symptom severity ($b = -.18$, 95% CI [-.43, .07], $p = .159$) and adolescents' e-cigarette use. ADHD symptom severity did not moderate the association between adolescent-reported parental messages and e-cigarette use, ($b = .04$, 95% CI [-.02, .11], $\chi^2(1, 76) = 1.65$, $p = .199$).

Table 9.

Moderation Analyses Results for Adolescent E-cigarette Harm Perceptions with Adolescent-Reported Parental Messages as Predictor

Variable	b	SE	95% CI		p
			LL	UL	
Age	1.61	.43	.74	2.47	<.001***
Gender	1.94	1.12	-.30	4.18	.088
Medication Status	.52	1.00	-1.47	2.51	.605
Constant	-10.99	6.63	-24.21	2.23	0.102
Adolescent-Reported Parental Messages	.16	.15	-.14	.47	0.292
ADHD Symptom Severity	.07	.16	-.25	.38	0.68
Adolescent-Reported Parental Messages x ADHD Symptom Severity	.03	.05	-.06	.13	0.497

Note. Predictor = Adolescent-Reported Parental Messages, Moderator = ADHD Symptom

Severity, Covariates = Age, Gender, Medication Status; CI = confidence interval; LL = lower limit; UL = upper limit.

* $p < .05$. ** $p < .01$. *** $p < .001$

Table 10.

Moderation Analyses Results for Adolescent Susceptibility to Use E-cigarette with Adolescent-Reported Parental Messages as Predictor

Variable	<i>b</i>	<i>SE</i>	95% CI		<i>p</i>
			<i>LL</i>	<i>UL</i>	
Age	-.21	.33	-.88	.45	.529
Gender	-.45	.86	-2.17	1.27	.602
Medication Status	.98	.77	-.55	2.51	.204
Constant	20.87	5.10	10.71	31.04	<.001***
Adolescent-Reported Parental Messages	-.19	.12	-.43	.04	.108
ADHD Symptom Severity	.08	.12	-.16	.33	.491
Adolescent-Reported Parental Messages x ADHD Symptom Severity	-.02	.04	-.09	.05	.575

Note. Predictor = Adolescent-Reported Parental Messages, Moderator = ADHD Symptom

Severity, Covariates = Age, Gender, Medication Status; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

p* < .05. *p* < .01. ****p* < .001

Table 11.

Moderation Analyses Results for Adolescent E-cigarette Use with Adolescent-Reported Parental Messages as Predictor

Variable	<i>b</i>	<i>SE</i>	95% CI		<i>p</i>
			<i>LL</i>	<i>UL</i>	
Age	.46	.31	-.15	1.07	.139
Gender	-.24	.83	-1.87	1.38	.767
Medication Status	-1.51	.75	-2.98	-.04	.044*
Constant	-7.64	4.87	-17.18	1.89	.116
Adolescent-Reported Parental Messages	.15	.11	-.06	.37	.163
ADHD Symptom Severity	-.18	.13	-.43	.07	.159
Adolescent-Reported Parental Messages x ADHD Symptom Severity	.04	.03	-.02	.11	.207

Note. Predictor = Adolescent-Reported Parental Messages, Moderator = ADHD Symptom Severity, Covariates = Age, Gender, Medication Status; CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

* $p < .05$. ** $p < .01$. *** $p < .001$

Discussion

The present study contributes to the existing literature by exploring e-cigarette perceptions, susceptibility, and use among adolescents with ADHD. In particular, the associations between parental socialization factors (i.e., parent- and adolescent-reported messages about tobacco use) and ADHD symptom severity on e-cigarette outcomes within this suggestible adolescent population were explored. The aims of this study were to: 1.) describe e-cigarette outcomes (i.e., perceptions of harmfulness, susceptibility to use e-cigarettes, and e-cigarette use), 2.) explore the mediating role of perceptions of e-cigarettes on the association between parental messages of tobacco and e-cigarette use, and 3.) the moderating role of ADHD symptom severity on the association between parental messages of tobacco and e-cigarette outcomes, in a sample of adolescents with ADHD.

E-cigarette Outcomes in Adolescents with ADHD

One-fifth of the adolescents in this sample reported ever-use of e-cigarettes. Although previous studies exploring e-cigarette use among youth with ADHD have not reported on e-cigarette ever-use, our sample reported ever-use prevalence rates below that of U.S. adolescents without ADHD. According to a report by the Office on Smoking and Health (2020), they found that the typical ever-use rates of e-cigarettes were approximately 25% among U.S. middle and high school students. Prior research suggests that adolescents with ADHD are at an increased risk of smoking traditional cigarettes than their peers without (Rhodes et al., 2016; Sibley et al.,

2014). Accordingly, it would be expected that our sample would have endorsed higher rates of e-cigarette ever use than the average rate of their peers without ADHD (Office on Smoking and Health, 2020). However, it is worth noting that the present study involved participation in an intervention meant to prevent the initiation and further progression of tobacco use (Corona et al., 2020), which may explain the low percentage of adolescents who reported having used e-cigarettes in the past. The adolescents participating in the present study may have already been less likely to engage in smoking behaviors prior to the start of the intervention and thus, during baseline surveys.

Furthermore, it is important to note that the rate of e-cigarette use is likely to increase with age. The bivariate correlations observed in the present study showed that the older the participant, the more likely they were to report e-cigarette ever use. For instance, Dvorsky and Langberg (2019) found that the percentage of adolescents with ADHD who used e-cigarettes increased as the students transitioned from high school and through the first and second semester of their first year in college. The increase in e-cigarette use with age could be attributed to a myriad of reasons including increased access to purchasing e-cigarettes through retail outlets (Baker et al., 2019) and more peers engaging in use (Wallace & Roche, 2018).

Prior research suggests that greater ADHD symptom severity is associated with an increased risk of e-cigarette use (Goldenson et al., 2018; Dvorsky & Langberg, 2019). Nonetheless, the bivariate correlations in the present study showed that e-cigarette ever use was associated with lower ADHD symptom severity. A possible explanation for this finding involves the sample's primary ADHD symptoms and presentations. Adolescents were screened eligible for the study if they exhibited at least four of nine DSM-5 ADHD symptoms of inattention. The majority of the sample (84%) of the adolescents presented with ADHD Predominately

Inattentive and 16.2% presented with ADHD Combined. Thus, ADHD symptom severity endorsed was primarily consistent with the ADHD inattentive presentation, which has not been found to be associated with e-cigarette use in recent studies.

Compared to previous findings reporting ADHD inattentive symptoms were associated with tobacco use in general (Brinkman et al., 2015; Burke et al., 2001; Molina & Pelham, 2003; Tercyak et al., 2002), recent findings show that inattentive symptoms are not associated with e-cigarette use (Goldenson et al., 2018; Dvorsky & Langberg, 2019). Goldenson et al. (2018) found that ADHD symptom total score, and hyperactive/impulsive symptoms were significantly associated with adolescent e-cigarette use, after accounting for other known risk factors (i.e., age, race/ethnicity, gender, family living situation, peer smoking, lifetime use of other substances, depression, and delinquent behavior). It is possible that impulsive symptomatology leads adolescents with ADHD to initiate e-cigarette use. Although Bold, Morean, et al. (2017) did not include adolescents with ADHD in their study, they found that impulsive adolescents were at a greater risk for more frequent e-cigarette use than their less impulsive peers, providing support for hyperactive and impulsive symptoms as possible indicators of e-cigarette use. Further research must be done to investigate the association between ADHD symptom type (i.e., Inattentive, Hyperactive/Impulsive, and Combined) and ADHD symptom severity, as they relate to adolescent e-cigarette use. Sampling for future studies should include even distributions of adolescents with the different ADHD symptom types in order to more closely explore and corroborate previously observed patterns between ADHD symptoms and e-cigarette use. This will help the field better understand how inattentiveness and/or hyperactivity/impulsivity interact with e-cigarette use.

Overall, the majority of the adolescents in the present study reported that they would definitely not use or experiment with an e-cigarette in the future, indicating the sample had a low susceptibility to use e-cigarettes. Using bivariate correlations, the present study found greater susceptibility to use e-cigarettes was associated with lower perceptions of e-cigarette harmfulness and the endorsement of e-cigarette use. That is, adolescents with ADHD who perceived e-cigarettes as less harmful and less addictive than regular cigarettes were more likely to be susceptible to e-cigarette use. This is consistent with recent findings. Kwon et al. (2018) found adolescents' perceptions of e-cigarettes were associated with susceptibility to initiate e-cigarette use. Using a nationally representative sample of adolescents who had never used e-cigarettes, they found that youth who believed e-cigarettes were harmful and addictive, were less likely to be susceptible to e-cigarette use than peers who believed otherwise. As such, attention must be given to the role of reduced perceptions of e-cigarette harmfulness as a risk factor for e-cigarette susceptibility (Bernat et al., 2018; Kwon et al., 2018; Lozano et al., 2019; Margolis et al., 2021). Moreover, the literature suggests e-cigarette susceptibility is a significant predictor of adolescent e-cigarette initiation and use (Bold, Kong, et al., 2017; Sawdey et al., 2019). In the current sample, bivariate associations showed that greater susceptibility to use e-cigarettes was associated with adolescents reporting e-cigarette ever use, indicating similar trends as those reported in previous literature. The present study's findings further emphasize the importance of focusing on adolescent's e-cigarette perceptions as an important factor in the pathway to adolescent with ADHD's e-cigarette use. Interventions that educate youth on the effects of e-cigarette use on their healthy development may reduce their susceptibility to use e-cigarettes and subsequently reduce the risk of e-cigarette use.

In line with previous literature involving adolescents without ADHD (Gorukanti et al., 2017; Pearson et al., 2012; Rohde et al., 2018; Owotomo et al., 2018), the majority of the adolescents in the present study agreed with the belief statements indicating e-cigarettes were of lesser harm and could aid in the reduction, and cessation, of traditional cigarette use. However, in regard to the statement that e-cigarettes were less addictive than traditional cigarettes, over half (51.2%) were in disagreement, 36.3% were neutral, and 12.6% were in agreement. This finding was consistent with previous distinctions made between perceptions of harmfulness and perceptions of addictiveness (Dobbs et al., 2017). While adolescents in the present study believed e-cigarettes were less harmful, they disagreed that e-cigarettes were less addictive, than traditional cigarettes. It is possible that the belief of reduced harm associated with e-cigarette use and e-cigarettes as a tobacco cessation device were endorsed because of the frequent advertising often directed at youth (Nicksic et al., 2017). On the other hand, adolescents are also likely to notice their peers continued use of e-cigarettes following initiation which may serve as an example of e-cigarettes as addictive.

Adolescents with ADHD's perceptions of e-cigarette addictiveness may be a distinctive belief to study in order to prevent future e-cigarette use. Prior literature suggests hyperactivity and impulsivity symptoms associated with ADHD are key markers in the progression of experimentation to regular smoking, and thus, the development of addiction (Fuemmeler et al., 2007). Given the possible association between hyperactivity/impulsivity and the e-cigarette initiation among adolescents with ADHD (Goldenson et al., 2018), the perception that e-cigarettes are just as, or more, addictive than traditional cigarettes, may be a crucial aspect to review in e-cigarette prevention programs for adolescents with ADHD.

Finally, bivariate correlations showed that lower harm perceptions were associated with older, adolescent boy participants, less parent-reported parental messages, and e-cigarette use. Whereas the present study explored the relative perceived harm of e-cigarettes in comparison to traditional cigarettes, the beliefs of absolute harm associated with e-cigarette use (Cooper et al., 2016) were not directly explored. Future studies may consider the inclusion of the items assessing absolute harm in order to more finely inform the link between perceptions of e-cigarettes and e-cigarette use in this population of adolescents.

There were notable differences in parental messages conveyed as dependent on the reporter. A significant difference was found between the frequency of parental messages about tobacco use reported between the parents and adolescents. Additionally, parent- and adolescent-reported parental messages were not significantly associated with each other, a finding similar to that of Guilamo-Ramos et al (2006). In the present study, parents were more likely to report giving their adolescents more messages about tobacco use than adolescents reported receiving, consistent with previous literature (Engels & Willemsen, 2004). In hopes of reporting more “good” parenting strategies (Bögels & van Melick, 2004; Schwarz et al., 1985), parents may be over-reporting the frequency in which they provide messages meant to prevent adolescents’ tobacco use. This has important implications on future intervention efforts. While interventions can focus on providing parents with the skills and information to curb their adolescents’ engagement in substance use, they must also assess for adolescent understanding and retention of the information given.

Moreover, there were two instances in which adolescents reported more or similar rates of parental messages than their parents had reported. Adolescents had higher reporting of messages of “discipline if [they] used tobacco.” While other messages related to rules and media

related to tobacco use were not similarly endorsed by adolescents, the data suggest that adolescents recalled messages in which sanctions for use would occur, at a greater rate than their parents reported providing. This type of messaging has been found to be associated with less adolescent smoking. Sargent and Dalton (2001) found adolescents perceptive of their mother's punishment for smoking held the highest negative correlation with adolescent smoking. The present study also found that adolescents had similar reports to their parents in regard to the message of "encouragement to choose friends who do not use tobacco." The literature examining social influences on adolescent tobacco use has found peers to be a common factor associated with adolescent experimentation and initiation of tobacco and e-cigarette use (Biglan et al., 1995; Durkin et al., 2021; Hall & Valente, 2007; Maxwell, 2001; Perikleous et al., 2018). Therefore, it is likely that parents relay messages about peer selection in order to curb their adolescent's engagement with peers who use tobacco or any other substances (Hoffman et al., 2007). Given the importance of peer groups as a context for socialization during adolescence (Ryan, 2001; Scholte & Van Aken, 2020), these types of messages are also likely to stand out to the adolescents, perhaps explaining the similar rates of report between parents and adolescents. The importance of forming peer relationships may be even more salient for adolescents with ADHD granted the commonly observed social skill deficits cited as sources for increased difficulty in establishing peer friendships (Bagwell et al., 2001; Gardner & Gerdes, 2015).

Of interest, adolescents who were medicated were less susceptible to use e-cigarettes and less likely to report e-cigarette use. Although not explored in the present study, this association may support the self-medication hypothesis, a widely cited theory that seeks to explain the association between ADHD and smoking (see review by Glass & Flory et al., 2010). Specifically, it is proposed that unmedicated people with ADHD may use nicotine to improve

their attentional and self-regulatory competence (Whalen et al., 2003). While the present study explored adolescent's general perceptions about e-cigarette harmfulness, it did not explore their perceptions of how e-cigarette use interacted with their ADHD symptoms. As such, future research should explore the self-medication hypothesis as it directly relates to e-cigarette initiation, susceptibility, and use for adolescents with ADHD.

E-cigarette Harm Perceptions as a Mediator

The present findings failed to support the prediction that e-cigarette harm perceptions would explain the association between parent- and adolescent-reported messages about tobacco and adolescents' e-cigarette use. One potential reason is that e-cigarette harm perceptions may work in the inverse direction as originally predicted. For instance, adolescent e-cigarette users are more likely to endorse lower harm perceptions of e-cigarettes (Ambrose et al., 2014; Bernat et al., 2018; Chaffee et al., 2015; Cooper et al., 2016), however the literature has seldom explored whether perceptions of harmfulness lead to adolescent e-cigarette use. It is also possible that adolescents may share their misperceptions of e-cigarettes around their parents, and this could prompt parents to discuss tobacco use in general.

Furthermore, the reasons why adolescents engage in e-cigarette use may be more highly influenced by social perceptions (Dvorsky & Langberg, 2019), rather than beliefs related to their harmfulness. Kong et al. (2015) found that the top five reasons for e-cigarette experimentation amongst adolescent lifetime e-cigarette users (i.e., ever-users) included curiosity, influence of friends and family, use of it as a smoking cessation device, availability of flavors, and the ability to do smoke tricks. As such, future research should also address social perceptions, in addition to harm and benefit perceptions of e-cigarettes, prior to use (Bernat et al., 2018). By defining the relevance of e-cigarette social and harm perceptions held about e-cigarettes by adolescents with

ADHD, it may help parents more adequately target those misperceptions. Moreover, in order to more appropriately assess for mediation paths resulting in adolescents with ADHD's e-cigarette use, future research should take a longitudinal approach to better assess the factors that can curtail the actual initiation of the product use.

Another explanation for the null findings might be a result of the nonsignificant direct association between parent- and adolescent-reported messages about tobacco use and e-cigarette use. Other factors may have also hindered the preventative role of parent communication about tobacco use and adolescent's use. For instance, parents who smoke do communicate anti-smoking messages to their children (Corona et al., 2015) yet these messages may not prevent adolescent smoking within the context of parental smoking (Chassin et al., 2005; Ennett et al., 2001). For instance, Herbert and Schiaffino (2007) found that parents who smoked were more likely to provide anti-smoking messages than parents who were non-smokers. However, the adolescents of parents who smoked were less likely than adolescents whose parents did not smoke to report receiving this messaging and they perceived the messages as being less credible. Bandura's (1971) social learning theory proposes that learning occurs through the observation of other people's behaviors and the consequences experienced by them. Thus, adolescents who receive anti-smoking messages from their parents, yet also see their parents engage in tobacco use, are likely to experience mixed messaging (Wakschlag et al., 2011). The majority of the caregivers who participated in the present study reported no current tobacco use which limited the statistical ability to examine this pathway.

ADHD Symptom Severity as a Moderator

Turning to ADHD symptom severity as a moderator, the author found no evidence that this factor moderates the association between parent- and adolescent- reported messages about

tobacco use and e-cigarette outcomes in the current sample of adolescents with ADHD. Of the several moderation models evaluated, there was one significant direct association found, regardless of ADHD symptom severity. Greater parent-reported messages about tobacco use were associated with greater harm perceptions of e-cigarettes, after controlling for medication status, gender, and adolescent age. Thus, the number of messages that parents reported providing to their adolescent played a role in the adolescents' beliefs of e-cigarette harmfulness. Consistent with Oetting, Donnermeyer, and Deffenbacher's (1988) primary socialization theory, the present study's findings provide evidence of a possible association between parent communication about tobacco use, as provided by the parent, and adolescent's e-cigarette perceptions. Although parents may not be frequently checking in on adolescent's perceptions of e-cigarettes, the findings in the present study provide support for focusing on parents as a socialization factor that could reduce adolescent's misperceptions of e-cigarettes. Given the aforementioned significant difference between parent- and adolescent- report of the frequency at which parent messages were conveyed to the adolescent, it is also worth noting that a direct association between adolescent-reported parental messages and perceptions of e-cigarette harmfulness was not found. Ehrlich et al. (2016) state that discrepancies in parent and adolescent reports may be indicators of the quality of parent-adolescent communication, rather than errors in measurement. Therefore, research must not only look at the content and frequency of the parental messages but also the quality of the communication perceived by the adolescent and parent.

One potential methodological reason for the null moderation results might be the method in which ADHD symptom severity was measured and incorporated in the model. Rather than taking a summed score as an indicator of symptom severity, it may have been more beneficial to distinguish the number of inattentive and the number of hyperactive/impulsive symptoms

endorsed for the adolescent. Smith et al. (2009) call into the question the validity of assessing a psychological construct through the use of a single total score for two reasons. First, they cite that the score could represent the influence of multiple psychological constructs. Second, different individuals could attain the same total score through the endorsement of different symptoms. Therefore, the number and the nature of the symptoms could have varied effects on predicted associations between parent socialization factors and adolescents with ADHD's e-cigarette outcomes and require further investigation.

Strengths and Limitations

A few areas should be noted as strengths within the present study. Of most interest, the present study contributed to the literature exploring substance use, specifically e-cigarette use, within a sample of adolescents with ADHD. Very few studies (Dvorsky & Langberg, 2019; Goldenson et al., 2018) to date, have examined this more recent form of substance use across this susceptible sample. Heeding the call by Kodl and Mermelstein (2004) to assess parent and adolescent report of parent's antismoking socialization, an additional strength of the study involved the inclusion of multiple informants to measure the frequency of parental messages of tobacco use.

This study has several limitations that merit attention. A limitation to the study involved the selected measure that assessed parental messages of tobacco use. While this measure (Ennett et al., 2001) evaluated the parent and adolescent's perceptions of the frequency of parent provided messages about tobacco use, e-cigarette products were not included as an example tobacco product. The measure included, "smoking cigarettes, cigars, little cigars, cigarillos, waterpipe/hookah or chewing tobacco." It is possible that the messages that parents provided were only specific to other tobacco products, rather than e-cigarettes, and thus adolescents may

not have linked the conversations to e-cigarettes. Parent anti-smoking communication that solely addresses traditional tobacco products may not be as impactful as e-cigarette specific messaging (Broun et al., 2021). Future research should explore the association between types of e-cigarette messages (i.e., smoking cessation aids) to determine impact on appeal of e-cigarettes to youth (Moore et al., 2020). Furthermore, recent literature suggests that caregivers are not sufficiently aware of the effects of e-cigarette use and thus may have a hard time communicating anti e-cigarette use messages (Patel et al., 2019; Sabbagh et al., 2020). Thus, future studies should also explore parental beliefs about e-cigarettes while specifically controlling for parent use of e-cigarettes. That is, parents with reduced perceptions of e-cigarette harm may talk about e-cigarette use differently if they are unaware of e-cigarettes or are using it for recreation or cessation reasons. Accordingly, it will be important that parents be informed of the effects of e-cigarette on health outcomes in order to cater their messaging in a more product-specific way to their adolescents.

Another important limitation is that the present sample was composed of middle-class White adolescents. Thus, the current findings may be limited in generalizability to more diverse populations. Additionally, although this study accounted for the number of inattentive and hyperactive-impulsive ADHD symptoms, the initial inclusion criteria for participation required caregivers endorse at least four of nine DSM-5 ADHD symptoms of inattention. As a result, the absence of significant associations in the present study could be due to restriction of range in the adolescent sample. Eighty-four percent of the sample presented with ADHD Predominately Inattentive and 16.2% presented with ADHD Combined, while no adolescents presented with ADHD Predominately Hyperactive-Impulsive. The skewed distribution of ADHD presentation

type also limits the findings of the present study as it cannot definitively generalize the risk of e-cigarette outcomes evenly across all ADHD presentations.

Finally, given the cross-sectional nature of the present study, no assumptions of the directionality between the associations can be made. As such, it is possible that the predicted mediation paths worked inversely to what was originally hypothesized. Previous literature encourages researchers to explore these associations in a longitudinal method to clarify the associations (Rocheleau et al., 2020). Bold et al. (2016) reiterate that longitudinal studies of e-cigarette patterns are a critical step in defining prevention efforts to reduce the appeal in e-cigarette use among youth. Future research may also benefit from the exclusion of youth who had ever used e-cigarettes products from their initial analytic sample in order to prospectively study e-cigarette initiation and better control for any reverse causality.

Conclusion

Despite the limitations mentioned above, the present study provides insight and contributes to a growing body of literature (Dvorsky & Langberg, 2019; Goldenson et al., 2018) examining the e-cigarette trends among adolescents with ADHD. Overall, the results of the present study found that adolescents with ADHD held similar e-cigarette harm perceptions, susceptibility to use e-cigarettes, and e-cigarette ever-use rates to that of their peer without ADHD. Although the proposed moderation and mediation pathways were not found to be significant, recommendations are made to better address these constructs in future studies. The results from this study can be used to further scholarship investigating the factors that may put adolescents with ADHD at an increased risk of engaging in e-cigarette use as well as possible points of prevention and intervention.

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Vita

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