Prospective associations of e-cigarette use with cigarette, alcohol, marijuana, and nonmedical prescription drug use among US adolescents.

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Abstract

Background: As e-cigarette use continues to increase in the U.S., research is needed to understand its prospective risk for cigarette smoking and other substance use in young adulthood, including alcohol, marijuana, and nonmedical prescription drugs (NMPDs).

Methods: This study used data from the Monitoring the Future (MTF) study a nationally representative annual survey of 12th graders (modal age 18) in the US. The analytic sample included 2014–2016 MTF cohorts that were selected and completed follow up one year later (modal age 19; n=717). Using logistic regression, we examined cross-sectional and prospective associations of past 30-day e-cigarette use with past 30-day cigarette, alcohol, marijuana, and NMPD use. We examined prospective associations among the full sample and associations with incidence of each of these substances among those who reported no history of use in 12th grade.

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Results: In cross-sectional analysis, those who reported past 30-day e-cigarette use at age 18 were more likely to report past 30-day cigarette use, alcohol use, marijuana use, and NMPD use at age 19. In multivariable longitudinal analysis, past 30-day e-cigarette users at age 18 were more likely to report past 30-day cigarette, marijuana, and NMPD use at age 19, including e-cigarette users who had no history of using these substances at age 18.

Conclusions: This study suggests that e-cigarette use may be an indicator of future substance use risk in young adulthood. Adolescent e-cigarette users may benefit from secondary prevention efforts to mitigate this risk.

1. Introduction

E-cigarette use continues to increase rapidly among adolescents and young adults in the US (Cullen et al., 2019; Miech et al., 2020; Schulenberg et al., 2020) making it essential to understand the risks associated with its use including a possible increased risk for other substance use. A growing body of research has found cross-sectional and prospective associations of e-cigarette use with cigarette smoking (Barrington-Trimis et al., 2016; Leventhal et al., 2015; Miech et al., 2017; Primack et al., 2015; Soneji et al., 2017). In addition, a growing number of studies have found a prospective association of e-cigarette use with marijuana use (for recent review see Chadi et al., 2019), including prospective studies finding associations with subsequent marijuana use (Evans-Polce et al., 2020; Ksinan et al., 2020) and initiation (Wong et al., 2020).

Little work has examined prospective associations of e-cigarette use with nonmedical prescription drug (NMPD) use or with alcohol use. It is important to know if e-cigarette risks extend beyond products that often contain the same drug (nicotine/marijuana) or the same route of administration (smoking/inhalation). Prospective associations of e-cigarette use with alcohol and with NMPD use would suggest a broader risk for drug use. In addition, each drug confers different short-term and long-term consequences making it important to examine multiple substance use outcomes to understand the full public health significance of e-cigarette use and potentially inform subsequent research to understand mechanisms of e-cigarette risk with other substance use. Recently, two studies examined the longitudinal association of e-cigarette use with later alcohol use behaviors in adolescents. One found an association of e-cigarette use with alcohol intoxication at follow-up in a community sample of adolescents (Park et al., 2020) and another found an association of lifetime e-cigarette use with any alcohol use among a national sample of adolescents (Silveira et al., 2018). A third study used a national sample of U.S. adults and found associations of risky alcohol use with dual cigarette and e-cigarette users and e-cigarette only users compared with nonusers (Roberts et al., 2020). Despite scarce prospective research, cross-sectional studies suggest associations of e-cigarette use with alcohol and other substance use (Demissie et al., 2017; McCabe et al., 2017; Miech et al., 2016; Staff et al., 2020; Wills et al., 2015). For example, in a national sample of U.S. high school students, those who used e-cigarettes were more

likely to also use alcohol and to binge drink (Demissie et al., 2017). Similarly, cross-sectional findings using a sample of 12th graders from the Monitoring the Future (MTF) study found that 12th graders who used e-cigarettes were more likely to use nonmedical prescription drugs compared to those who did not use e-cigarettes (McCabe et al., 2017).

Importantly, none of these longitudinal studies have yet examined the association of e-cigarette use with incident use. To further our understanding of the risks associated with e-cigarette use, incidence is particularly important metric in that it clarifies the timing and ordering of substance use and distinguishing new initiation of a substance. Given bidirectional associations that have been found between e-cigarette use and other substance use including alcohol and NMPDs (Silveira et al., 2018) and findings among adults that show an association of e-cigarette use with initiation of marijuana use (Wong et al., 2020), it is particularly important to examine associations of e-cigarette use with incident use of marijuana, alcohol, and NMPDs. Moreover, much of the research to date examining e-cigarette use prospectively has been among younger adolescents in middle and high school. The association of e-cigarettes with other substance use may differ for older adolescents transitioning to young adulthood. This transition is a critical and risky developmental period for substance use.

This study will extend prior work and address three specific gaps in the literature: (1) prospectively examining associations of e-cigarettes with NMPD use and alcohol use, (2) examine incidence of cigarette, marijuana, alcohol, and NMPD use, (3) examine these associations among older adolescents as they enter young adulthood.

2.   Methods

2.1.   Study sample

Data for the present study come from the longitudinal portion of the MTF study (Schulenberg et al., 2020). MTF conducts annual school-based surveys of a nationally representative samples of approximately 14,000 U.S. 12th graders (Miech et al., 2020). A multistage random sampling design is used to select 130 schools each year, and each school is given a monetary incentive for participation. Twelfth grade students complete a questionnaire that is administered in classrooms by MTF study staff. Participants randomly receive one of six possible forms of the survey, each containing a core set of questions common to all forms and some form-specific questions. E-cigarette use questions are on four of the six total forms through 2019. Annually, 2,450 students are randomly selected (with oversampling for drug users) to be followed longitudinally. Follow-up surveys are conducted one year after the baseline survey for a random half of the selected sample and two years after the baseline survey for the remaining half. Follow-up surveys are sent each spring along with an incentive payment. Additional data collection details are available elsewhere (Miech et al., 2020; Schulenberg et al., 2019). The MTF study has been approved by the University of Michigan IRB.

The present study focuses on individuals from the 2014–2016 12th grade cohorts who completed follow-up surveys one year later (at modal age 19) and provided data on all relevant variables of interest (n=717). Of the 2,453 individuals selected for one year follow-

up who received surveys with e-cigarette use questions, 948 completed their follow-up survey (39% response rate). Of these 948 individuals, 231 were excluded due to missing data on relevant variables. Descriptive characteristics of the analytic sample are provided in Table 1.

2.2. Measures

E-cigarette use.—At baseline, individuals reported their use of "electronic cigarettes (e-cigarettes)" in the past 30 days. We dichotomized this variable into any e-cigarette use vs. no e-cigarette use.

Outcomes.—Individuals were asked about past 30-day and past 12-month use of: cigarettes, marijuana, alcohol, and nonmedical prescription drugs (NMPDs). For NMPD use, questions were asked separately about four different classes: tranquilizers, sedatives, stimulants, and opioids. NMPD use was defined as use on their own, without a doctor's orders. These four classes were combined into a single measure of NMPD use. The most prevalent class was prescription stimulants (2.9% at age 18 and 2.3% at age 19) followed by opioids (1.8% at age 18 and 1.0% at age 19). Tranquilizer and sedative use was less common ranging from 1.4% to 0.6% across both time points. Cross-sectional analyses examined four dichotomous outcomes measured at age 18: past 30-day cigarette use, past 30-day alcohol use, past 30-day marijuana use, and past 30-day NMPD use. Prospective analyses examined these same four outcomes at age 19.

2.3. Analysis

We conducted three separate types of regression models to examine the association of e-cigarette use with cigarettes, alcohol, marijuana, and NMPD use: (1) cross-sectional models examining the associations of e-cigarette use at age 18 with use of each of these substances at age 18; (2) prospective models examining the association of e-cigarette use at age 18 with each substance at age 19; and (3) models examining incidence of use for each substance to study the prospective association of e-cigarette use at age 18 with each of the four outcomes at age 19 among those who reported no use for the given substance by age 18. Sample sizes for these incidence analyses varied, as only individuals who had not used the substance by age 18 were included: $n_{cigarette\ incidence} = 508$, $n_{alcohol\ incidence} = 258$, $n_{marijuana\ incidence} = 432$, $n_{NMPD\ incidence} = 567$. We also provide unadjusted prevalence estimates in the text of the results for each of these outcomes by age 18 e-cigarette use status.

Multivariable regression analyses controlled for *sex* (male/female), *race/ethnicity* (Black, white, Hispanic, other), *region* (Northeast, Midwest, South, West), *parent education* (parent(s) with college degree vs. not), and *college plans* (definitely will graduate vs. else) measured at age 18. Cross-sectional analyses also controlled for the other three substance use outcomes (e.g., analyses examining the association of e-cigarettes and cigarette use controlled for past 30-day alcohol use, past 30-day marijuana use, and past 30-day NMPD use) at age 18. Prospective analyses controlled use of each of the four substances at age 18. All analyses used sample weights, and longitudinal analyses used follow-up attrition weights (inverse probability of participation) to account for potential bias due to attrition.

3. Results

3.1. Cross-sectional findings

Table 1 provides unadjusted and adjusted associations of age 18 e-cigarette use with age 18 substance use. For all substances, there were large differences between e-cigarette users and non-users. Unadjusted odds ratios ranged from more than two times greater odds of past 30-day alcohol use for e-cigarette users compared to non-e-cigarette users, to a more than 11 times greater odds of NMPD use for e-cigarette users compared to non-e-cigarette users. In adjusted analyses with controls included, these differences were attenuated; however, significant differences remained between e-cigarette users and nonusers for all four substance use outcomes. E-cigarette use at age 18 was associated with greater odds of cigarette use (aOR=7.89 [95% CI= 3.93, 15.82]), greater odds of alcohol use (aOR= 2.81 [95% CI= 1.54, 5.12]), greater odds of marijuana use (aOR= 2.03 [95% CI=1.07, 3.86]), and greater odds of NMPD use (aOR=2.57 [95% CI=1.16, 5.71]) at age 18.

3.2. Prospective findings

Table 3 provides unadjusted and adjusted odds ratio estimates for associations of age 18 e-cigarette use with age 19 substance use. We also depict differences in Figure 1 by providing unadjusted prevalence estimates for age 19 substance use by age 18 e-cigarette use. Prevalence of substance use at age 19 differed considerably by age 18 e-cigarette use status. Over one-third (37%) of e-cigarette users reported past-30 day cigarette use at age 19, compared to 6% of non-e-cigarette users. In adjusted logistic regression analysis, a significant difference remained (aOR=2.62 [95% CI=1.06, 6.48]). Almost two-thirds of e-cigarette users reported alcohol use at age 19, compared to 43% of non-e-cigarette users. However, in adjusted analyses this difference was not statistically significant (aOR=0.82 [95% CI=0.43, 1.57]) after controlling for other substance use at age 18[1]. Over half (53%) of e-cigarette users reported past 30-day marijuana use at age 19, compared to 16% of nonusers. This difference remained in adjusted analyses (aOR= 3.75 [95% CI=1.94, 7.22]). For NMPD use, 14% of e-cigarette users reported past 30-day NMPD use, compared to 1% of nonusers. In adjusted logistic regression analysis this difference remained significant (aOR=4.28 [95% CI= 1.45, 12.63]).

3.3. Incidence findings

Table 4 provides unadjusted and adjusted associations of e-cigarette use at age 18 with age 19 substance use among those who had no history of use for that substance at age 18 (incident substance use). Among those who had no history of cigarette use at age 18 (n=508), those who were e-cigarette users at age 18 were more likely to report cigarette use one year later compared to those who were not e-cigarette users at age 18 (OR=4.65 [1.64, 13.14]). Among those who had no history of alcohol use at age 18 (n=258), those who used e-cigarettes at age 18 were not more likely to report alcohol use one year later compared to age 18 non-e-cigarette users (OR=0.64 [0.14, 2.82]). Among those who had no history of

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[1]In this study, the additional outcome of binge drinking in the past two weeks was also considered but given that we found similar results with the outcome of binge drinking (i.e., no significant association in adjusted prospective analyses once controls were included in the analysis) we opted to use alcohol use in the past 30 days to keep the time frame and threshold consistent across substances examined.

marijuana use at age 18 (n=432), age 18 e-cigarette users were more likely to report marijuana use one year later compared to age 18 non-e-cigarette users (OR= 4.50 [1.70, 11.93]). Among those who reported no NMPD use history at age 18 (n=567), age 18 e-cigarette users were more likely to report NMPD use one year later compared to age 18 non-e-cigarette users (OR=9.23 [3.94, 21.65]). In adjusted analyses we again found that e-cigarette use at age 18 was associated with incident cigarette use (aOR=4.21 [1.42, 12.44]), incident marijuana use (aOR=3.22 [1.03, 10.10]), and incident NMPD use (aOR=6.81 [1.85, 25.09]) one year later. E-cigarette use at age 18 was not significantly associated with incident alcohol use one year later.

4. Discussion

In this study we found large differences in substance use between age 18 e-cigarette users and age 18 non-e-cigarette users, both cross-sectionally and one year later among adolescents as they transition to young adulthood. This is the first study to show a prospective association of e-cigarette use with NMPD use and the first study to prospectively examine incidence of cigarette, marijuana, alcohol, and NMPD use net of each other. Most prospective associations were robust and remained significant even after controlling for sociodemographic characteristics as well as conservatively controlling for other substance use at baseline. We also add to a growing body of research indicating increased risk for cigarette use and marijuana use among e-cigarette users. Our study provides evidence of not only prospective associations with other substance use for age 18 e-cigarette users, but also incidence of use during a key developmental transition into young adulthood.

The association of e-cigarette use with subsequent NMPD use and incident NMPD use one year later is an important addition to the literature. This suggests that links of e-cigarette use with other substance use is not limited to nicotine products or substances with often similar routes of administration. Instead, substance use risks associated with e-cigarette use may be due in part to changes in risk perceptions (Miech et al., 2017; Wong et al., 2020), reinforcing effects (Levine et al., 2011; NIDA, 2020), social norms, or social networks (Chrisakis and Fowler, 2008; Vogel et al., 2020) among those who use e-cigarettes, in turn increasing their risk of other substance use. As we increase our understanding of the risks associated with e-cigarette use which include acute and chronic health risks such as lung impairment and injury (e.g. Krishnasamy et al., 2020; Wills et al., 2019) and risk for tobacco and other substance use disorders (Veliz et al., 2020), it is critical to understand the mechanisms behind this increased risk in order to develop effective prevention strategies and mitigate risks.

This study also showed a robust association of e-cigarette use with marijuana use. Marijuana vaping may explain some of this close association. Future work should examine if this association is present across multiple forms of marijuana use or if it is specific to marijuana vaping. In addition, the increasing trend of vaping marijuana among adolescents (Kowitt et al., 2019; Miech et al., 2019) may mean this association will strengthen for adolescents in the future. This link is particularly concerning given the risk of severe pulmonary injury linked to vaping marijuana (Kalininskiy et al., 2019; King et al., 2020).

We did not find a significant association of e-cigarette use with subsequent alcohol use or incident alcohol use at follow-up. However, it is important to note that 89% of e-cigarette users had already initiated alcohol use at age 18, 70% of whom were current alcohol users. Because the longitudinal MTF study first assesses individuals at age 18 when many individuals have already initiated alcohol use, we were unable to assess individuals who initiate alcohol at earlier ages. Previous research examining the order of initiation of substances found the most prevalent initiation sequence of e-cigarette use involved initiating other substances before e-cigarettes (McCabe et al., 2019), and that most current e-cigarette users had a history of alcohol or other substance use (Gilbert et al., 2020). Additionally, a prospective study of younger adolescents aged 12–17 found an association of e-cigarette use with subsequent alcohol use (Silveira et al., 2018). The age difference of that sample and the present study might account for the difference in findings. Additional research is needed to examine whether substance use risk associated with e-cigarette use among adolescents differs by age. Additionally, it is important to highlight that e-cigarette users were more likely to use alcohol one year later prior to adding control variables. The difference in control variables between the two studies, namely that we controlled for use of all four substances at baseline may account for the lack of significant findings in this study with regard to alcohol use compared to findings in previous studies.

There are some important limitations of this study to note. First, the nature and landscape of e-cigarette use is rapidly changing. As e-cigarette use is rapidly evolving and changing in terms of nicotine content and devices used (Rao et al., 2020; Yingst et al., 2019) it is critical that we continue to monitor the risks and consequences associated with its use. Second, this study is subject to self-report bias, however, the MTF study provides protections to help encourage and ensure valid and reliable responses (Miech et al., 2020). Finally, it should be noted that sample sizes examining incidence were small, and some confidence intervals were wide. Additional research is needed using larger samples to replicate these findings. Additionally, with larger samples, sex, racial/ethnic, and other sociodemographic differences are an important area of future inquiry.

This study suggests that e-cigarette use may be an indicator for future substance use risk among young adults. We found this even in our most rigorous test, which focused on incident substance use one year later. Adolescent e-cigarette users may benefit from secondary prevention efforts to mitigate this risk. These risks should continue to be monitored as e-cigarette use continues to evolve among adolescents and young adults.

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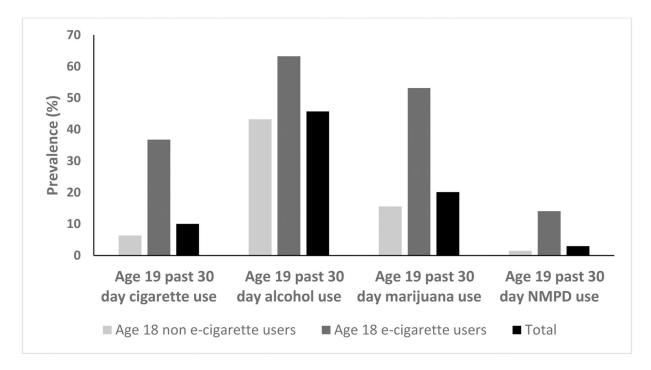
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Highlights

- E-cigarette users had greater odds of nonmedical prescription drug use one year later

- E-cigarette users had greater risk of incidence of other drug use one year later

- E-cigarette users had greater risk of alcohol use cross-sectionally only

Figure 1.
Prevalence of substance use at age 19 by age 18 e-cigarette use (n=717).

Table 1.

Sample descriptives (n=717)

	% (se)
Age 18 past 30 day e-cigarette use	12.14% (1.04)
Age 18 substance use	
Past 30 day cigarette use	10.90% (1.11)
Past 30 day alcohol use	34.88% (1.25)
Past 30 day marijuana use	19.31% (1.28)
Past 30 day NMPD use	4.98% (0.50)
Age 19/20 substance use	
Past 30 day cigarette use	10.03% (0.97)
Past 30 day alcohol use	45.71% (1.28)
Past 30 day marijuana use	20.12% (1.33)
Past 30 day NMPD use	2.97% (0.54)
Male	44.68% (1.62)
Race/ethnicity	
Black	14.07% (1.35)
White	57.36% (1.64)
Hispanic	17.89% (1.33)
Other	10.68% (0.85)
Region	
Northeast	14.07% (1.19)
Midwest	20.20% (1.23)
South	43.00% (1.62)
West	19.23% (1.26)
College plans	87.46% (1.18)
Parent with college degree	53.03% (1.64)

Table 2.

Cross-sectional associations of age 18 past 30-day e-cigarette use with age 18 cigarette use, alcohol use, marijuana use, nonmedical prescription drug (NMPD) use (n=717).

	Past 30-day cigarette use		Past 30 day alcohol use		Past 30-day marijuana use		Past 30-day NMPD use	
	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)
Age 18 Past 30-day e-cigarette use	12.97 (7.30, 23.05)	7.89 (3.93, 15.82)	5.55 (3.32, 9.27)	2.81 (1.54, 5.12)	5.64 (3.46, 9.19)	2.03 (1.07, 3.86)	6.31 (3.67, 10.84)	2.57 (1.16, 5.71)
Age 18 substance use								
Past 30 day cigarette use		--		2.35 (1.19, 4.68)		2.62 (1.29, 5.35)		2.13 (0.97, 4.68)
Past 30 day alcohol use		2.39 (1.21, 4.74)		--		4.71 (2.84, 7.81)		2.55 (1.25, 5.19)
Past 30 day marijuana use		2.95 (1.41, 6.20)		4.61 (2.79, 7.64)		--		5.83 (2.92, 11.66)
Past 30 day NMPD use		2.17 (0.90, 5.27)		2.25 (1.16, 4.36)		5.41 (2.72, 10.74)		--
Male		2.06 (1.09, 3.91)		0.74 (0.50, 1.10)		1.21 (0.73, 1.99)		0.61 (0.32, 1.19)
Race/ethnicity								
White		Ref		Ref		Ref		Ref
Black		0.74 (0.20, 2.78)		0.53 (0.25, 1.14)		1.31 (0.49, 3.45)		2.27 (0.96, 5.35)
Hispanic		0.89 (0.32, 2.47)		1.70 (0.97, 2.99)		1.71 (0.84, 3.49)		1.05 (0.41, 2.70)
Other		0.14 (0.04, 0.48)		1.00 (0.53, 1.86)		1.45 (0.70, 2.99)		2.65 (0.97, 7.13)
Parent with college degree		0.78 (0.37, 1.62)		1.17 (0.79, 1.74)		0.85 (0.53, 1.36)		1.65 (0.85, 3.18)
Region								
South		Ref		Ref		Ref		Ref
Northeast		0.84 (0.33, 2.16)		1.15 (0.69, 1.94)		1.96 (1.02, 3.77)		0.32 (0.10, 0.96)
Northcentral		0.78 (0.33, 1.80)		0.82 (0.49, 1.37)		1.08 (0.49, 2.40)		1.42 (0.69, 2.91)
West		0.52 (0.20, 1.35)		0.78 (0.44, 1.36)		1.81 (0.91, 3.57)		0.51 (0.20, 1.30)
College plans		0.36 (0.15, 0.84)		1.23 (0.64, 2.36)		0.86 (0.38, 1.96)		0.64 (0.25, 1.60)

Note: OR=odds ratio, 95% CI= 95% confidence interval, aOR=adjusted odds ratio, controls for other substance use, sex, race/ethnicity, parent education, region, college plans. **BOLD** indicates significance at p<0.05

Table 3.

Longitudinal associations of age 18 past 30-day e-cigarette use with cigarette use, alcohol use, marijuana use, nonmedical prescription drug (NMPD) use 1 year later (n=717)

	Past 30 day cigarette use		Past 30 day alcohol use		Past 30 day marijuana use		Past 30 day NMPD use	
	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)
Age 18 past 30 day e-cigarette use	**8.61 (4.96, 14.94)**	**2.62 (1.06, 6.48)**	**2.26 (1.40, 3.65)**	0.82 (0.43, 1.57)	**6.16 (3.77, 10.06)**	**3.75 (1.94, 7.22)**	**11.13 (4.69, 26.45)**	**4.28 (1.45, 12.63)**
Age 18 substance use								
Past 30 day cigarette use		**13.80 (6.29, 30.28)**		1.51 (0.71, 3.21)		1.14 (0.48, 2.71)		1.14 (0.40, 3.22)
Past 30 day alcohol use		0.92 (0.44, 1.95)		**4.87 (3.20, 7.42)**		1.14 (0.68, 1.93)		**4.15 (1.11, 15.50)**
Past 30 day marijuana use		**2.71 (1.24, 5.89)**		**1.83 (1.03, 3.27)**		**8.69 (4.87, 15.49)**		**2.42 (0.88, 6.65)**
Past 30 day NMPD use		1.28 (0.48, 3.42)		1.12 (0.55, 2.30)		1.27 (0.61, 2.61)		**2.44 (0.79, 7.55)**
Male		1.01 (0.52, 1.97)		1.01 (0.69, 1.47)		1.16 (0.71, 1.88)		1.49 (0.58, 3.80)
Race/ethnicity								
White		Ref		Ref		Ref		Ref
Black		0.36 (0.08, 1.60)		0.60 (0.30, 1.20)		1.50 (0.62, 3.64)		0.57 (0.04, 8.75)
Hispanic		1.28 (0.41, 3.99)		1.25 (0.71, 2.21)		1.22 (0.58, 2.57)		1.64 (0.56, 4.85)
Other		0.73 (0.21, 2.54)		0.57 (0.32, 1.02)		1.17 (0.53, 2.55)		1.35 (0.44, 4.13)
Parent with college degree		1.42 (0.70, 2.89)		**1.58 (1.07, 2.33)**		1.51 (0.93, 2.46)		2.09 (0.82, 5.35)
Region								
South		Ref		Ref		Ref		Ref
Northeast		0.49 (0.19, 1.29)		**1.83 (1.10, 2.06)**		1.32 (0.67, 2.57)		0.58 (0.15, 2.27)
Northcentral		1.06 (0.50, 2.23)		1.36 (0.84, 2.21)		1.23 (0.64, 2.35)		0.87 (0.29, 2.63)
West		0.40 (0.13, 1.23)		1.28 (0.76, 2.16)		**2.11 (1.05, 4.24)**		0.80 (0.26, 2.51)
College plans		1.08 (0.49, 2.39)		1.21 (0.67, 2.19)		1.46 (0.59, 3.59)		1.49 (0.27, 8.17)

Note: OR=odds ratio, 95% CI= 95% confidence interval, aOR=adjusted odds ratio, controls for all substance use at age 18, sex, race/ethnicity, parent education, region, college plans, age at follow up.
BOLD indicates significance at p<0.05

Table 4.

Longitudinal associations of age 18 past 30-day e-cigarette use with incident cigarette use, alcohol use, marijuana use, nonmedical prescription drug (NMPD) use 1 year later among those with no history of substance use outcome at age 18.

	Incident cigarette use (n=508)		Incident alcohol use (n=258)		Incident marijuana use (n=432)		Incident NMPD use (n=567)	
	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)
Age 18 past 30 day e-cigarette use	**4.65 (1.64, 13.14)**	**4.21 (1.42, 12.44)**	0.64 (0.14, 2.82)	0.34 (0.05, 2.63)	**4.50 (1.70, 11.93)**	**3.22 (1.03, 10.10)**	**9.23 (3.94, 21.65)**	**6.81 (1.85, 25.09)**
Age 18 substance use								
Past 30 day cigarette use		--		4.03 (0.52, 30.95)		3.04 (0.45, 20.41)		0.72 (0.16, 3.22)
Past 30 day alcohol use		0.79 (0.34, 1.83)		--		1.68 (0.83, 3.40)		1.20 (0.39, 3.65)
Past 30 day marijuana use		1.27 (0.50, 3.21)		2.59 (0.47, 14.30)		--		**4.38 (1.42, 13.45)**
Past 30 day NMPD use		4.02 (0.98, 16.50)		1.98 (0.36, 10.96)		1.96 (0.46, 8.4.)		--
Male		1.41 (0.61, 3.27)		0.61 (0.34, 1.11)		1.12 (0.62, 2.00)		1.10 (0.39, 3.07)
Race/ethnicity								
White		Ref		Ref		Ref		Ref
Black		0.88 (0.22, 3.42)		**0.55 (0.24, 1.29)**		1.45 (0.61, 3.44)		0.36 (0.04, 3.19)
Hispanic		1.99 (0.64, 6.24)		0.46 (0.15, 1.43)		0.80 (0.29, 2.21)		2.16 (0.65, 7.22)
Other		0.62 (0.13, 2.75)		**0.69 (0.29, 1.64)**		0.87 (0.36, 2.10)		0.29 (0.06, 1.48)
Parent with college degree		0.83 (0.36, 1.93)		**1.14 (0.64, 2.05)**		1.24 (0.70, 2.20)		**3.00 (1.04, 8.61)**
Region								
South		Ref		Ref		Ref		Ref
Northeast		1.26 (0.47, 3.40)		0.86 (0.37, 1.97)		1.35 (0.64, 2.85)		1.42 (0.48, 4.18)
Northcentral		1.53 (0.56, 4.17)		0.85 (0.38, 1.88)		1.01 (0.48, 2.15)		1.81 (0.58, 5.65)
West		0.68 (0.22, 2.12)		1.01 (0.43, 2.36)		1.68 (0.78, 3.61)		0.64 (0.15, 2.69)
College plans		2.88 (0.33, 24.99)		**2.69 (0.68, 10.74)**		2.47 (0.57, 10.62)		0.64 (0.16, 2.50)

Note: OR=odds ratio, 95% CI= 95% confidence interval, aOR=adjusted odds ratio, controls for all substance use at age 18, sex, race/ethnicity, parent education, region, college plans. **BOLD** indicates significance at p<0.05