



Original Investigation

Exploring How Social Media Exposure and Interactions Are Associated With ENDS and Tobacco Use in Adolescents From the PATH Study

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Abstract

Introduction: Tobacco use is a current public health epidemic that puts individuals at risk for many health conditions and diseases, and adolescents are at high risk for the initiation and persistence of tobacco use behaviors partly due to engagement with social media content. The objective of this study is to examine the association between engaging in social media behaviors and patterns of electronic nicotine delivery systems (ENDS) and tobacco use at a 1-year follow-up among 11 279 adolescents from the PATH study.

Methods: Five social media variables were questioned at Wave 2 and then compared to ENDS and tobacco status transitions (i.e., initiation, persistence, and escalation) at a 1-year follow-up, respectively. Survey-weighted multivariable logistic regression models were used to calculate adjusted odds ratios and 95% confidence interval.

Results: Passive behaviors on social media were related to higher likelihoods of starting to use ENDS and other tobacco products. Additionally, active behaviors on social media were related to higher likelihoods for the initiation and persistence of tobacco use. In particular, sending tobacco content to other users was further associated with a higher likelihood of escalation of tobacco product use.

Discussion: Both exposure to and interactions with social media tobacco content had a significant impact on the patterns of ENDS and tobacco use in adolescents. Due to the amount of time adolescents spend engaging with online content, social media may be a critical place in which to intervene, possibly with the use of antitobacco or tobacco prevention messages.

Implications: The results of this study have implications for public health and the policies surrounding adolescents and their exposure to social media. Reducing the ENDS and tobacco content to which adolescents are exposed has the potential to decrease the instances of initiation and persistence of ENDS and tobacco use. Intervening on social media may prevent or slow the progression of ENDS and tobacco use, and increase motivation and actions toward the cessation of tobacco use in adolescents.

Introduction

Tobacco use is a current public health epidemic that puts individuals at risk for many chronic health conditions and diseases.¹ In addition to combustible tobacco, the use of electronic nicotine delivery systems (i.e., electronic nicotine delivery systems [ENDS]) has been on the rise in the last decade, with more than 5 million adolescents in the United States using e-cigarettes in 2019, including 10.5% of middle school students and 27.5% of high school students.² Previous studies have demonstrated that using nicotine in adolescence has been shown to increase risk of nicotine addiction, combustible tobacco product uptake, and future addiction to other drugs³⁻⁶; however, interpretations of these findings have attracted some debate in the public health community.⁷ Therefore, ENDS use in adolescents represents an increasingly important area for further research.

In the United States, adolescent engagement with online content and social media has become ubiquitous. For tobacco prevention efforts, this trend is concerning as over half of adolescents report seeing tobacco-related content on social media in the past month alone, and media promotions about tobacco greatly influence adolescents' attitudes toward its use.⁸⁻¹⁰ In addition to tobacco-related content posted by peers, reports have shown that in 2019 the top e-cigarette brands in the United States spent more than \$1 million to market their products on the Internet including campaigns on social media platforms and hiring social media influencers (i.e., a person who can exert influence on social media) for product promotion.¹¹⁻¹³ Numerous studies indicate that adolescents who deliberately *interact* on social media via liking (i.e., clicking the like button to show approval), following, and/or posting tobacco-related content (i.e., "active" engagement) are at higher odds of using tobacco products than individuals who do not actively engage with this content.^{10,14-16} However, even adolescents who only view tobacco-related content passively (i.e., are exposed to online content about tobacco but do not actively generate the tobacco content) on social media have increased risk for ENDS and tobacco use uptake.¹⁷⁻¹⁹

It is unclear how shifts in ENDS and tobacco use behaviors over time are potentially influenced by various social media behaviors. For instance, there are no known studies examining how various types of social media interactions (e.g., actively generating content versus passive viewing) may influence one's escalation from using a single tobacco product to becoming a polytobacco user, which can have significant implications for developing a tobacco use disorder. The use of a longitudinal study design would allow for the identification of different ENDS and tobacco use trajectories over time and help to delineate the social media use behaviors that promote persistent ENDS or tobacco use after initiation to inform intervention efforts.

In response, the present study uses a nationally representative data set from the U.S. PATH (Population Assessment of Tobacco and Health) study to determine the influence of social media content on various types of ENDS and tobacco use behaviors of adolescents. Understanding the relationship between behaviors on social media to specific types of ENDS and tobacco use behaviors using a longitudinal design can provide vital information toward the development of interventions and regulatory efforts aimed at preventing or stopping adolescent use. Therefore, the purpose of this study is to explore whether tobacco-related social media engagement has an effect on the initiation, persistence, and escalation of ENDS and tobacco use among adolescents over time. Furthermore, this study aimed to determine whether active social media interactions (e.g., generating content, sending content to others) corresponded with higher ENDS

and tobacco use outcomes compared with passive tobacco-related social media interactions.

Materials and Methods

Study Design and Population

The PATH study is a nationally representative, longitudinal cohort study of 45 971 adults and adolescents in the United States aged 12 years and older, which was collaborated and funded by the National Institute on Drug Abuse (NIDA), National Institutes of Health (NIH), the Center for Tobacco Products (CTP), and the Food and Drug Administration (FDA).²⁰ This study was designed to gather data on tobacco use behaviors, self-perceptions about attitudes toward tobacco (including current and newly emerging tobacco products) and health, tobacco using status, and health outcomes, which can assist in identifying the differences between population and individual use patterns over time by oversampling tobacco users, young adults aged 18–24, and African Americans.²¹ The PATH study collected extensive self-reported information by in-person data collection via audio computer-assisted self-interview.^{20,21} Wave 1 was conducted in September 2014 to December 2014, Wave 2 was conducted in October 2014 to October 2015, and Wave 3 was conducted in October 2015 to October 2016. More information about the PATH study design and methodology can be found in previous literature.²⁰⁻²²

This study includes only adolescents who participated in Wave 2 (baseline) and Wave 3 (1 year follow-up) of the PATH study. Wave 1 data were not used in this study because this wave did not assess comprehensive social media information. Wave 2 had more comprehensive social media information (i.e., Wave 2 assessed for eight tobacco brands but Wave 1 assessed for only five brands), so Wave 2 data were used as baseline. At Wave 2, we assessed social media exposures to online tobacco content, then at Wave 3 we assessed the outcome of tobacco use status transitions. We used Wave 2 exposures to predict Wave 3 outcomes. There were 12 172 adolescents aged 12–17 years who completed the adolescent questionnaire and among those who participated in Wave 2, 88.7% answered the questions that they were asked.²⁰ Between Wave 2 and Wave 3, 1733 adolescents grew to 18 years of age and filled out the adult questionnaire rather than the adolescent questionnaire; however, their information was still included in our data analyses. Participants who did not provide complete data on variables of interest or who were lost at 1-year follow-up were excluded (7%, $N = 893$). The total sample size for analysis was 11 279.

Measures

Social Media Exposure to Online Tobacco Content (Wave 2)

All participants in Wave 2 were between the ages of 12 and 17. All of the social media exposure data used in our analyses came from Wave 2 assessments. Five primary variables of interest were questioned at baseline to measure the extent to which participants experienced and interacted with online content on social media (i.e., Internet-based social networks people use to connect with others, including Facebook, Google Plus, YouTube, MySpace, LinkedIn, Twitter, Tumblr, Instagram, Pinterest, or Snapchat). The first question asked adolescents if they had ever seen content posted about tobacco products (including ENDS) on social media sites. The second question asked respondents if they had engaged in any online activities surrounding tobacco products (including ENDS), including (1) signing

up for email alerts; (2) reading articles, and (3) watching videos. Participants were asked to choose all options that applied, and according to their responses, they were classified into two groups: none of the above versus yes (at least one online activity). The third question asked participants if they had posted content about tobacco products (including e-cigarettes) on any personal social media accounts. The fourth question asked participants if they had liked or followed any tobacco brands on social media sites, including Camel, Marlboro, Newport, Swisher Sweets, Blu, Fin, Vuse, and NJOY. The fifth question asked participants if they had sent a link or any other information on social media sites to others regarding the tobacco brands listed above. All exposures were recoded as dichotomous variables, either yes or no. The measurement period of all exposures was within the past 12 months.

Tobacco Use Status Transitions (Wave 3)

Initiation, escalation, and persistence were the three tobacco use status outcomes examined at follow-up. Participants were questioned “Have you ever tried [Tobacco product], even one or two puffs?” at both baseline and follow-up. Based on their responses at baseline, they were grouped as never tobacco users and ever tobacco users. We then examined the initiation among never smokers at baseline and escalation and persistence among ever tobacco users.

Initiation of tobacco use was defined as never users at baseline who reported any level of tobacco product use during the follow-up, which was consistent with previous studies.^{15,22} Escalation of tobacco use was considered as any increase in the total number of tobacco products ever used during follow-up, among ever tobacco users at baseline. Persistence of tobacco use was defined as participants who reported use of any tobacco product within the past 30 days at follow-up among ever tobacco users (including if the tobacco product used at follow-up was different from the tobacco product used at baseline).

In Wave 3, adolescents were asked about using any of the following twelve tobacco products during both waves: cigarettes, ENDS (i.e., products that are battery powered, may use fluid containing nicotine rather than tobacco leaves, and produce vapor instead of smoke), traditional cigars, cigarillos, filtered cigars, pipes, hookah, smokeless tobacco (i.e., loose snus, moist snuff, dip, spit, or chewing tobacco), snus pouches, dissolvable tobacco, bidi, and kretek. Due to the low prevalence of bidis and kreteks use among adolescents, these products were not queried in the adult questionnaire. To be consistent with the adult questionnaire, analysis of bidis and kreteks use was excluded from this study.

To determine whether youth started using tobacco product (initiation analyses), we assessed first time use of tobacco at Wave 3. First time use of tobacco was grouped into three mutually exclusive categories: (1) ENDS use only; (2) conventional tobacco use only; and (3) ENDS and conventional tobacco. In the second part of this analysis, we limited the sample to adolescents who had already had tobacco use history at baseline (ENDS only or any tobacco product). We then assessed whether the adolescents in this group tried a new/additional product (i.e., “escalation”) or continued to use the products that they had been using previously (i.e., “persistence”) in Wave 3. In these analyses, we only compared ENDS only or any tobacco product users.

Covariates

Sociodemographic information was collected at baseline, including age range (12–14 years/15–17 years), sex (female/male), race

(White/Black/others), and ethnicities (Hispanic/not Hispanic). Because the majority of the research population were adolescents, marital status of parents or guardians (married/ widowed or divorced or separated/ never married), total household income within the past 12 months, peer tobacco use (assessed by: “How many of your best friends use tobacco products, including cigarettes, e-cigarettes, traditional cigars, cigarillos, filtered cigars, and smokeless tobacco?”), and time spent on social media sites on a typical day were also assessed in this study.

Lifetime substance use history was assessed from the participants’ responses to questions asking if they had ever used substances at baseline, including alcohol, marijuana (including blunts, i.e., cigars with tobacco removed and replaced with marijuana), and other illicit drugs that were misused or not prescribed to the participants. The list of other illicit drugs included prescription drugs (i.e., Ritalin, Adderall, painkillers, sedatives, tranquilizers), cocaine, crack, stimulants (i.e., methamphetamine or speed), heroin, inhalants, solvents, and hallucinogens. The responses were recoded as a three-category variable: (1) have never used any substance, (2) have used any single substance, and (3) have used two or more substances.

Lifetime internalizing disorder (i.e., depression, anxiety) and externalizing disorder (i.e., conduct disorder, attention-deficit/hyperactivity disorder, and oppositional defiant disorder) were also considered in this study. These mental health comorbidities were assessed via the short version of the Global Appraisal of Individual Needs (GAIN-SS) questionnaire, which was modified for the PATH study.²¹ Four items assess for internalizing disorder symptoms, five items assess for externalizing disorder symptoms, and two items assess for hyperactivity. Researchers have previously found hyperactivities to be highly collinear with items of externalizing; therefore, these two items were also included in the externalizing disorder scale for a total of seven items.²² Points were assigned for each subitem if participants had ever experienced this symptom. All these responses were summed for scaling (0–4 symptoms for internalizing disorders and 0–7 symptoms for externalizing disorders) and recoded as three-category variables: no or low (0–1 symptoms), moderate (2–3 symptoms), and severe (4 symptoms for internalizing disorders and ≥4 symptoms for externalizing disorders).

Statistical Analyses

Distributions of characteristics among all participants at baseline were examined as a whole and according to tobacco use status groups (never users, single tobacco product users, polytobacco with ENDS users, and polytobacco without ENDS users).

To examine the initiation of tobacco use at follow-up among never users, five separate unadjusted multinomial logistic regression models were used to examine each combination of social media exposures and tobacco use status transitions (ENDS only users, any tobacco users including ENDS, any tobacco users excluding ENDS), referred as nonusers. Next, adjusted multinomial logistic regression analyses were conducted, controlling for sociodemographics (age range, gender, race, ethnicities, parents’ marital status, household income, and if they currently live with smokers), substance use, and mental health symptoms.

Furthermore, to evaluate the associations between escalation and social media exposures among ENDS only users and any tobacco users at baseline, logistic regression models were performed respectively. For multivariable-adjusted models, the adjusted odds ratios and 95% confidence intervals were controlled for sociodemographics, substance use, and mental health symptoms. The same approach was

applied in examining the associations between persistence and social media exposures among participants.

All analyses were conducted using SAS Version 9.4. The majority of our participants were age 12–17 (84.6%). Some participants (15.4%) in the sample were age 18. The reason for this is as follows. During the study period, some adolescents who participated in the youth survey turned age 18 during the study. When they turned age 18, they transition to participating in the adult version (ages 18 and older) of the survey rather than the youth version (ages 12–17). These 18 year olds were asked the exact same questions about tobacco use as they were in the youth survey. We used both the youth survey weights and the adult survey weights to account for this transition. Estimates were weighted to represent the U.S. adolescent and young adult population. All results are estimated using the balanced repeated replication method with Fay's adjustment set to 0.3 to increase the stability.²⁰ All the statistical analyses were two sided, and *p* values < 0.05 were considered statistically significant.

Results

Characteristics of the sample at baseline have been reported in [Supplementary Table 1](#) (*N* = 11,279). Distribution characteristics among participants with and without follow-up (*N* = 893) are shown in [Supplementary Table 2](#). At baseline, 23.0% of participants (*N* = 2599) had tried/used tobacco products during their lifetime. Additionally, 12.5% of participants were polytobacco product users (*N* = 1415), and nearly 88.0% of these polytobacco users reported having used ENDS. Compared with the general population and those who had never used any tobacco, those who reported having used any type or amount of tobacco congregated in the older age range (15–17 years). Furthermore, those who reported having used tobacco had a higher odds of having a positive history of substance

use in their lifetime, severe internalizing or externalizing disorders during their lifetime, and spent longer time on social media sites per day.

As shown in [Table 1](#) (Initiation), we documented 749 cases of initiation among baseline never tobacco users (*N* = 8619). Specifically, at follow-up, 304 participants reported use of ENDS only, 283 responses reported use of conventional tobacco product, and 162 cases indicated use of both ENDS and at least one other conventional tobacco product. The results suggested that specific social media exposures are positively associated with initiation of either ENDS or other tobacco use. Seeing content posted about tobacco products on social media sites was found to be positively associated with starting ENDS use only (adjusted odds ratio [AOR] = 2.09, 95% confidence interval [CI] = 1.43–3.06) and the use of other tobacco products (AOR = 1.41, 95% CI = 1.01–1.97). Online activities related to tobacco products, including having signed up for email alerts, read articles online, or watched a video online, were associated with starting to use ENDS and other tobacco products at follow-up (AOR = 1.68, 95% CI = 1.04–2.72). No association was observed for behaviors such as liking or following tobacco brands on personal social media accounts. Adolescents who had sent a link or information on social media sites to others had higher odds of initiating conventional tobacco product use rather than ENDS (AOR = 2.00, 95% = 1.02–3.81). Due to the small case number of individuals who indicated posting content about tobacco products on any social media accounts, these results were statistically unreliable, and the table does not present them.

Associations between social media exposures and escalation were examined separately among baseline ENDS only users and any tobacco users, as shown in [Table 2](#) (Escalation). No association was observed between escalation and social media exposures, neither among baseline ENDS only users nor any tobacco users.

Table 1. Initiation Among Participants Who Had Not Used Any Tobacco Product at Baseline (Wave 2)

	Tobacco use status at follow-up (ref: nonusers)		
	ENDS only	Conventional tobacco (no ENDS)	ENDS and conventional tobacco
	<i>N</i> = 304	<i>N</i> = 283	<i>N</i> = 162
Viewed content (ref: no)			
Unadjusted model	2.80 (2.08, 3.77)	1.86 (1.40, 2.47)	1.64 (1.10, 2.44)
Adjusted model ^a (AOR, 95% CI)	2.30 (1.59, 3.32)	1.56 (1.12, 2.17)	1.14 (0.73, 1.77)
Adjusted model ^b (AOR, 95% CI)	2.09 (1.43, 3.06)	1.41 (1.01, 1.97)	1.04 (0.67, 1.62)
Online activities (ref: no)			
Unadjusted model	1.72 (1.24, 2.39)	1.27 (0.86, 1.88)	2.47 (1.55, 3.95)
Adjusted model ^a (AOR, 95% CI)	1.40 (0.92, 2.12)	1.18 (0.73, 1.88)	1.99 (1.20, 3.30)
Adjusted model ^b (AOR, 95% CI)	1.20 (0.78, 1.84)	0.99 (0.61, 1.61)	1.68 (1.04, 2.72)
Liked or followed (ref: no)			
Unadjusted model	1.12 (0.57, 2.22)	2.01 (1.31, 3.07)	2.42 (1.23, 4.74)
Adjusted model ^a (AOR, 95% CI)	0.76 (0.33, 1.75)	1.72 (0.97, 3.03)	2.00 (0.94, 4.27)
Adjusted model ^b (AOR, 95% CI)	0.67 (0.29, 1.56)	1.48 (0.80, 2.75)	1.86 (0.83, 4.13)
Sent to others (ref: no)			
Unadjusted model	1.06 (0.42, 2.67)	2.99 (1.73, 5.18)	1.61 (0.53, 4.93)
Adjusted model ^a (AOR, 95% CI)	0.90 (0.31, 2.61)	2.34 (1.21, 4.52)	1.42 (0.47, 4.35)
Adjusted model ^b (AOR, 95% CI)	0.77 (0.27, 2.25)	2.00 (1.02, 3.81)	1.30 (0.44, 3.81)

Bold text indicates statistically significant values. The case number of post is too small to estimate. AOR = (multivariable) adjusted odds ratio; CI = confidence interval.

^aAdjusted by sociodemographics, including age range (12–14 vs. 15–17), gender, race, and ethnicities, total household income in past 12 mo, parental marital status (married/widowed, divorced, or separated/never married), peer tobacco use, time spent on social media sites (per day).

^bAdditionally adjusted by substance use history, including marijuana, alcohol and drug (never, 1, or more than 2), internalizing disorders level (no or low/moderate/severe), and externalizing disorders level (no or low/moderate/severe).

Table 2. Escalation of Tobacco Use by Used ENDS Only at Baseline and Used Any Tobacco Product at Baseline in the Past 12 Month

Escalation of tobacco use at Wave 3 (1-y follow-up)					
Used ENDS only at baseline (N = 712)	No		Yes		Used any tobacco product at baseline (N = 2599)
	N = 567	N = 145	N = 1878	N = 721	
Viewed content (ref: no)					Viewed content (ref: no)
Unadjusted model	1.00 (ref)	0.96 (0.63, 1.47)	Unadjusted model	1.00 (ref)	1.23 (1.01, 1.50)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	0.97 (0.63, 1.51)	Adjusted model ^a	1.00 (ref)	1.23 (0.97, 1.55)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	0.91 (0.58, 1.45)	Adjusted model ^b	1.00 (ref)	1.12 (0.89, 1.41)
Online activities (ref: no)					Online activities (ref: no)
Unadjusted model	1.00 (ref)	0.96 (0.56, 1.64)	Unadjusted model	1.00 (ref)	1.35 (1.06, 1.74)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	0.89 (0.53, 1.50)	Adjusted model ^a	1.00 (ref)	1.25 (0.96, 1.64)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	0.83 (0.46, 1.50)	Adjusted model ^b	1.00 (ref)	1.15 (0.88, 1.49)
Post (ref: no)					Post (ref: no)
Unadjusted model	1.00 (ref)	1.11 (0.38, 3.23)	Unadjusted model	1.00 (ref)	1.45 (1.03, 2.03)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	0.98 (0.30, 3.22)	Adjusted model ^a	1.00 (ref)	1.32 (0.89, 1.95)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	0.92 (0.26, 3.27)	Adjusted model ^b	1.00 (ref)	1.18 (0.79, 1.78)
Liked or followed (ref: no)					Liked or followed (ref: no)
Unadjusted model	1.00 (ref)	1.30 (0.53, 3.19)	Unadjusted model	1.00 (ref)	1.21 (0.91, 1.61)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	1.33 (0.38, 4.69)	Adjusted model ^a	1.00 (ref)	1.30 (0.95, 1.77)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	1.26 (0.35, 4.52)	Adjusted model ^b	1.00 (ref)	1.16 (0.86, 1.56)
Sent to others (ref: no)					Sent to others (ref: no)
Unadjusted model	1.00 (ref)	1.83 (0.62, 5.42)	Unadjusted model	1.00 (ref)	1.34 (0.98, 1.84)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	1.66 (0.47, 5.88)	Adjusted model ^a	1.00 (ref)	1.30 (0.95, 1.77)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	1.45 (0.44, 4.76)	Adjusted model ^b	1.00 (ref)	1.16 (0.86, 1.56)

Bold text indicates statistically significant values. AOR = (multivariable) adjusted odds ratio; CI = confidence interval.

^aAdjusted by sociodemographics, including age range (12–14 vs. 15–17), gender, race, and ethnicities, total household income in past 12 mo, parental marital status (married/widowed, divorced, or separated/never married), peer tobacco use, and time spent on social media sites (per day).

^bAdditionally adjusted by substance use history, including marijuana, alcohol and drugs (never, 1, or more than 2), internalizing disorder level (no or low/moderate/severe), and externalizing disorder level (no or low/moderate/severe).

As shown in Table 3 (Persistence), we conducted analyses on the continuation of current (past 30-day) tobacco use among baseline ENDS only users and any tobacco ever users separately. There were 150 cases of persistence among baseline ENDS only users, which indicates use of ENDS at baseline and continued use of any tobacco product in the past 30 days during the follow-up. No association was observed between this outcome and any social media exposures. Of the 1038 cases of persistent tobacco use at baseline and follow-up, active behaviors on social media sites were positively associated with persistence. Compared with those who did not send content to others, adolescents who sent content to others had higher odds of continuing use of any tobacco product in the past 30 days during follow-up (AOR = 1.76, 95% CI = 1.22–2.54). Additionally, those who liked or followed tobacco-related content on social media sites had higher odds of continuing use of any tobacco product than adolescents who did not like or follow this content (AOR = 1.68, 95% CI = 1.26–2.25).

Discussion

This study explored the relationship between several online and social media behaviors and ENDS and tobacco use trajectories over time among adolescents in the PATH study, a large scale, nationally representative and longitudinal database. Findings signal an increased risk for various tobacco and ENDS use behaviors among adolescents who encounter or engage with online content about tobacco. Furthermore, risk for initiation and persistence is even more pronounced among adolescents who self-report actively interacting

with online content about tobacco on social media. These associations remained significant even after controlling for a variety of covariates, such as demographics, other drug use, and mental health problems that could potentially influence tobacco and ENDS use.

The results of this study have implications for public health and the policies surrounding adolescents and their exposure to social media. Our findings suggest that adolescents who actively like, follow, or share tobacco-related content to others on social media have a higher likelihood of initiating use of any tobacco products than those who passively view such content. However, passive use of social media (viewed content regarding tobacco product on social media sites) has a stronger association with initiation of ENDS when compared with initiation of other tobacco products. These specific associations extend the literature, which similarly states that engagement and exposure to social media increases initiation of ENDS and tobacco use.^{9,10} Furthermore, Soneji et al.¹⁵ found that online marketing, including marketing on social media, affects tobacco use initiation, a finding that our study expanded on with similar results related to ENDS use. With both the high level of social media use among adolescents and the varying affects this use has on initiation of tobacco products, the use of online platforms may be crucial for preventative measures in tobacco use. Given the emphasis on ENDS initiation among passive social media users, spreading anti-ENDS messages and marketing may be important for intercepting onset of use.

Our findings also add to the literature on escalation and persistence of tobacco and ENDS product use. Passively viewing social

Table 3. Persistence of Tobacco Use by Used ENDS only at Baseline and Used Any Tobacco Product at Baseline in the Past 30 Day

	Persistence of tobacco use at Wave 3 (1-y follow-up)			
	Used ENDS only at baseline (N = 712)		Used any tobacco product at baseline (N = 2599)	
	No N = 562	Yes N = 150	No N = 1561	Yes N = 1038
Viewed content (ref: no)			Viewed content (ref: no)	
Unadjusted model	1.00 (ref)	0.92 (0.60, 1.41)	Unadjusted model	1.00 (ref) 0.98 (0.80, 1.21)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	0.80 (0.50, 1.29)	Adjusted model ^a	1.00 (ref) 0.85 (0.67, 1.06)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	0.74 (0.43, 1.25)	Adjusted model ^b	1.00 (ref) 0.77 (0.62, 1.03)
Online activities (ref: no)			Online activities (ref: no)	
Unadjusted model	1.00 (ref)	1.10 (0.63, 1.92)	Unadjusted model	1.00 (ref) 1.23 (1.00, 1.51)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	1.01 (0.55, 1.85)	Adjusted model ^a	1.00 (ref) 1.05 (0.83, 1.33)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	1.01 (0.53, 1.93)	Adjusted model ^b	1.00 (ref) 0.98 (0.78, 1.25)
Post (ref: no)			Post (ref: no)	
Unadjusted model	1.00 (ref)	0.69 (0.18, 2.60)	Unadjusted model	1.00 (ref) 1.58 (1.14, 2.21)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	0.64 (0.14, 2.85)	Adjusted model ^a	1.00 (ref) 1.45 (0.97, 2.18)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	0.57 (0.13, 2.55)	Adjusted model ^b	1.00 (ref) 1.26 (0.83, 1.90)
Liked or followed (ref: no)			Liked or followed (ref: no)	
Unadjusted model	1.00 (ref)	1.25 (0.45, 3.47)	Unadjusted model	1.00 (ref) 1.88 (1.47, 2.40)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	1.82 (0.59, 5.59)	Adjusted model ^a	1.00 (ref) 1.90 (1.39, 2.58)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	1.79 (0.62, 5.14)	Adjusted model ^b	1.00 (ref) 1.68 (1.26, 2.25)
Sent to others (ref: no)			Sent to others (ref: no)	
Unadjusted model	1.00 (ref)	1.50 (0.44, 5.16)	Unadjusted model	1.00 (ref) 1.89 (1.36, 2.62)
Adjusted model ^a (AOR, 95% CI)	1.00 (ref)	1.50 (0.40, 5.54)	Adjusted model ^a	1.00 (ref) 1.94 (1.34, 2.82)
Adjusted model ^b (AOR, 95% CI)	1.00 (ref)	1.25 (0.34, 4.62)	Adjusted model ^b	1.00 (ref) 1.76 (1.22, 2.54)

Bold text indicates statistically significant values. AOR = (multivariable) adjusted odds ratio; CI = confidence interval.

^aAdjusted by sociodemographics, including age range (12–14 vs. 15–17), gender, race, and ethnicities, total household income in past 12 mo, parental marital status (married/widowed, divorced, or separated/never married), peer tobacco use, and time spent on social media sites (per day).

^bAdditionally adjusted by substance use history, including marijuana, alcohol and drugs (never, 1, or more than 2), internalizing disorder level (no or low/moderate/severe), and externalizing disorder level (no or low/moderate/severe).

media content did not have any association with persistence or escalation of tobacco use. However, our findings suggest that active use of social media was correlated with a higher likelihood of persistent use of tobacco at follow-up. Yoo et al.²³ found that expressing prosmoking messages on social media is directly related to smoking intentions in adolescents, which our findings expand on by demonstrating that such active engagement is correlated with persistent use of tobacco. Furthermore, our results demonstrate that sending tobacco content to others on social media was additionally associated with a high likelihood of escalated tobacco use. These findings add to the literature by portraying how differing forms of active social media engagement may be related to differences in tobacco use patterns.^{24,25} This represents an area for future research to explore how tobacco interventions can use social media as a platform to negate persistent and escalated tobacco use in adolescents.

Social norms are a possible mechanism influencing tobacco use initiation,²⁶ and there is emerging concern that pro-tobacco norms are spread and/or sustained via social media platforms.²⁷ Related, we observed that adolescents who actively like, follow, or share tobacco-related content to others on social media have a higher likelihood of initiating use of any tobacco products than those who passively view such content. Therefore, it may be that adolescents who actively socially network about tobacco have stronger attitudes about these products and communicate these attitudes online with peers who they view as similarly valuing tobacco use. These more active social online behaviors (vs. passive) can further perpetuate pro-tobacco norms and subsequently lead to uptake of tobacco, as

is supported by the theory of reasoned action that suggests people are likely to initiate a behavior when they believe influential groups (i.e., peers) similarly value that behavior.²⁸ Our findings further indicate that this is could be more relevant for tobacco use versus ENDS use that may be driven more by misperceptions and favorable attitudes toward these products versus cigarettes. Studies have found that young adults are aware of some of the risks associated with ENDS, but many of them have misconceptions of the products and hold more favorable attitudes toward e-cigarette use than cigarette use.^{29,30} Furthermore, it may be that ENDS use is perceived as more of a social experience versus traditional tobacco use behaviors as they offer opportunities for adolescents to boast about their knowledge and personal experiences with these trendy products.³¹

This study has several strengths. First, by utilizing a large, nationally representative data set of adolescents, we were able to conduct rigorous analyses and control for numerous covariates that could confound outcomes related to ENDS and tobacco use. In particular, we controlled for substance abuse and mental health covariates. In the initiation section analysis, we provided a detailed analysis of the onset of ENDS products when compared to tobacco products rather than an analysis of both products as a whole. In addition, the longitudinal analysis allowed for the identification of different ENDS and tobacco use trajectories over time. Last, our study was able to look at the effect of specific social media use behaviors, both active and passive, on the ENDS and tobacco use statuses of adolescents, an extension from previous literature referring only to overall online engagement.¹⁵

Limitations of the current study include the use of self-report measures to assess ENDS and tobacco use status. However, self-reporting of tobacco use is not affected by significant bias in population-based surveys.³² Additionally, we could not determine participants' level of exposure to other types of media and tobacco marketing within, which could have also contributed to tobacco interest and engagement. Furthermore, we were unable to assess other potentially confounding variables related to social media use, such as advertisement exposure and peer social media behaviors that could impact adolescent ENDS and tobacco use. Likewise, escalation of tobacco use was not quantified, and persistence of tobacco use was only assessed within the past 30 days of the survey. Examining persistence of tobacco use in this way could allow for our findings to be influenced by reverse causality. Further studies can expand on our results by working to quantify escalation results and analyzing persistence of tobacco use behaviors over a longer period of time.

Overall, both exposure to and interactions with related social media content had a significant impact on the patterns of ENDS and tobacco use in adolescents. Given that merely viewing content about ENDS and tobacco increased adolescents' likelihood to initiate use of these products, it is clear that more regulation is needed surrounding tobacco marketing tactics that appeal to adolescents on social media, such as endorsements by social media influencers, the use of flavors, and animated graphics.¹¹ Likewise, active engagement with social media can lead to the initiation, escalation, and persistence of tobacco use behaviors, making it imperative to further study these online interactions and communities and develop strategies for the promotion of antitobacco content on these platforms. Due to the amount of time adolescents spend engaging with online content and other users, it follows that this platform may be a critical place in which to intervene, possibly with the use of online and mobile health interventions. Together, these approaches aim to prevent or slow the progression of ENDS and tobacco use, and increase motivation and actions toward the cessation of tobacco use in adolescents.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at <https://academic.oup.com/ntr>.

Funding

This work was supported by the National Institutes of Health (K02 DA043657, R21 AA025689, R01 DA042195, F32 AA027941).

Declaration of Interests

Dr. Borodovsky is a member of the board of directors and treasurer of MySafeRx Inc., a nonprofit scientific research organization. He receives no financial compensation from this organization.

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