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Associations between social media engagement and young adults' subsequent onset of ENDS dependence symptoms one year later

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Abstract

Background: Young adults are more vulnerable than older adults to engagement with online tobacco marketing and to the use of electronic nicotine delivery systems (ENDS) products. Our study examined the longitudinal associations between engagement with pro- and anti-tobacco information on social media (SM) and young adults' subsequent onset of symptoms of dependence on ENDS products one year later, which remain unclear.

Methods: Participants were college students in the Marketing and Promotions Across Colleges in Texas study. We analyzed data collected in spring 2018 (wave 8, baseline) and spring 2019 (wave 9), which involves 1,764 college students (Mean age = 24.48, 34.8% White) who reported having ever used any ENDS products but no ENDS dependence symptoms at baseline. Logistic regression analyses were conducted to examine the associations between pro- and anti-engagement with tobacco information at baseline and onset of ENDS dependence symptoms at one-year follow-up, controlling for baseline sociodemographic characteristics and tobacco smoking status. We also examined participant sex and depressive symptoms as moderators of the aforementioned associations.

Results: Engagement with both pro-(*Odds Ratio* = 1.73, $p < 0.05$) and anti-(*Odds Ratio* = 1.36, $p < 0.05$) tobacco information at baseline predicted the subsequent onset of symptoms of dependence on ENDS products one year later. The association between pro-engagement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Qinghua Yang: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Stephanie L. Clendennen:** Writing – review & editing, Writing – original draft, Investigation. **C. Nathan Marti:** Writing – review & editing, Funding acquisition, Formal analysis, Data curation. **Alexandra Loukas:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

and subsequent onset of ENDS dependence symptoms was stronger among females than males ($Exp(\beta) = 3.21, p < 0.05$). Depressive symptomology did not moderate any of the associations.

Conclusions: Findings suggest that engaging with tobacco information on SM, regardless of its valence, serves as a risk factor for the development of subsequent dependence symptoms among young adult ever ENDS users. Considering the uncertainty of ENDS products' health effects, regulation of SM is encouraged to reduce young adults' (re)posting thoughts or comments about the advantages of ENDS products.

Keywords

Electronic nicotine delivery system; Dependence; Social media; Marketing; Young adults

1. Introduction

Public health efforts related to the use of electronic nicotine delivery systems (ENDS) largely focus on adult cigarette smokers who may benefit from switching from combustible cigarette use to ENDS use, or adolescent non-smokers who may later initiate combustible cigarette smoking (Thorndike, 2019), whereas fewer efforts are focused on young adults. However, ENDS use prevalence is greatest among young adults compared to all other age groups (Stanton et al., 2020) and has increased significantly in recent years, from 6.2% of United States (U.S.) young adults reporting past 30-day use in 2017 to 16.1% in 2021 (Patrick et al., 2022). Increased use is concerning given that ENDS devices can deliver very high levels of nicotine; for example, the amount of nicotine in one JUUL cartridge (approximately 200 puffs) is equivalent to one package of 20 cigarettes. Moderate JUUL users typically use one cartridge per day (Prochaska et al., 2022). Thus, ENDS are considered highly addictive and significantly greater nicotine dependence in exclusive ENDS users compared to traditional tobacco smokers has been reported (Jankowski et al., 2019).

Greater than 70 % of young adult ENDS users report symptoms of ENDS dependence (Lin et al., 2022; Liu et al., 2017). Young people are susceptible to the effects of nicotine on pleasure, learning, self-control, and stress due to the plasticity of the developing brain (U.S. Department of Health and Human Services, 2016). ENDS dependence makes quitting ENDS more difficult leading to established patterns of ENDS use, use of other tobacco products and other substances, and worse health (Mishra et al., 2015; U.S. Department of Health and Human Services, 2016). As such, ENDS dependence is a particularly problematic outcome, and it is understudied compared to other ENDS-related outcomes (e.g., ENDS use), especially among young adults.

Coinciding with escalating ENDS use among young adults is the burgeoning volume of information about tobacco products (Collins et al., 2019), especially via the Internet and social media (SM), which largely consists of young adult audiences (Pew Research Center, 2022). A number of studies document positive, longitudinal associations between passive exposure to tobacco promotions via online media and ENDS use among young adults (Chen-Sankey et al., 2023; Chen-Sankey et al., 2019; Clendennen, Loukas, et al., 2020; Cruz et al., 2019; Do et al., 2022; Yang et al., 2023). However, limited research examines

active engagement with online information, such as reacting to, commenting on, and posting content about tobacco products. Although young adults may be more likely to engage with online tobacco marketing compared to adolescents (Soneji et al., 2019), very little is known about the role of active engagement with tobacco content on young adults' ENDS use outcomes, particularly their symptoms of ENDS dependence.

Active SM engagement is an important behavioral phenomenon that emerged as tobacco and ENDS companies began to widely promote their products online. SM offers and encourages user interactions, unlike more traditional marketing platforms, and this deeper level of influence warrants further study (Smith et al., 2023). Engagement with tobacco information on SM is significantly associated with subsequent ENDS use (Clendennen, Loukas, et al., 2020; Soneji et al., 2019; Yang et al., 2023). Although young adults engage with promotional messages about tobacco products (i.e., pro-tobacco messages), they also engage with anti-tobacco messages, such as those about quitting ENDS use. Research shows that their engagement with anti-tobacco messages is more prevalent than engagement with pro-tobacco messages (Clendennen, Loukas, et al., 2020; Yang et al., 2023). Limited research examines the differential roles of engagement with pro- and anti-tobacco information on SM on young adults' ENDS use and dependence. An exception is a study showing that pro-engagement elevated the risk and anti-engagement decreased the risk of subsequent ENDS use one year later (Yang et al., 2023). Results from another study indicate that engagement with pro-tobacco information on SM is associated with a higher likelihood of using ENDS, cigarettes, cigars, and hookah while anti-engagement is not associated with a higher likelihood of using ENDS products one year later (Clendennen, Loukas, et al., 2020). To our knowledge, no study has examined the influence of engagement with tobacco information on ENDS dependence. Thus, this study aims to investigate associations between engagement with tobacco information on SM and the subsequent onset of symptoms of ENDS dependence among a sample of young adult ENDS users. Based on the existing literature, we hypothesize that:

H1: Young adults' engagement with pro-tobacco information on SM will positively predict the onset of symptoms of dependence on ENDS products one year later.

H2: Young adults' engagement with anti-tobacco information on SM will negatively predict the onset of symptoms dependence on ENDS products one year later.

This study also aims to investigate if two important intrapersonal factors, biological sex and depressive symptoms, moderate the aforementioned associations. Compared to males, female young adults are heavier SM users (Pew Research Center, 2021). One study reported that females engage with Facebook, Instagram, Snapchat, and Pinterest 64%, 78%, 86%, and 166% times more than males, respectively (Sethna et al., 2021). Among a sample of young adult college students, females had greater odds of engaging with anti-tobacco messages on SM compared to males (Clendennen, Vandewater, et al., 2020). Although one study did not find significant difference between college males and females in engaging with pro-tobacco messages on SM (Clendennen, Vandewater, et al., 2020), another study documented more pro-tobacco engagement for adolescent females compared to males (Hébert et al., 2017). Moreover, females are at higher risk for ENDS use than males when they are specifically

targeted by ENDS promotions (Kong et al., 2017). Compared to males, females are also more susceptible to tobacco dependence (Mason, Mennis, et al., 2014; Mason, Zaharakis, et al., 2014). Thus, sex may moderate the associations between engagement with tobacco information and subsequent symptoms of ENDS dependence. Thus, we hypothesize that:

H3: Sex will moderate the association between engagement with a) pro- and b) anti-tobacco information and the onset of symptoms of ENDS dependence one year later, such that the associations will be stronger for females than males.

Young adults experiencing symptoms of depression, the most common mental health condition worldwide (World Health Organization, 2022), are more likely than their peers to use and be dependent on tobacco products (Boehm et al., 2016). Tobacco information, especially on SM, often portray young, social, fun, and appealing messages and images that may appeal to young adults with depressive symptoms who are experiencing negative emotions and social withdrawal (Collins et al., 2019; Tercyak et al., 2002), and believe that using tobacco products will alleviate their stress and depressive symptoms (Suka et al., 2019; Truth Initiative, 2021). Among a sample of young adult college students, participants with high depressive symptoms compared to those with low depressive symptoms had significantly greater odds of reporting both pro- and anti-tobacco engagement indicating young adults with depression are more vulnerable to persuasive messages (Clendennen, Vandewater, et al., 2020). A recent study documented the moderating effect of depressive symptom on the association between cigarette marketing exposure and cigarette use (Pasch et al., 2023). Thus, depressive symptoms may moderate the associations between engagement with tobacco information and subsequent onset of symptoms of dependence on ENDS products. We hypothesize that:

H4: Depressive symptoms will moderate the association between engagement with a) pro- and b) anti-tobacco information and the onset of symptoms of dependence on ENDS products one year later such that the associations will be stronger for young adults experiencing symptoms of depression than non-depressed young adults.

2. Methods

2.1. Sample and procedure

Participants were drawn from the Marketing and Promotions across Colleges in Texas (M-PACT) Project, a longitudinal surveillance study of college students' tobacco use behaviors. Project M-PACT recruited a cohort of 5,482 students in Fall 2014/Spring 2015 from 12 two- and 12 four-year Texas colleges in the five counties surrounding Austin, Dallas/Fort Worth, Houston, and San Antonio. Students were recruited via email to participate in a longitudinal, web-based survey study. To be eligible, participants were 1) 18–29 years old, and 2) full- or part-time degree- or certificate-seeking undergraduates attending a 4-year college or a vocational/technical program at a 2-year college. The wide age range maximized vocational student participation, given that they are older than 4-year students (Sanem et al., 2009; U.S. Department of Education, 2000). In total, 5,482 students completed the Wave 1 survey and were re-surveyed bi-annually until Fall 2017 (Wave 7). We then conducted two additional one-year follow-ups in Spring 2018 (Wave 8) and Spring 2019 (Wave 9). Project M-PACT

was approved by the Institutional Review Board of the University of Texas at Austin (#2013–06–0034).

Data for this study were drawn only from Wave 8 ($N = 4,124$), henceforth referred to as baseline, and Wave 9, henceforth referred to as follow-up ($N = 3,797$). These two waves were selected because they are the most recently collected data and captured the major surge of JUUL sales in late 2017. Response rates were 75% and 69% of the original sample size, for the two waves respectively. Given that the objective of this study is to examine the longitudinal associations between engagement with tobacco information on SM and onset of ENDS dependence symptoms, only participants who reported having ever used any ENDS products at the follow-up and who reported no symptoms of ENDS dependence at baseline ($n = 1,801$) were included. Finally, only participants who had complete data at both waves were included. Therefore, the final sample comprised 1,764 ever ENDS users who reported no ENDS dependence symptom at baseline.

2.2. Measures

2.2.1. Engagement with tobacco information on SM—Both pro- and anti-engagement with tobacco information on SM were measured at baseline by three items each that asked participants to rate how often they engaged with messaging about any tobacco or ENDS products via (a) posting links about the advantages or disadvantages of using tobacco or ENDS products, (b) posting thoughts or comments about the positive or negative aspects of tobacco or ENDS products, and (c) encouraging or discouraging other people from using a tobacco or ENDS products – on SM (Clendennen, Loukas, et al., 2020; Hébert et al., 2017). Pro-engagement included posting links or comments encouraging use whereas anti-engagement included posting links or comments discouraging use. Answers were coded on a 5-point Likert scale (1 = *never*, 5 = *very frequently*). The three pro-engagement items (Cronbach's $\alpha = 0.85$, $mean [M] = 1.09$, $standard deviation [SD] = 0.37$) and the three anti-engagement items ($\alpha = 0.80$, $M = 1.18$, $SD = 0.49$) demonstrated satisfactory reliability. Items were averaged to create two composite scores, one for pro-engagement and one for anti-engagement, and higher scores reflected higher levels of engagement.

2.2.2. ENDS dependence symptoms—Participants' symptoms of dependence on ENDS products were evaluated at follow-up using two items based on the Hooked on Nicotine Checklist (HONC) (DiFranza et al., 2002). Participants were asked “Have you ever had a strong craving for an ENDS product (i.e., e-cigarette, vape pen, or e-hookah)?”, and “Have you ever felt like you really needed an ENDS product (i.e., e-cigarette, vape pen, or e-hookah)?”, with responses coded dichotomously (0 = *no*, 1 = *yes*). Consistent with previous research (Mantey et al., 2017), the two scores were summed to create a single item ranging from 0 to 2 ($M = 0.25$, $SD = 0.62$ at Wave 8; $M = 0.31$, $SD = 0.67$ at Wave 9), with higher scores reflecting more symptoms of dependence. We further recoded ENDS dependence symptoms as a dichotomous variable (0 = *No Symptoms*, 1 = *Reported At Least One Symptom*) considering that 88.6 % of participants reported neither symptom at follow-up (see Results).

2.2.3. Moderators—The first moderator was evaluated by asking participants' sex at birth (0 = *male*, 1 = *female*). The second moderator, depressive symptoms, was assessed at baseline using the 10-item short-form Center for Epidemiologic Studies Depression 10 Scale (CES-D-10) (Andresen et al., 1994). The CES-D-10 is a valid measure of depressive symptoms for young adults (Bouvier et al., 2019) that includes ten items evaluating participants' feelings in the past week, including eight assessing negative mood (e.g., "I felt lonely/fearful") and two assessing positive mood (e.g., "I was happy/hopeful"). These response choices were given a score of 0 = *rarely or none of the time (0 days)* to 3 = *most or all of the time (5–7 days)*, with the two positive mood items reverse-scored. Scores were considered invalid if more than one item was missing. If only one item was missing, its value was imputed as the mean of the participant's other nine-item scores. Items were summed and total scores ranged from 0 to 30. A score of 10 or greater was considered as screening positive for clinically significant depressive symptomology (Andresen et al., 1994; Bouvier et al., 2019). Thus, the total score was dichotomized (0 = *CES-D-10* < 10, 1 = *CES-D-10* ≥ 10) and participants with a total score of 10 or greater were considered to have clinically significant depressive symptoms.

2.2.4. Covariates—All models were adjusted for potential confounders, including participants' sociodemographic characteristics at baseline— i.e., age and race/ethnicity (i.e., non-Hispanic white, Hispanic/Latino, Asian, African American/black, and other), which was dummy coded with other race/ethnicity as the reference group. We also controlled for the baseline sensation seeking assessed by the Brief Sensation Seeking Scale (BSSS) (Stephenson et al., 2003), current (past 30-day) cigarette smoking status (0 = *No*, 1 = *Yes*), and number of participants' close friends (1 = *none*, 5 = *all*) who used tobacco or ENDS products as potential intra- and inter-personal confounders.

2.3. Analysis

Binary logistic regression models were fit to examine longitudinal associations between participants' self-reported pro- and anti-engagement with tobacco information on SM at baseline and onset of ENDS dependence symptoms one year later. Separate models were conducted for the pro- and anti-engagement variables, given a relatively high correlation between them (Pearson correlation $r = 0.61$, $p < 0.001$). To test if sex and depressive symptoms were moderators of the aforementioned associations, four two-way interactions, between pro-engagement and either sex or depressive symptoms and between anti-engagement and either sex or depressive symptoms, were included in regression models. Pro- and anti-engagement variables were centered before being multiplied with sex and depressive symptoms, and two-way interactions were tested in separate models (Aiken & West, 1991). All models were adjusted for intra- and inter-personal covariates assessed at baseline. Missing data resulted in listwise deletion.

The final sample size for logistic regressions was 1,764. Attrition analyses using independent samples t-tests for continuous variables (e. g., age) and Chi-square tests for categorical variables (e.g., sex, race/ethnicity) showed no significant difference between the participants in the final sample ($n = 1,764$) and those excluded due to missing values ($n = 37$) on the sociodemographic and baseline intra- and interpersonal variables.

3. Results

3.1. Sample characteristics

Descriptive statistics of all study variables are reported in Table 1. Participants were 21 to 33 years old ($M = 24.48$, $SD = 2.45$) at baseline and 65.1% were female. The majority of participants self-reported as non-Hispanic White (34.8%) or Hispanic (33.8%). One third of the participants reported clinically significant depressive symptoms at baseline and 11.4% reported at least one symptom of ENDS dependence at one-year follow-up.

3.2. Prevalence of engagement with tobacco information on SM

Overall, 19.6% of participants reported ever engaging with any tobacco information on SM at baseline. The prevalence of engagement with any anti-tobacco messages (17.7%) was higher than with any pro-tobacco messages (7.0%). When measured on the 5-point Likert scale (1 = *never*, 5 = *very frequently*), the frequency of both pro- ($M = 1.06$, $SD = 0.28$) and anti-tobacco engagement ($M = 1.16$, $SD = 0.43$) was low (see Table 1 for more details).

3.3. Associations between SM engagement and ENDS dependence

After controlling for baseline covariates, results from the logistic regression analysis showed that pro-engagement was significantly associated with the onset of ENDS dependence symptoms one year later (*Odds Ratio* = 1.73, $p < 0.05$) consistent with H1. Anti-engagement also was significantly associated with ENDS dependence on year later (*Odds Ratio* = 1.36, $p < 0.05$), but contrary to H2, this association was positive and not negative (see Table 2).

3.4. Moderating effects of sex and depressive symptoms

After adjusting for baseline covariates, only participant sex moderated the association between pro-engagement and subsequent onset of ENDS dependence symptoms one year later ($Exp(\beta) = 3.21$, $p < 0.05$) while all other interactions were non-significant (see Table 3). Thus, H3 was partially supported but H4 was not. The roles of pro- and anti-engagement with tobacco information on SM on subsequent ENDS dependence symptoms one year later were consistent across participants with clinically significant depressive symptoms and those without.

4. Discussion

Although young adults are the most vulnerable population to engage with online tobacco marketing (Soneji et al., 2019), no study has examined whether engagement with tobacco and ENDS information on SM is associated with subsequent symptoms of ENDS dependence. To fill this gap in the literature, we conducted longitudinal analyses investigating the onset of two symptoms of dependence (craving and need) among a sample of young adult ever ENDS users. The most noteworthy finding is that young adults' engagement with both pro- and anti-tobacco and ENDS information was significantly associated with a higher risk of developing ENDS dependence symptoms one year later, and the effect of pro-engagement was stronger among female young adults. It is also noteworthy that the effects of pro- and anti-engagement on the onset of ENDS dependence symptoms

were present even after controlling for sociodemographic and intra- and inter-personal variables that may affect young adults' ENDS behaviors.

Consistent with previous studies (Clendennen, Loukas, et al., 2020; Yang et al., 2023) and our first hypothesis, young adults' posting links, thoughts, or comments about the advantages of tobacco or ENDS products, and encouraging other people to use tobacco or ENDS products on SM were associated with a higher risk of developing ENDS dependence symptoms, which could be attributed to young adults' confirmation bias. Confirmation bias refers to individuals' tendencies to prefer information that conforms to their initial beliefs, attitudes, and behaviors (Klayman & Ha, 1987; Yin et al., 2016). Although the intensity of confirmation bias varies in terms of confidence and trust in prior beliefs and existing attitudes (Jonas et al., 2001; Yin et al., 2016), we have reason to infer that young adults who engage with pro-tobacco information on SM tend to hold positive attitudes towards tobacco or ENDS products, and are more likely to use these products compared to those who do not. Pro-tobacco posts, comments, or thoughts, which may elicit agreement or support from other SM users, function as a validation of young adults' positive ENDS attitudes and behaviors, further entrenching their vaping behaviors. Considering that ENDS products contain nicotine that is highly addictive and may be even more addictive than traditional cigarettes (Jankowski et al., 2019), it is reasonable that young adults who continue to vape will develop symptoms of dependence, including a craving and need for ENDS products.

Engagement with anti-tobacco information also was associated with the onset of subsequent ENDS dependence symptoms. Contrary to H2, however, engagement with tobacco or ENDS information on SM that discouraged use was associated with increased, rather than decreased, risk for developing symptoms of ENDS dependence one year later. This finding is also at odds with previous studies that documented null or negative associations between engagement with anti-tobacco information on SM and subsequent ENDS use (Clendennen, Loukas, et al., 2020; Yang et al., 2023). However, it should be noted that these prior studies were conducted with both ENDS users and non-users whereas the present study was conducted only with ever past-30-day/current ENDS users. It is possible that current ENDS users may engage with anti-tobacco or ENDS messages on SM if they are attempting to cut down or quit using ENDS or, alternatively, if they are using ENDS to quit smoking cigarettes (Harlow et al., 2022; Walton et al., 2020). These users may post about the negative effects of tobacco or ENDS products on SM, but may not successfully quit. As such, continued ENDS use may lead to triggering symptoms of dependence on ENDS products one year later. Given the lack of studies examining the role of SM engagement in symptoms of ENDS dependence, additional longitudinal research is needed to replicate the current findings, and to determine how both pro- and anti-engagement influence the development of nicotine dependence among young adults.

Finally, examination of sex and depressive symptoms as moderators of the associations between engagement and subsequent onset of ENDS dependence symptoms indicated that only sex moderated the pro-engagement and ENDS dependence symptoms association. The association was stronger among females than males, which may be attributed to females' higher level of pro-tobacco engagement (Hébert et al., 2017) and susceptibility to tobacco dependence (Mason, Mennis, et al., 2014; Mason, Zaharakis, et al., 2014). The other non-

significant moderating effects, albeit contrary to our third and fourth hypotheses, indicated that the associations between any engagement with tobacco information on SM and ENDS dependence are generally consistent among males and females, and among young adults with and without depressive symptoms. Considering the paucity of research in this area, future investigations are imperative to understand whether such associations are consistent or vary across diverse sociodemographic populations.

Several limitations should be noted. First, we measured young adults' engagement with both tobacco and ENDS information on SM, without differentiating these products. Future research should measure SM engagement separately for tobacco and ENDS products to pinpoint the nuanced associations between engaging with information about specific products and subsequent symptoms of ENDS dependence. Second, we measured ENDS dependence symptoms using only two items of the 10-item HONC (DiFranza et al., 2002). Although the two items (crave and need ENDS) are among the most prevalent among young adult ENDS users (Cristol et al., 2024), this may have resulted in an under-estimation of nicotine dependence. Additional research using all 10 HONC items should be conducted to replicate study findings. Third, although the study sample was demographically diverse, participants were initially recruited from Texas colleges and therefore are not nationally representative, which hinders the generalizability of our findings. Fourth, although self-report is the most prevalent method used to assess young people's engagement with tobacco information on SM and their use of tobacco products (Clendennen, Loukas, et al., 2020; Hébert et al., 2017; Soneji et al., 2019; Yang et al., 2023), such measures are subject to recall and social desirability bias. Future investigations should replicate study findings with a nationally representative sample, and apply mixed methods to assess SM engagement with tobacco information more comprehensively, including but not limited to ecological momentary assessment (Hébert et al., 2023) and automated textual analyses (Liu et al., 2022).

To the best of our knowledge, our study is the first to show that engaging with tobacco information on SM is associated with the subsequent onset of ENDS dependence symptoms one year later among young adults. Considering that young adults are the heaviest SM users (Pew Research Center, 2021) and are the most vulnerable to the use of ENDS products, which are even more addictive than traditional cigarettes (CDC, 2023; Jankowski et al., 2019; Patrick et al., 2022), our study provides important empirical evidence for this pressing public health issue. Findings are particularly concerning given that tobacco-related information on SM is still not well-regulated. There are only a few SM platforms that self-regulate tobacco-related posts. For instance, TikTok's user guidelines indicate that posting content that either promotes tobacco products or depicts young people's possessing or consuming tobacco products is prohibited (TikTok, 2023), although there are still posts on TikTok that clearly violate this content policy (Jancey et al., 2023). However, the enforcement of such policies to regulate promotional posts of tobacco products on other popular SM, such as Facebook, remains lacking (Jackler et al., 2019), leading to scholars' call for more strict and thorough restrictions of posting tobacco and ENDS marketing information on SM (Kong et al., 2022). Our findings provide further support for regulating tobacco-related information on SM. More specifically, our findings indicate the regulations should not only encompass posting tobacco-related information, but also

commenting on others' posts. For example, regulations could require SM companies to provide a health warning message or 'fact-check' when misinformation about ENDS is identified that accompanies young adults' posts or comments related to tobacco or ENDS products (Al-Rawi et al., 2023). Health warning messages and fact-checks may be especially important for females, who are more vulnerable to the effects of engaging with pro-tobacco information on SM and developing dependence on ENDS products. Such warning messages may serve as a barrier that deters young adults from engaging with tobacco-related information on SM and therefore reduces their risk of using ENDS and developing ENDS dependence symptoms. Given that young adulthood is the developmental period when tobacco use is solidified (Ling & Glantz, 2002), actions that aim to prevent and decrease use during this vulnerable period are sorely needed.

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Data availability

Data will be made available on request.

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Table 1

Descriptive statistics of variables included in the lagged regression models (N = 1,764).

Variables	Baseline (Spring 2018)	Follow-Up (Spring 2019)
Age (years; M)	24.48 (SD = 2.45)	
Female (%)	65.1	
Race/ethnicity (%)		
Non-Hispanic White	34.8	
Hispanic	33.8	
Non-Hispanic African American	7.8	
Asian	15.5	
Other	8.1	
Depressive Symptoms (CES-D-10; %)	31.7	
Sensation Seeking (Min = 1, Max = 5; M)	3.30 (SD = 0.93)	
Current smoking status (%)	20.0	
Close friend use (Min = 0, Max = 5; M)	2.63 (SD = 1.65)	
Pro-engagement with tobacco/ENDS information on social media (Min = 1, Max = 5; M)	1.06 (SD = 0.28)	
Anti-engagement with tobacco/ENDS information on social media (Min = 1, Max = 5; M)	1.16 (SD = 0.43)	
ENDS dependence (%)		11.4

Note. M = Mean. SD = Standard deviation. Current smoking status = Past-30-days cigarette smoking. Close friend use = Number of participants' close friends who used tobacco or ENDS products. The percentage was calculated based on the final sample for multiple regression analyses and without including the cases with missing data. Close friends who use tobacco products were measured based on the number of tobacco (referred to as cigarettes, cigars, hookah, and smokeless tobacco) and ENDS products that had ever been used by participants' close friends.

Table 2

Multiple regressions of baseline engagement with tobacco and nicotine information on social media predicting ENDS dependence symptoms one year later (N = 1,764).

Baseline Variables	DV: ENDS Dependence (Follow-Up)			
	OR	p	OR	p
Age	0.95	0.824	0.95	0.866
Female	0.94	0.094	0.93	0.073
Race/ethnicity				
Non-Hispanic White	0.83	0.759	0.82	0.716
Hispanic	0.55	0.011	0.55	0.013
Non-Hispanic AA	0.90	0.111	0.92	0.143
Asian	0.77	0.083	0.79	0.124
Depressive symptoms	1.46	0.020	1.48	0.024
Sensation seeking	1.17	0.076	1.18	0.068
Current smoking status	3.50	0<.001	3.57	0<.001
Close friend use	1.10	0.067	1.10	0.061
Pro-engagement with tobacco/ENDS information on SM	1.73	0.010		
Anti-engagement with tobacco/ENDS information on SM			1.36	0.047

Note. OR = Odds ratio. AA = African American. Close friend use = Number of participants' close friends who used tobacco or ENDS products. SM = social media. Participants' race/ethnicity was dummy coded with "other race/ethnicity" as the reference group.

Lagged multiple regressions examining the moderating effects of sex and depressive symptoms on the associations between engagement with tobacco and nicotine information on social media and ENDS dependence symptoms one year later (N = 1,764).

Table 3

Baseline Variables	DV: ENDS Dependence (Follow-Up)					
	Exp (β)	p	Exp(β)	p	Exp(β)	p
Age	0.95	0.142	0.95	0.137	0.95	0.124
Female	1.05	0.796	0.99	0.942	0.93	0.665
Race/ethnicity						
Non-Hispanic White	0.85	0.566	0.83	0.491	0.83	0.504
Hispanic	0.56	0.041	0.55	0.037	0.54	0.034
Non-Hispanic AA	0.91	0.802	0.93	0.844	0.91	0.794
Asian	0.78	0.435	0.79	0.462	0.76	0.388
Depressive symptoms	1.50	0.012	1.49	0.013	1.41	0.037
Sensation seeking	1.16	0.103	1.18	0.063	1.17	0.078
Current smoking status	3.53	0<.001	3.59	0<.001	3.56	0<.001
Close friend use	1.10	0.056	1.10	0.058	1.10	0.063
Pro-engagement	0.71	0.508			2.22	0.004
Anti-engagement			0.82	0.594		1.49
Pro-engagement \times Female	3.21	0.044				
Anti-engagement \times Female			1.89	0.121		
Pro-engagement \times Depression					0.60	0.200
Anti-engagement \times Depression						0.79
						0.459

Note. AA = African American. Close friend use = Number of participants' close friends who used tobacco or ENDS products. Pro-/Anti-engagement = pro-/anti-engagement with tobacco/ ENDS information on SM. Participants' race/ethnicity was dummy coded with "other race/ethnicity" as the reference group. Pro- and antiengagement variables were centered before being multiplied with the two dichotomous moderators (i.e., female, depressive symptoms) and being included in the regression models.