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Social media's influence on e-cigarette use onset and escalation among young adults: What beliefs mediate the effects?

Pallav Pokhrel[a,*], **Claire Ing**[b], **Crissy T. Kawamoto**[a], **Linnea Laestadius**[c], **Wayne Buente**[d], **Thaddeus A. Herzog**[a]

[a]Cancer Prevention in the Pacific, University of Hawaii Cancer Center, University of Hawaii at Manoa, Honolulu, HI, United States

[b]Department of Native Hawaiian Health, University of Hawaii at Manoa, Honolulu, HI, United States

[c]Joseph J. Zilber School of Public Health, University of Wisconsin-Milwaukee, Milwaukee WI53205, United States

[d]School of Communications, University of Hawaii at Manoa, Honolulu, HI, United States

Abstract

As an extension of a previous cross-sectional study, this study employed prospective data to test positive outcome expectancy beliefs as mediators of social media's influence on e-cigarette use progression among young adults. Self-report data were collected from 2327 young adult college students (Mean age = 21.2; SD = 2.1; 54% women) between 2017 and 2019, every 6-month, at 3 time-points. Structural equation modeling was used to test the mediational models. Among baseline never e-cigarette users, higher affect regulation expectancies—e.g., beliefs that e-cigarette use results in feeling good, reduced boredom and stress—mediated the effects of higher baseline social media e-cigarette exposure on e-cigarette use onset one year later. Among baseline lifetime e-cigarette users, higher positive sensory, positive "smoking" experience, and affect regulation expectancy beliefs mediated the effects of higher social media e-cigarette exposure at baseline on increased current e-cigarette use one year later. E-cigarette content on social media may persuade young adults to try e-cigarettes by imparting the sense that e-cigarettes make one feel good and help reduce stress. E-cigarette content on social media that promote e-cigarette flavors and e-cigarettes as cleaner and a socially more acceptable alternative to cigarettes may work to escalate

*Corresponding author at: University of Hawaii Cancer Center, 701 Ilalo St., Honolulu, HI 96813, United States. ppokhrel@cc.hawaii.edu (P. Pokhrel).

5.Contributors

PP designed the study, performed the data analysis, and supervised the manuscript writing process. CI assisted with conceptualization and manuscript preparation. CTK administered the project, managed the data collection, assisted conceptualization and reviewed the manuscript. WB, LL, and TAH assisted with data interpretation and helped review and revise the manuscript.

CRediT authorship contribution statement

Pallav Pokhrel: Conceptualization, Methodology, Formal analysis, Writing - original draft, Funding acquisition, Supervision. **Claire Ing:** Writing - original draft. **Crissy T. Kawamoto:** Project administration, Methodology, Writing - review & editing. **Linnea Laestadius:** Conceptualization, Writing - review & editing. **Wayne Buente:** Conceptualization, Writing - review & editing. **Thaddeus A. Herzog:** Conceptualization, Writing - review & editing.

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.

e-cigarette use among experimenters. Efforts to prevent e-cigarette use onset and escalation may need to target the outcome expectancy beliefs influenced by social media.

Keywords

Young adults; E-cigarettes; Social media; Outcome expectancies

1. Introduction

Among U.S. adults, current electronic or e-cigarette use prevalence is highest among young adults, between the ages of 18 and 25 (Mirbolouk et al., 2018). Young adults are also the main target of tobacco product marketing (USDHHS, 2016). Although considered less harmful than combustible cigarettes, a number of recent studies have linked e-cigarette use with adverse health consequences, including poor respiratory health (Bozier et al., 2020). There are also concerns that youths and young adults are increasingly being introduced to nicotine via e-cigarettes (McMillen, Klein, Wilson, Winickoff, & Tanski, 2019).

Currently, e-cigarette marketing faces limited regulations in the US (Walley, Wilson, Winickoff, & Groner, 2019). Marketing of e-cigarettes on social media is of particular concern. Approximately 90% of U.S. young adults use social media platforms such as Facebook and Instagram daily (Smith & Anderson, 2018). Tobacco product marketing on social media appears to combine traditional product advertisement—marketing in which an e-cigarette manufacturer or retailer is clearly identifiable as a sponsor—with product promotion through “influencers” and other entities who may not be easily identifiable as agents of the e-cigarette or tobacco industry (Hickman & Delahunty, 2019; Kostygina, Tran, Shi, Kim, & Emery, 2016; Laestadius, Wahl, Pokhrel, & Cho, 2019; Phua, Jin, & Hahm, 2018). In the context of social media, “influencers” refer to individuals who have a large following on social media and can be cultivated as agents of marketing (Lou & Yuan, 2019). The followers look up to the influencer for guidance on lifestyle choices. Employing influencers as marketers is an effective strategy because unlike overt representatives of the industry, influencers are seen as lay members of the society, authentic and trustworthy (Lou & Yuan, 2019).

Several studies (Kwon & Park, 2020; McCausland, Maycock, Leaver, & Jancey, 2019) have documented the overwhelming presence of pro-e-cigarette content on social media, across platforms such as Facebook, Instagram, Twitter, and YouTube. As expected, creators of this content have ranged from e-cigarette manufacturers and retailers to influencers and lay e-cigarette enthusiasts (McCausland et al., 2019). Self-reported exposure to e-cigarette content on social media among young people in the U.S. appears to be high as well. For example, a multi-country survey involving samples from the U.S., Canada, and England showed that approximately 40% of adolescents report exposure to e-cigarette marketing on social media in the past 30 days (Cho, Thrasher, Reid, Hitchman, & Hammond, 2019).

There have been a number of cross-sectional studies that have linked higher exposure to e-cigarette content on social media to higher e-cigarette use behavior or intentions (Phua et al., 2018; Pokhrel, Fagan, et al., 2018; Sawdey, Hancock, Messner, & Prom-Wormley, 2017).

Fewer have examined the association longitudinally (Camenga et al., 2018). In a sample of U.S. middle and high school students, Camenga et al. (2018) found that higher exposure to e-cigarette content on Facebook was significantly associated with increased odds of e-cigarette use onset one year later. At least one experimental study (Vogel et al., 2020) has shown that among youths, exposure to e-cigarette content on social media is associated with increased e-cigarette use susceptibility and higher positive attitudes towards e-cigarettes. However, at present, very few studies have attempted to examine the mechanisms of the influence of social media on young people's e-cigarette use behavior.

To our knowledge, thus far, only two studies (Cho, Li, Shen, & Cannon, 2019; Pokhrel, Fagan, et al., 2018), both cross-sectional, have attempted to examine the mediators of the effects of social media on e-cigarette use behavior. Cho et al. (2019) investigated different motivations for social media use (e.g., self-expression, social learning, social comparison) as moderators and mediators. They found that under conditions of higher pro-e-cigarette social norms, social learning motives were strongly associated with higher e-cigarette use. Pokhrel, Fagan, et al. (2018) examined outcome expectancies as mediators. Outcome expectancies refer to beliefs that certain outcomes will occur if one were to engage in a behavior, and feature centrally in several etiologic models of substance use (Brandon, Juliano, & Copeland, 1999). Some of the positive e-cigarette use outcome expectancies include beliefs that e-cigarette use helps one become popular or better liked by opposite sex (i.e., positive social expectancies); that e-cigarettes help one reduce stress, control anger, reduce boredom, and feel good (i.e., affect regulation expectancies); that e-cigarettes are pleasant to the senses (i.e., positive sensory expectancies); that e-cigarettes provide positive "smoking" experience (i.e., positive "smoking" expectancies); and that e-cigarette use helps control weight (i.e., weight control outcome expectancies) (Harrell et al., 2015; Pokhrel, Fagan, et al., 2018; Pokhrel, Herzog, Muranaka, & Fagan, 2015; Pokhrel, Lam, Pagano, Kawamoto, & Herzog, 2018; Pokhrel, Little, Fagan, Muranaka, & Herzog, 2014). The previous study tested whether the influence of social media and young adults' e-cigarette use behavior was mediated by the above-mentioned outcome expectancies, except weight control outcome expectancies, which was not assessed in the study. The study found that positive "smoking" and sensory experience expectancies mediated the effects of higher social media exposure and higher recent e-cigarette use. Positive "smoking" experience represented the beliefs that e-cigarettes provided a better smoking alternative that was more socially approved, cleaner, and healthier. A major limitation of the study was that it was cross-sectional. As a result, the mediational model made assumptions regarding directions of effects on conceptual grounds rather than the order of precedence based on actual time.

The current study was designed to address the limitations of the past study by prospectively testing the mediational model. Employing data collected at three time-points at six month intervals, we tested the hypothesis that the effect of higher baseline exposure to e-cigarette content on social media on e-cigarette use onset and escalation at one year follow-up would be mediated by each of the five positive outcome expectancy variables—namely, social enhancement, affect regulation, weight control, positive "smoking" experience, and positive sensory experience—at six-month follow-up. We tested the effects of social media e-cigarette exposure on e-cigarette use onset among young adults who had never used an e-cigarette at baseline, adjusting for baseline cigarette smoking status and demographic

covariates. The effects of baseline social media exposure on increased current e-cigarette use at one-year follow up were tested among lifetime e-cigarette users at baseline, adjusting for baseline current e-cigarette use, cigarette smoking, and demographic variables.

2. Methods

2.1. Procedures

2.1.1. Recruitment—Students from two four-year and four two-year (community) colleges under the same university system in Hawaii were approached with the opportunity to participate in the study. To be eligible to participate in the study, participants had to be 18–25 years old. We obtained e-mail addresses for all 18–25 year olds enrolled across the college campuses. A link to the screener survey was e-mailed to a list of randomly selected e-mail addresses, inviting potential participants to participate in the study, which was described in generic terms, as a study on marketing and young adult health behavior. The screener survey included questions on age, sex, tobacco, alcohol, and dietary behaviors. In addition, the survey collected potential participants' basic contact information such as phone number and university e-mail address. The response rate was approximately 60%, which is similar to or higher than reported response rates for e-mail-based recruitment among college students (Loukas, Marti, & Perry, 2019; Sutfin et al., 2015). However, in the current study, respondents to the e-mail invitation were predominantly women never cigarette smokers. Hence, to increase the proportion of men in the sample and for adequate representation of cigarette smokers and experimenters in the sample (relative to nationally representative samples of 18–25 year olds), we conducted classroom-based recruitment as well. For classroom-based recruitment, on average 40 classes from each participating campus were randomly selected and instructors of those classes were approached with requests for classroom visit. On average, 25% of the instructors who were approached (i.e., approximately 10 classes per college) either did not respond to the research team's request or actively denied participation. Hence, the research staff visited, on average, 30 classrooms per college and presented the study and the opportunity to participate in the study to the students. Interested students completed the paper-and-pencil version of the screener survey. The average response rate among students across classrooms was 80%.

Of the students who completed the screener, either online or in the classroom, 3,664 students were eligible to participate in the study. Of these, informed consent was obtained from 2,884 (i.e., 79%) potential participants; the remainder could not be reached for consent procedure. Participants who provided consent were sent unique links to the baseline survey via e-mail.

2.1.2. Data collection—A total of 2622 participants completed the baseline survey. The baseline participants were contacted 6 and 12 months later to complete the six-month and one-year follow-up surveys. Of the 2622 participants, 2401 participants completed the six-month, and 2327 completed the one-year, follow-up surveys. Thus the six-month and one-year follow-rates were 91.5% and 89%, respectively. All surveys were programmed on Inquisit 4 (2015). A participant was provided $40 Amazon gift-card for completing each survey.

2.2. Measures

2.2.1. Demographics—Participants self-reported age, ethnicity, sex, and parental income. To determine ethnicity, participants were asked "What is your ethnic background?" and were provided with a list of ethnicities common in Hawaii and the U.S. The question was asked in two different ways. The first question asked participants to refer to the list and "check all that apply." The second question asked participants to choose the ethnic background that they identify with most. The response to the second question was utilized to assign mixed-ethnicity individuals to a particular racial/ethnic category.

2.2.2. Social media use and exposure to e-cigarette content—As in the previous study, (Pokhrel, Fagan, et al., 2018) participants were asked to rate, on a 4-point scale (i.e., "Never", "Rarely", "Sometimes", "Often"), the frequency of their use of the following social media platforms that are popular among U.S. young adults (Smith & Anderson, 2018): Facebook, Instagram, Twitter, YouTube, and Snapchat. Next, participants were asked how often they had seen e-cigarette related posts on each of the 5 social media platforms. An option was provided to select "I don't use this social networking medium." Other options included "Never", "Rarely", "Sometimes", and "Often." In a similar way, participants were also asked how often they had seen e-cigarette advertisements on each of the 5 social media platforms. Two separate indices were created for social media e-cigarette exposure through posts and ads, by summing up responses across the 5 social media.

2.2.3. E-cigarette use outcome expectancies—Participants were provided a list of 55 e-cigarette use outcomes and asked to rate on a 10-point scale how likely or unlikely it would be for them to experience each outcome if they were to use an e-cigarette. This measure of e-cigarette outcome expectancies was developed over a series of studies (Pokhrel et al., 2014, 2015; Pokhrel, Lam, et al., 2018). The 55 items assessed both positive and negative outcome expectancies. This study concerns only the positive outcome expectancies: *social enhancement* (11 items; $\alpha = 0.91$; e.g., "Look cool", "Increase your chances of being liked by members of the opposite sex"); *positive "smoking" experience* (7 items; $\alpha = 0.79$; e.g., "Smoke with family members' approval", "Enjoy 'smoking' without bothering others"); *affect regulation* (7 items; $\alpha = 0.91$; e.g., "Feel calm", "Feel good"); *positive sensory experience* (3 items; $\alpha = 0.89$; e.g., "Smell good", "Have a good taste"); and *weight control* (3 items; $\alpha = 0.79$; e.g., "reduce appetite," "prevent weight gain").

2.2.4. Social network characteristics—Characteristics of participants' in-person or "offline" social networks (i.e., as opposed to virtual or online social network) were assessed using the egocentric method (Burt, 1984). Participants were asked to nominate up to 5 individuals who they spend the most time with or talk to most often. Next, they were asked a number of questions on each of the individuals that they nominated. One of the questions was on e-cigarette use: "Does this person use e-cigarettes?" (Response options: "No, not at all," "Yes, sometimes," and "Yes, regularly"). For analysis, an index for presence of e-cigarette users in social networks was created by summing up the responses across the 5 nominees.

2.2.5. Cigarette smoking—Lifetime cigarette smoking was assessed with a single item: "How many cigarettes have you smoked in your entire life?" ("None, I have never smoked a cigarette," "1–100," "More than 100 cigarettes"). For analysis, the variable was dichotomized into "ever use" (1) and "never use" (0). Current cigarette smoking was assessed in terms of past-30-day smoking: "During the last 30 days (1 month), on how many days did you smoke a cigarette?" (8-point scale: "0 days," "1–2 days," "3–5 days,"…, "All days"). Participants were also asked: "How do you describe your current cigarette smoking behavior?" ("I don't smoke," "I smoke sometimes," "I smoke regularly"). Those who had smoked a cigarette in their lifetime but were current non-smokers were classified as "experimenters."

2.2.6. E-cigarette use—Lifetime e-cigarette use was measured with a single item: "Have you ever used an electronic cigarette (e-cigarette) or a similar vaping device, even if it was just a puff?" (Yes, No). Current e-cigarette use was assessed in terms of past-30-day e-cigarette use: "During the last 30 days (1 month), on how many days did you use an electronic cigarette (e-cigarette) or a similar vaping device?" (8-point scale: "0 days," "1–2 days," "3–5 days,"…, "All days"). In addition, we asked participants: "How often, if at all, do you currently use an e-cigarette?"(Response options: "Daily", "Less than daily, but at least once a week", "Less than weekly, but at least once a month", "Less than weekly, but at least once a month", "Less than monthly", "Not at all") (Pearson et al., 2018).

2.2.7. Data analysis—Descriptive statistics were computed using SAS statistical software (SAS software, 2019. Part of the descriptive analysis involved comparing the baseline sample that was lost to follow-up with the sample that was retained, on baseline measures using chi-square and *t*-tests. The purpose was to determine changes in the prospective sample, and potential bias, due to sample attrition. Hypotheses were tested by conducting structural equation modeling (SEM) on M*plus* (Muthen & Muthen, 2012). The SEM involved testing two models. The first model tested the effects of baseline social media e-cigarette exposure on e-cigarette use initiation a year later, mediated by the following five positive outcome expectancy variables: social enhancement, affect regulation, positive sensory experience, positive "smoking" experience, and weight control expectancies. This model was tested among participants who had never used an e-cigarette at baseline. To establish the model, social media e-cigarette exposure was specified as an exogenous variable, along with covariates, which included age, sex, ethnicity, family/household income, college type (two-year vs. four-year), e-cigarette use prevalence in social networks (i.e., "offline" social networks) at baseline (T1), and baseline cigarette smoking. Social media e-cigarette exposure was measured as a latent variable as indicated by exposure to e-cigarette-related posts and advertisements. Ethnicity was dummy-coded as Asian, Filipino, Native Hawaiian/Other Pacific Islander, and Other (e.g., Black, Hispanic, and other groups), with non-Hispanic White as the reference group. Cigarette smoking experience was dummy-coded as Experimenter and Current Smoker, with never smokers as the reference group. Next, the five outcome expectancy variables at six month follow-up were specified as mediators. The mediators were specified to co-vary with each other. Then, lifetime e-cigarette use at one-year follow-up was specified as the criterion variable. Paths were specified from all exogenous variables to all mediators and to the criterion variable; and

from all mediator variables to the criterion variable. The model's fit to the data was estimated using the Weighted Least Square Mean and Variance adjusted (WLSMV) estimator.

The second model examined the effects of exposure to baseline social media e-cigarette content on past-30-day e-cigarette use at one-year follow-up via outcome expectancies at six-month follow-up. Thus, the second model too employed data from three time-points. However, this model was estimated among baseline lifetime e-cigarette users only. The same exogenous variables as the previous model were specified, except that this model also included baseline current (past-30-day) e-cigarette use as a covariate. Similar to the first model, six-month positive outcome expectancy variables were specified as mediators, and past-30-day e-cigarette use was specified as the criterion variable. The mediators were specified to co-vary. Paths were specified from all exogenous variables to all mediators and the criterion variable; and, from all mediator variables to the criterion variable. Treating the criterion variable as an ordinal variable, the model was estimated using the WLSMV estimator. For both models, the goodness-of-fit of the models to the data were determined based on absolute (e.g., Chi-square) and relative [Comparative Fit Index (CFI)] indices. Because of some selective participant attrition (see below, Section 3.1), missing data were handled as not missing at random (MNAR) in M*plus*, using pattern-mixture model. Both models included binary dummy dropout variables for cigarette smoking experimentation, current cigarette smoking, and two-year college status as covariates.

3. Results

3.1. Participants

Table 1 shows the characteristics of the sample at baseline and at six-month and one-year follow-ups. Attrition analyses showed that those who were lost to follow-up, compared on baseline variables with those who were retained in the study, tended to represent significantly more cigarette experimenters and current smokers ($p < 0.001$) and community college students ($p < 0.001$). These are reflected in Table 1 in the cases of cigarette smoking and two-year college status. Otherwise, those lost to follow-up did not differ statistically significantly from those retained on key study variables. However, as seen in Table 1, participants tended to report greater presence of e-cigarette users in their social networks over time. In addition, participants tended to report lower levels of positive sensory and positive "smoking" experience expectancies over time.

3.2. Exposure to e-cigarette content on social media

Table 2 shows participants' social media use frequencies and self-reported exposure to e-cigarette-related posts and advertising on social media by participants' current e-cigarette use status. In the overall sample, participants reported using YouTube (68%), Instagram (60%), Snapchat (57%), and Facebook (49%) most often. Also, in the overall sample, participants reported seeing e-cigarette advertising and e-cigarette-related posts most (i.e., "sometimes" or "often") on Facebook (15%) and Instagram (24%), respectively. Current e-cigarette users tended to be more frequent users of Instagram and Snapchat. Across almost

all social media platforms, current users were likely to see e-cigarette-related posts and ads more frequently than non-users.

3.3. Correlations among positive outcome expectancy variables

Table 3 shows the correlations among positive outcome expectancy variables for lifetime e-cigarette users and non-users. For both groups, the correlations were found to be positive and highly significant. All correlations were greater than 0.40.

3.4. Social media e-cigarette exposure, outcome expectancies, and e-cigarette use initiation

Fig. 1 shows the results of the SEM analysis examining the relations among social media e-cigarette exposure at baseline, positive outcome expectancies at six-month follow-up, and current e-cigarette use at one-year follow-up, among those who had never used an e-cigarette at baseline. To simplify presentation, only the statistically significant paths are shown in the figure. The model showed an excellent fit to the data [χ^2 = 15.86, DF = 16, p = .46; CFI = 0.99; Root Mean Square Error of Approximation (RMSEA) = 0.001 (90% CI = 0.00–0.03] . We found that greater exposure to social media e-cigarette content at baseline was positively and significantly associated with increased positive e-cigarette use outcome expectancies at six-month follow up, across all expectancy variables. Of the expectancy variables at six-month follow up, only higher affect regulation outcome expectancies were associated with e-cigarette use onset at one year follow up. The indirect effect of baseline social media exposure on e-cigarette onset one year later, via affect regulation outcome expectancies at six-month follow up, was statistically significant [Indirect effect estimate = 0.023, standard error (SE) = 0.01, p = .02]. We also found a direct path from social media e-cigarette exposure on e-cigarette use onset. Additionally, there were direct paths from social network e-cigarette use and baseline cigarette smoking status (both experimentation and current use) on e-cigarette use onset one year later.

3.5. Social media e-cigarette exposure, outcome expectancies, and e-cigarette use escalation

Fig. 2 shows the results of the SEM analysis examining the relations among social media e-cigarette exposure at baseline, positive e-cigarette use outcome expectancies at six-month follow up, and current e-cigarette use at one-year follow up, adjusting for the effects of current e-cigarette use at baseline, among those who had used e-cigarette at least once in their lifetime at baseline. The model fit well to the data [χ^2 = 22.38, DF = 17, p < 0.17; CFI = 0.99; TLI = 0.98 RMSEA = 0.014 (90% CI = 0.00–0.028)]. We found that higher exposure to e-cigarette content on social media at baseline was significantly associated with higher positive outcome expectancies for all expectancy variables. Only affect regulation outcome expectancies, positive “smoking” experience outcome expectancies, and positive sensory experience expectancies were significantly and positively associated with current e-cigarette use at one-year follow up. No association was found between social enhancement outcome expectancies and future current e-cigarette. Accounting for the effects of all positive outcome expectancy variables, we found weight control outcome expectancies to have an inverse association with current e-cigarette use at one-year follow-up. The indirect effect of baseline social media exposure on current e-cigarette use at one-year follow-up was

statistically significant [indirect effect estimate = 0.03, SE = 0.005, $p < .001$]. There were direct paths from baseline cigarette use status (experimentation and current use) and current e-cigarette use to current e-cigarette use at one-year follow up.

4. Discussion

A previous, cross-sectional study (Pokhrel, Fagan, et al., 2018) suggested that outcome expectancies related to positive "smoking" experience and positive sensory experience may mediate the effects of social media e-cigarette use on higher e-cigarette use among young adults. The study was based on a small, convenience sample of young adults and being cross-sectional, precluded the possibility of testing hypotheses related to onset and increased use. The current study, built on the previous study, addresses several of the latter's limitations.

Consistent with the national data on young adults' social media use patterns (Smith & Anderson, 2018), our data suggested that participants tended to use YouTube, Instagram, Snapchat, and Facebook most often. Also, consistent with studies that have examined e-cigarette content on social media, we found that participants were more likely to report seeing e-cigarette advertisements and posts on Facebook and Instagram, respectively, than other social media platforms (Cho et al., 2019). So far very few studies have studied Snapchat in relation to influence on e-cigarette use behavior. Research may need to pay more attention to Snapchat due to its growing popularity among young people (Smith & Anderson, 2018).

The current findings indicate that, among positive outcome expectancy variables, affect regulation outcome expectancies are a significant mediator of the effects of exposure to e-cigarette content on social media and e-cigarette use onset one year later. Other outcome expectancy variables considered in the analysis were not found to mediate the effect. Higher affect regulation outcome expectancies represent increased beliefs that e-cigarette use is likely to result in immediate positive and negative reinforcement outcomes such as feeling good or calm, and feeling less stressed, bored, or angry. Several past studies (Collins, Glasser, Abudayyeh, Pearson, & Villanti, 2019; McCausland et al., 2019) have documented that messages communicating how e-cigarettes make one feel good or help reduce stress, directly or implicitly, are pervasive in e-cigarette marketing content. Besides, peers' e-cigarette-related posts are likely to project e-cigarette use as a "fun" activity and as a means of coping with life's stresses (Wagoner et al., 2016). Hence, it is not surprising that e-cigarette naïve young people with higher exposure to social media e-cigarette content are more likely to believe in the affect regulation potential of e-cigarette use, which, in turn, places them at greater risk for e-cigarette experimentation.

What is somewhat surprising is that we did not find social enhancement and positive sensory outcome expectancies as significant mediators. Social media is known to shape behavior by promoting conformity and social comparison (Cho et al., 2019). Given this, it is plausible that social enhancement motives, which reflect beliefs such as e-cigarette use would help fit in with friends, would mediate the relation between social media exposure and e-cigarette use. Perhaps our data did not support this proposition because our participants were young

adults, not adolescents. In a similar way, despite recent studies (Chen-Sankey, Kong, & Choi, 2019) implicating flavors in the risk for e-cigarette use onset, we did not find positive sensory outcome expectancies to mediate the effects between social media exposure and uptake of e-cigarette use. It is likely that when considered with other positive outcome expectancies, the relative effect of positive sensory expectancies on onset are not significant.

Our findings among baseline lifetime e-cigarette users related to the positive sensory expectancies and positive "smoking" experience as being mediators of the effects of social media e-cigarette exposure and increased current e-cigarette use one year later are consistent with the findings of the previous cross-sectional study (Pokhrel, Fagan, et al., 2018). It appears that e-cigarette content on social media that promotes e-cigarettes as a cleaner, healthier, and better tasting alternative to cigarettes (McCausland et al., 2019) is effective in increasing e-cigarette use. Unlike in the previous cross-sectional study (Pokhrel, Fagan, et al., 2018), the current study found affect regulation outcome expectancies to be a mediator of the effects on social media exposure. As with onset, higher exposure to social media content promoting e-cigarette use as fun, stress-reducing behavior appears to result in increased e-cigarette use over time.

The current study also tested weight control outcome expectancies (Pokhrel, Bennett, & Boushey, 2020) as a potential mediator, which was not considered in the previous cross-sectional study. Interestingly, contrary to our hypothesis, weight-control expectancies were found to be inversely associated with future e-cigarette use. This should be interpreted in light of our analysis approach which involved testing all five outcome expectancy variables simultaneously as mediators, allowing to covary, so as to tease out their relative, unique effects. Because weight control outcome expectancy variable was positively and significantly correlated with other positive outcome expectancy variables, for both never and ever e-cigarette users, its construct validity is not in question. What the current findings may suggest is that after accounting for the effects of other positive outcome expectancies, weight control expectancies are inversely associated with future current e-cigarette use, perhaps because failing to lose weight through e-cigarette use, users may actually reduce e-cigarette use.

4.1. Limitations

There are some limitations to this study. Although we had a high participant retention rate across the three waves of data collection, the participants we lost represented significantly higher proportions of cigarette smokers and community college students. This may have increased the threat of external validity concerning current findings. Secondly, the exposure to e-cigarette content on social media was self-reported and was not validated against an objective measure. In addition, the measure did not frame the frequency of exposure within a time-frame (e.g., past 30 days or six months). Third, in order to reign in the scope of the manuscript, we did not examine negative e-cigarette outcome expectancies as mediators. For the same reason, we did not run the current analysis separately by gender. Fourth, because the current study focused on young adults, the findings may not generalize to adolescents. Lastly, because our items for positive "smoking" experience expectancies refer to smoking,

misinterpretation of the items as referring to combustible cigarette smoking may need to be considered as a possibility.

4.2. Conclusions

Despite the limitations, the current study is highly significant for determining the beliefs that are influenced by exposure to e-cigarette content on social media and subsequently influence e-cigarette use onset and escalation among young adults. We tested the mediation models in a longitudinal design, which accounted for the temporal sequence among exogenous, mediator, and criterion variables so as to facilitate causal inferences. Additionally, we accounted for potential confounders such as use of e-cigarettes in "offline" social networks as well as cigarette and cigarette smoking and e-cigarette use history. In sum, the study indicated that, among never e-cigarette users, higher exposure to e-cigarette content on social media may lead to e-cigarette use onset via increased beliefs that e-cigarettes are enjoyable and help reduce negative affect. Among those who have tried e-cigarettes, higher exposure to e-cigarette content on social media may lead to increased e-cigarette use via increased beliefs that e-cigarettes are better tasting and safer alternatives to cigarettes and that e-cigarettes help regulate stress and boredom. Efforts to counter the effects of pro-e-cigarette content on social media may benefit from targeting these beliefs.

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HIGHLIGHTS

- Social media influences e-cigarette use initiation and escalation.
- Social media influences e-cigarette use onset through affect regulation beliefs.
- Social media influences e-cigarette use escalation via positive 'smoking' beliefs.
- Social media influences e-cigarette use escalation via positive sensory beliefs.

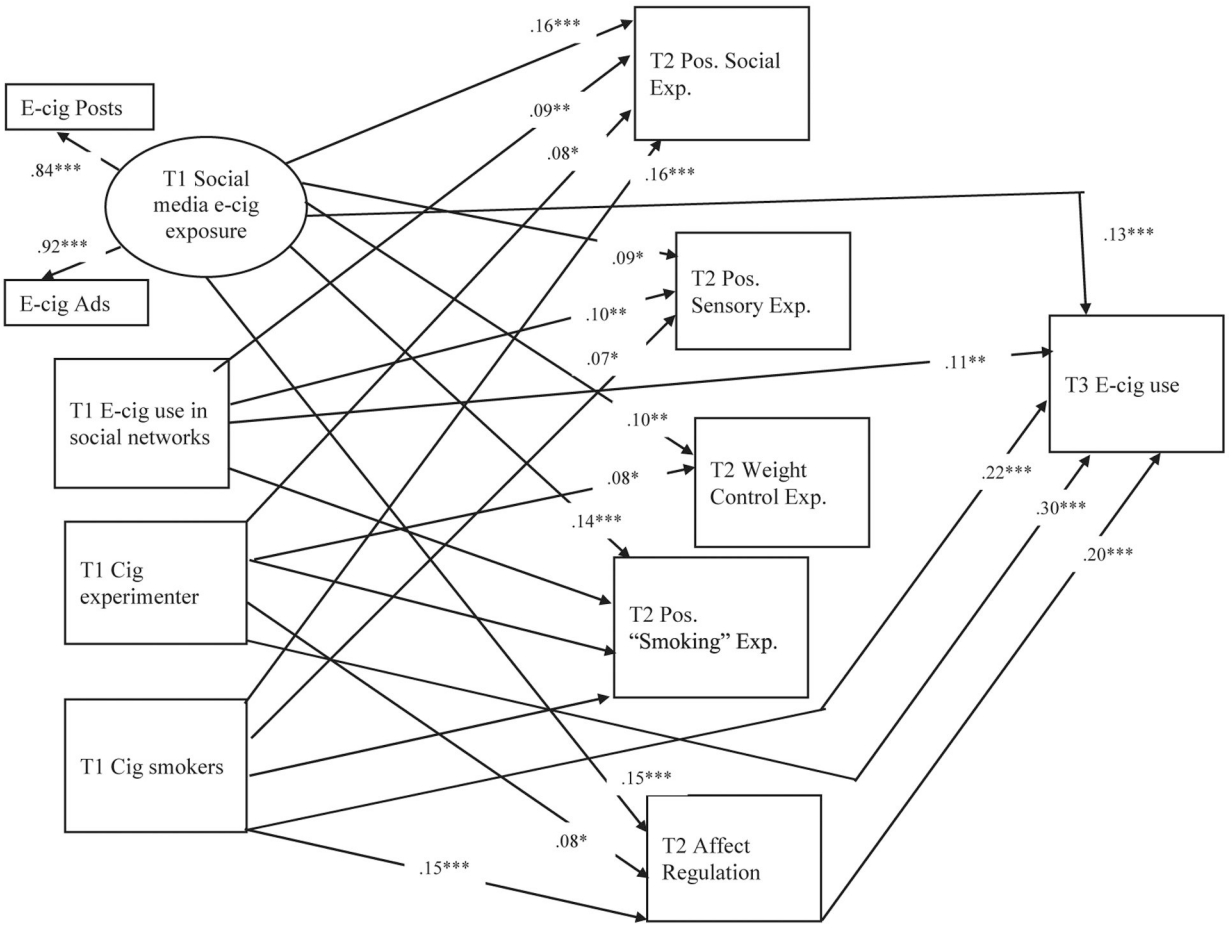

Fig. 1.

Structural equation model showing the associations among social media e-cigarette exposure at baseline (T1), positive e-cigarette use outcome expectancies at six-month follow-up (T2), and evere-cigarette use at one-year follow up (T3) among e-cigarette never-users at baseline. E-cig = Electronic (e)-cigarette; Cig = Cigarette; Pos. = Positive. The model adjusted for, but does not show, the following demographic variables: age, sex, ethnicity (Asian, Native Hawaiian/Pacific Islander, Filipino, and Other dummy-coded with White as the reference group), family/household income, and college type (two-year vs. four-year). Circles represent latent variables and rectangles represent manifest variables. Arrows represent regression paths. Numbers represent standardized factor loadings or path coefficients. Only statistically significant paths are shown. All exogenous variables were correlated with each other. Co-variances between mediators were included in the model but are not shown in the figure. *** = $p < .001$, ** = $p < .01$, *$p < .05$.

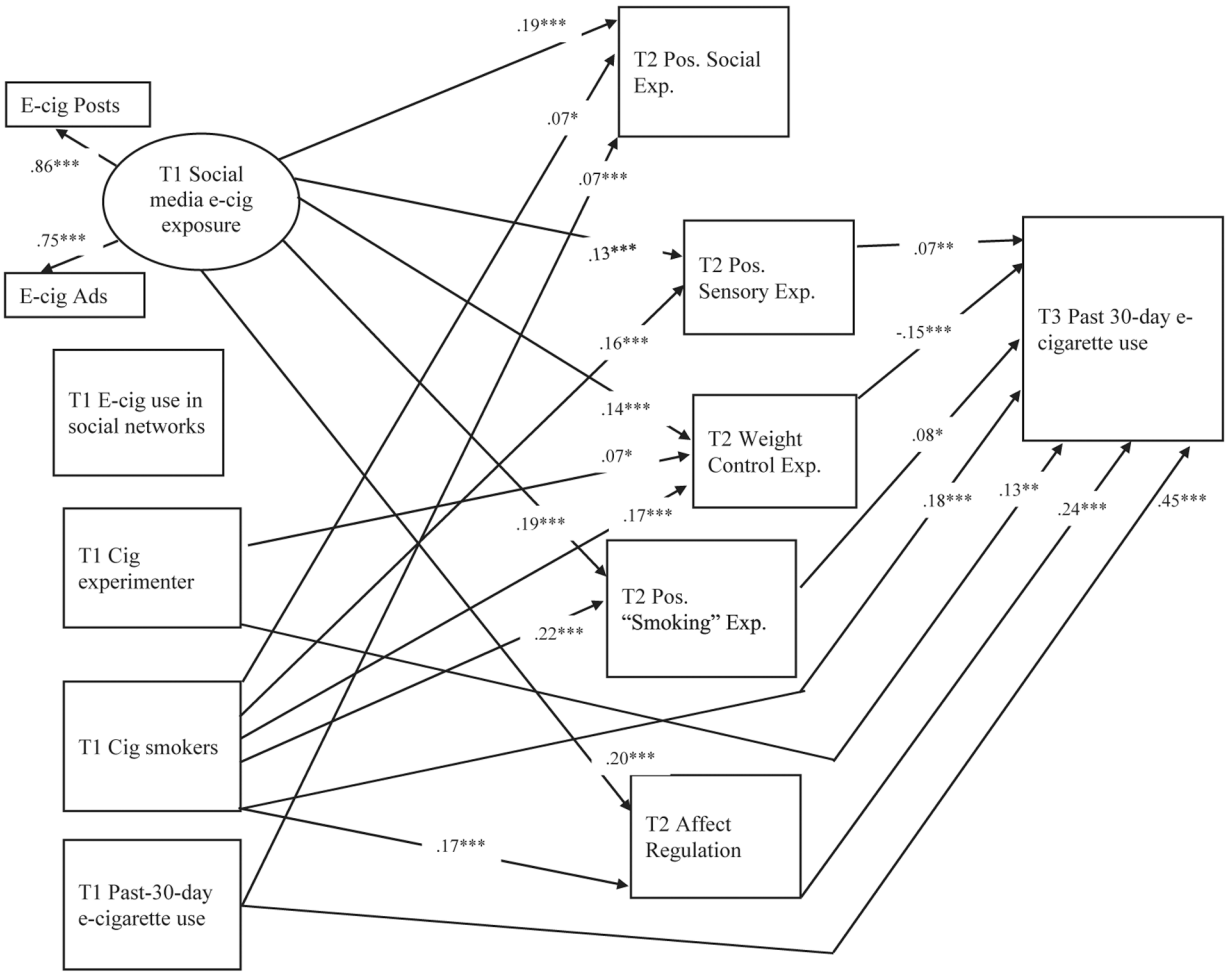

Fig. 2.

Structural equation model showing the associations among social media e-cigarette exposure at baseline (T1), positive e-cigarette use outcome expectancies at six-month follow-up (T2), and current (past-30-day) e-cigarette use at one-year follow up (T3) among lifetime e-cigarette users at baseline. E-cig = Electronic (e)-cigarette; Cig = Cigarette; Pos. = Positive. The model adjusted for, but does not show, the following demographic variables: age, sex, ethnicity (Asian, Native Hawaiian/Pacific Islander, Filipino, and Other dummy-coded with White as the reference group), family/household income, and college type (two-year vs. four-year). Circles represent latent variables and rectangles represent manifest variables. Arrows represent regression paths. Numbers represent standardized factor loadings or path coefficients. Only statistically significant paths are shown. All exogenous variables were correlated with each other. Co-variances between mediators were included in the model but are not shown in the figure. *** = $p < .001$, ** = $p < .01$, *$p < .05$.

Table 1

Characteristics of the baseline and longitudinal samples.

		T1 (N = 2622)		T2 (N = 2401)		T3 (N = 2327)		
		Mean (SD)	**% (n)**	**Mean (SD)**	**% (n)**	**Mean (SD)**	**% (n)**	**Range**
Baseline Age		21.2 (2.2)		21.2 (2.2)		21.2 (2.1)		18–25
Sex								
	Women		54 (1456)		55 (1321)		55 (1280)	
	Men		46 (1166)		45 (1080)		45 (1047)	
Ethnicity								
	White		24 (629)		24 (576)		24 (558)	
	Asian		26 (682)		26 (624)		26 (605)	
	Filipino		18 (472)		18 (432)		18 (419)	
	NHPI		21 (551)		21 (504)		21 (489)	
	Other		11 (288)		11 (264)		11 (256)	
Family/household Income								
	0–39,999		23 (603)		23 (552)		22 (512)	
	40,000–79,999		34 (891)		33 (792)		31 (721)	
	80,000–119,999		25 (656)		26 (624)		26 (605)	
	120,000–159,999		10 (262)		10 (240)		10 (233)	
	160,000 or over		8 (210)		9 (216)		8 (186)	
College type *								
	4-year		57 (1495)		59 (1417)		60 (1396)	
	2-year		43 (1127)		41 (984)		40 (931)	
Number of e-cigarette users in social network **		1.13 (1.36)		1.16 (1.36)		1.25 (1.38)		0–5
Lifetime e-cigarette use			65 (1704)		63 (1513)		63 (1466)	
Current e-cigarette use			31 (813)		31 (744)		30 (698)	
Lifetime cigarette smoking			53 (1390)		50 (1201)		50 (1164)	
Current cigarette smoking ***			21 (551)		17 (408)		16 (372)	
Positive e-cigarette use outcome expectancies								
	Social	1.26 (1.6)		1.26 (1.6)		1.24 (1.6)		0–9
	Sensory *	2.53 (2.4)		2.38 (2.30)		2.26 (2.25)		0–9

		T1 (N = 2622)		T2 (N = 2401)		T3 (N = 2327)		
		Mean (SD)	% (n)	Mean (SD)	% (n)	Mean (SD)	% (n)	Range
	"Smoking" experience *	2.02 (2.0)		1.92 (1.9)		1.81 (1.9)		0–9
	Weight control	1.63 (2.1)		1.62 (2.1)		1.58 (2.1)		0–9
	Affect regulation	2.42 (2.3)		2.38 (2.3)		2.33 (2.2)		0–9

Notes. T1 = Baseline; T2 = Six-month follow-up; T3 = One-year follow-up; % = frequency; n = Number of participants; SD = Standard Deviation; NHPI: Native Hawaiian/Other Pacific Islander. Chi-square and analysis of variance tests were conducted to test for statistically significant differences in frequencies and means, respectively, across T1, T2, T3.

* $p < 0.05$;

** $p < 0.01$,

*** $p < 0.001$.

Table 2

Social media use frequencies and self-reported exposure to e-cigarette content on social media by current e-cigarette use status.

Social media use								
	Current e-cigarette users (n = 812) % (n)				**Current e-cigarette non-users (n = 1810) % (n)**			
	Never	**Rarely**	**Sometimes**	**Often**	**Never**	**Rarely**	**Sometimes**	**Often**
Facebook	13 (106)	17 (140)	22 (178)	47 (380)	13 (227)	16 (292)	22 (389)	49 (885)
Instagram***	9 (72)	8 (60)	18 (144)	65 (523)	16 (289)	11 (192)	15 (268)	58 (1039)
Twitter	50 (404)	16 (130)	11 (88)	23 (181)	55 (979)	17 (296)	10 (180)	19 (335)
Youtube	1 (7)	7 (57)	24 (190)	68 (547)	2 (31)	9 (160)	22 (396)	67 (1204)
Snapchat***	12 (98)	9 (69)	16 (126)	64 (511)	21 (369)	11 (188)	15 (272)	54 (963)
Exposure to e-cigarette ads								
	Current e-cigarette users (n = 812) % (n)				**Current e-cigarette non-users (n = 1810) % (n)**			
	Never	**Rarely**	**Sometimes**	**Often**	**Never**	**Rarely**	**Sometimes**	**Often**
Facebook**	53 (423)	28 (221)	17 (131)	3 (24)	59 (1049)	27 (487)	12 (207)	2 (35)
Instagram***	55 (440)	27 (216)	12 (95)	6 (47)	70 (1231)	20 (348)	9 (155)	2 (37)
Twitter***	83 (660)	11 (84)	5 (43)	1 (10)	88 (1562)	8 (158)	3 (48)	1 (9)
Youtube**	55 (439)	28 (223)	13 (104)	3 (22)	61 (1080)	28 (493)	10 (173)	2 (31)
Snapchat***	81 (648)	12 (92)	5 (36)	3 (27)	85 (1509)	11 (190)	4 (63)	1 (16)
Exposure to e-cigarette posts								
	Current e-cigarette users (n = 812) % (n)				**Current e-cigarette non-users (n = 1810) % (n)**			
	Never	**Rarely**	**Sometimes**	**Often**	**Never**	**Rarely**	**Sometimes**	**Often**
Facebook***	46 (366)	27 (215)	21 (171)	6 (49)	53 (943)	28 (507)	15 (274)	3 (63)
Instagram***	31 (315)	27 (213)	19 (150)	15 (123)	59 (1059)	21 (382)	14 (245)	6 (101)
Twitter***	75 (604)	13 (107)	8 (63)	6 (29)	84 (1499)	10 (172)	5 (84)	2 (32)
Youtube	45 (364)	29 (233)	19 (153)	7 (52)	53 (943)	30 (540)	14 (258)	3 (47)
Snapchat***	64 (508)	14 (113)	10 (78)	13 (103)	76 (1363)	13 (226)	6 (115)	5 (85)

Notes. Statistically significant differences is social media use frequencies between current e-cigarette users and non-users were tested using chi-square test.

*$p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$.

Table 3

Zero-order correlation among positive e-cigarette outcome expectancies by baseline lifetime e-cigarette use status.

	Social	Sensory	"Smoking" experience	Weight control	Affect regulation
Social	1	0.54***	0.66***	0.62***	0.69***
Sensory	0.49***	1	0.51***	0.43***	0.62***
"Smoking" experience	0.54***	0.58***	1	0.56***	0.59***
Weight control	0.56***	0.43***	0.50***	1	0.54***
Affect regulation	0.59***	0.65***	0.65***	0.51***	1

Note. Pearson correlation coefficients above and below the diagonal are for e-cigarette never and ever users at baseline, respectively.

*** = $p < .0001$.