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How Age and E-cigarette Use Status Interact to Influence E-cigarette Ad Perceptions

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Abstract

Purpose: The prevalence of e-cigarette use among young people remains high. Young people are susceptible to e-cigarette advertising, although potential heterogeneity in perceptions of e-cigarette ads with respect to age and e-cigarette use history remain unexplored. We aimed to assess differences in perceptions of e-cigarette ads and product use intention, by age and e-cigarette use status.

Methods: Participants from an online convenience sample (N=497, M_{age}=31.9) viewed two randomly selected e-cigarette ads and reported their perceptions of the ads and product use intention. We used mixed effects linear regression models to estimate associations between age group (18–20 years, 21–25 years, 26+ years), e-cigarette use status (never, former, and current use), and their interaction effects, on outcomes related to perceptions of ads and use intention. Models controlled for demographics and other tobacco use.

Results: Current e-cigarette users (vs. never users) and participants who were 26+ years old (vs. 18–20 years old) had greater liking of the ads, perceived ad relevance, and perceived ad effectiveness. Among current e-cigarette users, participants who were 26+ years old (vs. 18–20 years old) had lower use intention.

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Conclusion: The effect of e-cigarette ad exposures on perceptions of the ad and use intention are heterogeneous with respect to age group and e-cigarette use history. While ads appealed more to adults who were 26+ years old across e-cigarette use groups, current e-cigarette users who were 18–20 years old demonstrated high use intention following ad exposure, suggesting a need for marketing interventions to mitigate continued e-cigarette use among young people.

Keywords

e-cigarettes; age; advertising; media

INTRODUCTION

Background

Approximately 20% of young adults report being current e-cigarette users, and more than 60% are susceptible non-users of the product, despite the legal age to purchase tobacco products in the United States (US) being 21 years old.[1,2] Use of e-cigarettes among this age group exposes young adults to harmful toxicants at a time when their brains are still developing.[3] In addition, use of e-cigarettes may lead to future initiation of even more harmful products, such as cigarettes.[4–6] Therefore, it is important to understand how we can best deter young adults from using e-cigarettes.

As one of the leading reasons young adults use e-cigarettes,[7–9] advertising partially explains e-cigarettes' rapid rise in popularity among young adults.[10,11] Research has shown that e-cigarette ads have appealing features that target youth and young adults,[12,13] and that exposure to e-cigarette advertisements is associated with current e-cigarette use.[14,15] Exposure to e-cigarette advertising is consistently correlated with lower harm perceptions, increased curiosity, and e-cigarette use,[9,16–18] thus, identifying the factors that affect the appeal of e-cigarette advertising to young adults could inform interventions to reduce use. Most studies examining consumers' receptivity and responses to e-cigarette advertising have focused on a specific age group (e.g, just young adults or just adults) or e-cigarette user status (e.g., current users).[19–21] Investigating the joint effects of age and e-cigarette use status is needed to for developing targeted strategies to combat e-cigarette use in specific population groups, informing prevention and cessation efforts among young people, and understanding the impact the industry advertising is having on specific groups. Yet, no studies have examined the joint effect of age group and e-cigarette use on perceptions of e-cigarette advertisements, and this study will uncover whether young people under the age of 21 continue to find e-cigarette advertisements appealing.[12]

We evaluated whether associations between age group and ad perceptions were modified by e-cigarette use status. We hypothesized that e-cigarette ads would be most appealing and have higher product use intention for young adults (e.g., age 18–20 or age 21–25) who are also current e-cigarette users. Results will identify whether the effects of e-cigarette prevention messaging could be optimized by targeting individuals based on their age group and e-cigarette use status.

METHODS

Sample.

Data for this analysis were obtained from an online experiment among 497 participants (publication of main outcomes is forthcoming). Participants were enrolled through the online consumer research panel, Prolific, in October 2021. Participants were eligible to participate in the study if they were 18 years or older and resided in the United States (US).

Study Design.

Potential participants interested in the study reviewed a brief description on Prolific and provided consent. Participants reported their e-cigarette, tobacco, and alcohol use. Then, each participant viewed two e-cigarette ads that were randomly selected from a sample of over 170 ads, identified as including popular features, such as people in the ads, flavors, and the product in use (ad images were sourced from https://trinketsandtrash.org and https://tobacco.stanford.edu).[12] Ads came from media including: print mail (18.2%), print magazines (70.2%), and social media (8.1%) (3.6% were coded as "Unclear" in the original study).[12] After seeing each ad, participants completed post-assessment measures including their perceptions of the ad and product use intention. After completion, participants were compensated accordingly via Prolific's policies ($3.96). All procedures were approved by the Institutional Review Board.

Measures.

Pre-exposure variables—Participants were asked to report their e-cigarette use. The item asked if they had ever "used an electronic cigarette (e-cigarette), even one or two times?" If participants answered "Yes," they were then asked, "During the past 30 days, on how many days did you use an e-cigarette?" Participants were categorized as "current users" if they used an e-cigarette in the past 30 days, "ever users" if they ever used e-cigarettes but reported 0 days of e-cigarette use in the past 30 days, and "never users" if they responded "No" to ever using an e-cigarette even one or two times.

Participants reported their age in years. We then recoded this continuous age variable to the following categories: 18–20 (young adult age that is under the minimum legal sales age for tobacco products), 21–25 (young adult age before the brain is fully developed at around age 25),[22] and 26+ (adults).

Outcome Measures

Perceived relevance of the ad.: Perceived relevance of the ad was assessed using two questions: "The ad seemed to be written personally for me," and "The ad was very relevant to my situation."[23] Scores from a five-point Likert scale ranged from 1 (Strongly disagree) to 5 (Strongly agree). Scores were averaged across the two questions (Cronbach's alphas > 0.90).

Liking of the ad.: Liking of the ad was assessed using a single item: "I liked this ad" on a five-point Likert scale of 1 (Strongly disagree) to 5 (Strongly agree).[24]

Product use intention.: Product use intention was assessed using a single item: "This ad made me want to use the product" on a five-point Likert scale of 1 (Strongly disagree) to 5 (Strongly agree).[25]

Perceived ad effectiveness.: Perceived ad effectiveness was assessed using five questions about whether participants thought the ad was: worth remembering, grabbed their attention, powerful, convincing, and meaningful.[26] Scores from a five-point Likert scale ranged from 1 (Strongly disagree) to 5 (Strongly agree). Scores were averaged across the five questions to obtain one overall perceived ad effectiveness score (Cronbach's alphas > 0.93).

Demographics—Participants reported their age, gender (female, male, non-binary), race and ethnicity (Non-Hispanic White, Non-Hispanic Black, other/multiple, Hispanic), and individual income (<$50,000, $50,000). Participants reported their sexual orientation (Straight or heterosexual, Lesbian or gay, Bisexual, Other non-heterosexual). We oversampled for non-heterosexual orientation in the sample, as the parent study focused on sexual minorities.

Participants also reported their use of combustible cigarettes and other tobacco products. Similar to how we categorized e-cigarette use status, we recoded participants to "current," "ever," and "never" users of combustible cigarettes. We combined all other types of tobacco use (cigar, smokeless, and hookah) together as one combined "other tobacco" use variable that represented any use of the three substances. We similarly recoded this other tobacco use status as "current," "ever," and "never."

Statistical analysis.

Analyses were conducted using R software [version 1.1.456].[27] Descriptive statistics were used to calculate distributions of all variables including the outcome measures: perceived ad relevance, perceived ad effectiveness, liking of the ad, and product use intention. We then used a linear mixed effects model, fit with restricted maximum likelihood estimation, with random intercepts for each participant to estimate unadjusted associations of age group and e-cigarette use status with each outcome variable. We also included product interaction terms between the age and e-cigarette use variables and assessed their statistical significance using partial F-tests.

Next, we ran adjusted models that included fixed effects for race/ethnicity, gender, sexual orientation, income, cigarette use status, and other tobacco use status. We controlled for these sociodemographic and tobacco use variables given their expected confounding effects on the association between e-cigarette use and ad perceptions.[28,29]

Statistical significance of fixed effects, including the interaction terms, was assessed using a partial F-test with an alpha of 0.05. In the models where the interaction between age category and e-cigarette use status was statistically significant, we reported stratified results and conducted post-estimation pairwise comparisons, adjusting the alpha using the Tukey test.

RESULTS

Participants

Our analytic sample included N=497 participants with an average age of 31.9 years old (SD=10.6) and were approximately half female (45.1%) and male (47.9%). The majority of participants identified as straight or heterosexual (54.3%), Non-Hispanic White (71.2%), and had an income below $50,000 (54.3%). See Table 1 for the complete demographics of our study participants, also stratified by age category.

Associations between age group, e-cigarette use, and perceptions of advertisements and e-cigarettes

Perceived relevance of the ad—There was a significant overall interaction effect between age category and use status on perceived relevance of the ad in the unadjusted model (p<0.001). Among participants who had never used e-cigarettes, perceived relevance of the ad was higher among those who were 26+ years old than it was among those who were 18–20 years old (p=0.003; Table 2). Among participants who were current e-cigarette users, perceived relevance of the ad was higher among those who were 26+ years old than it was among participants who were 18–20 years old (p<0.001) and participants who were 21–25 years old (p<0.001).

However, in the adjusted model, there was not a significant interaction effect between age category and e-cigarette use. E-cigarette use was associated with perceived relevance of the ad in the adjusted model (p<0.001). Participants who were current e-cigarette users had higher perceived relevance of the ads compared to participants who had never used e-cigarettes (p<0.001; Table 3) and compared to participants who had ever used e-cigarettes (p<0.001).

Liking of the ad—There was a significant interaction effect between age category and e-cigarette use in the unadjusted model for liking of the ad (p=0.013). Among participants who had never used e-cigarettes, liking of the ad was higher among participants who were 26+ years old than it was among participants who were 18–20 years old (p=0.007). Among participants who were current e-cigarette users, liking of the ad was higher among participants who were 26+ years old than it was among participants who were 18–20 years old (p=0.002) and participants who were 21–25 years old (p<0.001).

In the adjusted model, there was not a significant interaction effect between age category and e-cigarette use for liking of the ad. E-cigarette use was associated with liking of the ad in the adjusted model (p=0.001). Participants who were current e-cigarette users had higher liking of the ad compared to participants who had never used e-cigarettes (p=0.002) and participants who had ever used e-cigarettes (p=0.037).

Product use intention—There was a significant overall interaction effect between age category and e-cigarette use on product use intention in the unadjusted model (p=0.013). Among participants who had never used e-cigarettes, product use intention was higher among participants who were 26+ years old than among participants who were 18–20 years old (p=0.001). Among participants who were current e-cigarette users, product use intention

was higher among participants who were 26+ years old than among participants who were 18–20 years old (p=0.004) and participants who were 21–25 years old (p=0.006).

There was a significant overall interaction effect between age category and e-cigarette use on product use intention in the adjusted model (p=0.008). Among participants who had never used e-cigarettes, product use intention was higher among participants who were 26+ years old than it was among participants who were 18–20 years old (p=0.016). Among participants who were current e-cigarettes users, product use intention was lower among participants who were 26+ years old than it was among participants who were 18–20 years old (p=0.035).

Perceived ad effectiveness—There was a significant interaction effect between age category and e-cigarette use on perceived ad effectiveness in the unadjusted model (p<0.001). Among participants who had never used e-cigarettes, perceived ad effectiveness was higher among participants who were 26+ years old than it was among participants who were 18–20 years old (p<0.001). Among participants who were current e-cigarettes users, perceived ad effectiveness was higher among participants who were 26+ years old than it was among participants who were 18–20 years old (p<0.001) and participants who were 21–25 years old (p<0.001).

There was not a significant interaction effect between age category and e-cigarette use in the adjusted model for perceived ad effectiveness. Participants who were 26+ years old had higher perceived ad effectiveness compared to participants who were 18–20 years old (p=0.003). Additionally, participants who were current e-cigarette users had higher perceived ad effectiveness compared to participants who had never used e-cigarettes (p=0.010).

Appendix A includes the full regression results for all outcomes, exposures, and covariates.

DISCUSSION

Using ads from popular e-cigarette brands, our study found that age group and e-cigarette use were associated with liking of the ad, perceived ad relevance, product use intention, and perceived ad effectiveness. In our unadjusted models, participants who were 26+ years old who were also current e-cigarette users tended to have greater liking of the ads, perceived ad relevance, product use intention, and perceived ad effectiveness. The insights gained by our study corroborates prior research that have found that e-cigarette ads tend to appeal to specific audiences, such as e-cigarette users.[30] This research, combined with future research examining specific aspects of the ads that affect appeal to young people could inform regulatory decisions.

In the adjusted models, current users tended to have greater perceived ad relevance, liking of the ads, and perceived ad effectiveness than never users, regardless of age. This points to how the industry designs ads that directly appeal to their consumer population and continue to keep them interested in their e-cigarette products.[31,32] Additionally, in the adjusted model, participants who were 18–20 years old reported lower perceived ad effectiveness than participants who were 26+ years old. This finding does not support our hypothesis

and previous research that has found that the e-cigarette industry clearly targets younger age groups.[33–35] One explanation for this could be that the majority of ads included in the sample of ads shown to participants came from platforms such as print mail and print magazine,[12] media that require either enrolling with the product company or purchasing a physical magazine. Younger people, a more technology-oriented generation, would be more likely to respond to ads on social media,[35,36] and future studies should focus on social media as a channel of e-cigarette ad exposure. Another explanation for this unexpected finding could be that our study did not look at whether specific features in the ads affected appeal, and future research with a more nuanced analysis of the features of the ads may provide more insight into the age category associations.

In the unadjusted model, participants who were current e-cigarette users in the younger age category of 18–20 years old tended to have lower product use intention, than current users who were 26+ years old. But this association changed direction after including covariates in the model. In the adjusted model, participants who were current e-cigarette users in the younger age category of 18–20 years old tended to have higher product use intention, than current users who were 26+ years old. After conditioning on the effect of certain sociodemographic factors and other tobacco use behaviors, e-cigarette ads were appealing to a younger population of current e-cigarette users, which is consistent with prior research findings around e-cigarette ad appeal.[35,37,38]

Unexpectedly, in the adjusted models, participants who were never e-cigarette users in the younger age category of 18–20 years old tended to have lower product use intention, than never users who were 26+ years old. This is also an interesting finding as research has shown that the industry targets younger populations,[33–35] and that e-cigarette uptake is high before the age of 21 and much less after the age of 21.[39] Our findings suggest that the industry may have moved on from targeting young never users and promoting e-cigarettes as an "alternative to smoking" product.[12,40]

Our study shows that regulatory decisions regarding e-cigarette ads may need to consider various correlates including age category and product use. Our findings suggest that ads are serving both to promote intention to use e-cigarettes among young adults who have never used e-cigarettes and to encourage maintained e-cigarette use among existing users of all ages, making it critical to produce public health campaigns targeted at specific age and use categories both as a form of prevention and intervention.

Although our study addresses a novel issue in e-cigarette ad research, our study has its limitations. In our sampling and data collection methods, we used convenience sampling and oversampled for certain population groups; therefore, our analytic sample is not nationally representative. However, tobacco research studies using online survey panels, such as Prolific, have found comparable results to studies using probability sampling and are a widely accepted method of online data collection.[41] We used self-report measures to collect our outcomes data, which may raise social desirability bias in answering questions around tobacco-related behaviors.[42] For the outcome of "Liking" and product use intention, we used a single-item measure that was originally validated in a larger sample size (N > 5000),[24] and future research conducting a similar analysis to this study should aim to utilize a larger

sample size. We decided to keep gender as a trichotomous variable and sexual orientation as a four-level variable due to the fact that we oversampled for non-heterosexual participants and wanted to maintain the sexual and gender minority diversity of our sample in our adjusted regression results. This may have resulted in slightly larger standard error sizes for certain levels of gender and sexual orientation in our adjusted models. There were also limited sample sizes for certain age categories by e-cigarette use status, further warranting future work with a larger sample size. Additionally, the age category of 26+ years old includes a diversity of ages, which makes this group far more heterogenous than the other two age categories of 18–20 and 21–25 years old.

Despite these limitations, the findings from our analysis point towards areas for future research to further examine the association between how different age categories and e-cigarette use status may perceive e-cigarette ads differently. This research is critical to gather the evidence needed to inform evidence-based interventions and prevention efforts to reduce the effect and appeal of e-cigarette industry advertising on specific groups.

Conclusion

This study highlights the importance of considering both age category and e-cigarette use status together when understanding the impact of e-cigarette ads. To our knowledge, this was the first investigation of how age category and e-cigarette use status interact to influence perceptions of e-cigarette ads. This study found that age category, use status, and their interaction were associated with perceptions of ads and use intention. Most recent prevention and intervention research has focused on adolescents,[43] and we should not disregard older populations as needing more targeted intervention efforts. Ultimately, our findings can inform interventions and corrective measures taken to prevent e-cigarette brands from appealing to certain age categories and attracting another generation of consumers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements and Funding

Appendix

Appendix

Appendix A:

Adjusted associations between age category, e-cigarette use status, their interaction, and perceived relevance of the ad, liking of the ad, product use intention, and perceived ad effectiveness, including all covariates in the adjusted model

	Beta	SE	p-value
Perceived relevance of the ad			
Age			
18–20 years	Ref		
21–25 years	–0.08[a]	0.14	0.554
26+ years	0.11[a]	0.14	0.410
E-cigarette use			
Never	Ref		
Ever	0.06[a]	0.11	0.610
Current	0.75[b]	0.12	**<0.001**
Gender			
Female	Ref		
Male	0.36	0.11	**0.001**
Non-binary	0.58	0.19	**0.002**
Race/ethnicity			
Non-Hispanic White	Ref		
Non-Hispanic Black	–0.02	0.13	0.877
Other/multiple	–0.37	0.16	**0.019**
Hispanic	–0.21	0.13	0.098
Sexual Orientation			
Straight/heterosexual	Ref		
Lesbian/gay	–0.36	0.13	**0.007**
Bisexual	–0.35	0.11	**0.001**
Other non-heterosexual	–0.39	0.19	0.043
Income			
<$50,000	Ref		
>$50,000	0.36	0.10	**<0.001**
Combustible cigarette use			
Never	Ref		
Ever	–0.17	0.12	0.164
Current	0.26	0.14	0.063
Other tobacco use			
Never	Ref		
Ever	–0.32	0.11	**0.005**
Current	0.53	0.15	**<0.001**
Liking of the ad			

	Beta	SE	p-value
Age			
18–20 years	Ref		
21–25 years	0.00[a]	0.15	0.999
26+ years	0.08[a]	0.16	0.590
E-cigarette use			
Never	Ref		
Ever	0.13[a]	0.13	0.302
Current	0.45[b]	0.13	**<0.001**
Gender			
Female	Ref		
Male	0.20	0.11	0.073
Non-binary	0.21	0.19	0.273
Race/ethnicity			
Non-Hispanic White	Ref		
Non-Hispanic Black	0.19	0.14	0.190
Other/multiple	−0.23	0.18	0.194
Hispanic	−0.29	0.14	**0.045**
Sexual Orientation			
Straight/heterosexual	Ref		
Lesbian/gay	−0.44	0.15	**0.003**
Bisexual	−0.30	0.12	**0.012**
Other non-heterosexual	−0.29	0.22	0.182
Income			
<$50,000	Ref		
>$50,000	0.20	0.11	0.066
Combustible cigarette use			
Never	Ref		
Ever	−0.01	0.13	0.943
Current	0.23	0.16	0.150
Other tobacco use			
Never	Ref		
Ever	−0.18	0.13	0.155
Current	0.53	0.16	**0.001**
Product use intention			
Never e-cigarette users			
18–20 years	Ref		
21–25 years	0.33[a]	0.25	0.184
26+ years	0.52[a]	0.22	**0.016**
Ever e-cigarette users			
18–20 years	Ref		
21–25 years	−0.35[a]	0.27	0.188
26+ years	−0.25[a]	0.26	0.331

	Beta	SE	p-value
Current e-cigarette users			
18–20 years	Ref		
21–25 years	−0.32[a]	0.25	0.206
26+ years	−0.50[a]	0.24	**0.035**
Gender			
Female	Ref		
Male	0.36	0.11	**0.001**
Non-binary	0.58	0.19	**0.002**
Race/ethnicity			
Non-Hispanic White	Ref		
Non-Hispanic Black	0.01	0.14	0.939
Other/multiple	−0.43	0.17	**0.013**
Hispanic	−0.24	0.14	0.089
Sexual Orientation			
Straight/heterosexual	Ref		
Lesbian/gay	−0.51	0.14	**<0.001**
Bisexual	−0.31	0.11	**0.007**
Other non-heterosexual	−0.36	0.21	0.085
Income			
<$50,000	Ref		
>$50,000	0.20	0.10	0.053
Combustible cigarette use			
Never	Ref		
Ever	−0.06	0.13	0.670
Current	0.38	0.15	**0.013**
Other tobacco use			
Never	Ref		
Ever	−0.31	0.12	**0.012**
Current	0.61	0.16	**<0.001**
Perceived ad effectiveness			
Age			
18–20 years	Ref		
21–25 years	0.11[a]	0.14	0.408
26+ years	0.41[b]	0.13	**0.003**
E-cigarette use			
Never	Ref		
Ever	0.11[a]	0.11	0.329
Current	0.30[a]	0.12	**0.010**
Gender			
Female	Ref		
Male	0.13	0.10	0.182
Non-binary	0.55	0.17	**0.001**

	Beta	SE	p-value
Race/ethnicity			
Non-Hispanic White	Ref		
Non-Hispanic Black	0.24	0.13	0.059
Other/multiple	−0.36	0.16	**0.024**
Hispanic	−0.17	0.13	0.189
Sexual Orientation			
Straight/heterosexual	Ref		
Lesbian/gay	−0.39	0.13	**0.003**
Bisexual	−0.30	0.10	**0.004**
Other non-heterosexual	−0.60	0.19	**0.002**
Income			
<$50,000	Ref		
>$50,000	0.20	0.09	**0.033**
Combustible cigarette use			
Never	Ref		
Ever	−0.28	0.12	**0.017**
Current	0.01	0.14	0.952
Other tobacco use			
Never	Ref		
Ever	−0.24	0.11	**0.036**
Current	0.53	0.14	**<0.001**

*P-values were calculated using Wald tests. Tukey's tests were used to assess statistical significance of pairwise comparisons. P-values that meet the criteria for statistical significance are bolded. Means without a common superscript letter differ (p<0.001). Models analyzed the interaction between e-cigarette use status and age group, but results are only stratified by age group status when the interaction was statistically significant. Stratified results are presented from models with statistically significant interactions between age group and e-cigarette use status.

References

1. Vallone DM, Cuccia AF, Briggs J, Xiao H, Schillo BA, Hair EC. Electronic Cigarette and JUUL Use Among Adolescents and Young Adults. JAMA Pediatr. 2020;174(3):277–286. doi:10.1001/jamapediatrics.2019.5436 [PubMed: 31961395]

2. Cuccia AF, Patel M, Kierstead EC, Evans WD, Schillo BA. Associations of e-cigarette industry beliefs and e-cigarette use and susceptibility among youth and young adults in the United States. Drug Alcohol Depend. 2022;231:109126. doi:10.1016/j.drugalcdep.2021.109126 [PubMed: 35030507]

3. National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health. Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General. Atlanta, GA; 2012. https://www.ncbi.nlm.nih.gov/books/NBK99237/.

4. Hair EC, Kreslake JM, Mowery P, Pitzer L, Schillo B, Vallone DM. A longitudinal analysis of e-cigarette use and cigar, little cigar or cigarillo initiation among youth and youth adults: 2017–2019. Drug Alcohol Depend. 2021;226:108821. doi:10.1016/j.drugalcdep.2021.108821 [PubMed: 34218009]

5. Khouja JN, Suddell SF, Peters SE, Taylor AE, Munafò MR. Is e-cigarette use in non-smoking young adults associated with later smoking? A systematic review and meta-analysis. Tob Control. 2020;30(1):8–15. doi:10.1136/tobaccocontrol-2019-055433 [PubMed: 32156694]

6. Soneji S, Barrington-Trimis JL, Wills TA, et al. Association Between Initial Use of e-Cigarettes and Subsequent Cigarette Smoking Among Adolescents and Young Adults: A Systematic Review and Meta-analysis. JAMA Pediatr. 2017;171(8):788–797. doi:10.1001/jamapediatrics.2017.1488 [PubMed: 28654986]

7. Mantey DS, Cooper MR, Clendennen SL, Pasch KE, Perry CL. E-Cigarette Marketing Exposure Is Associated with E-Cigarette Use among US Youth. J Adolesc Heal. 2016;58(6):686–690. doi:10.1016/j.jadohealth.2016.03.003

8. Padon AA, Lochbuehler K, Maloney EK, Cappella JN. A Randomized Trial of the Effect of Youth Appealing E-Cigarette Advertising on Susceptibility to Use E-Cigarettes Among Youth. Nicotine Tob Res. 2018;20(8):954–961. doi:10.1093/ntr/ntx155 [PubMed: 29106669]

9. Villanti AC, Rath JM, Williams VF, et al. Impact of Exposure to Electronic Cigarette Advertising on Susceptibility and Trial of Electronic Cigarettes and Cigarettes in US Young Adults: A Randomized Controlled Trial. Nicotine Tob Res Off J Soc Res Nicotine Tob. 2016;18(5):1331–1339. doi:10.1093/ntr/ntv235

10. Huang J, Kornfield R, Szczypka G, Emery SL. A cross-sectional examination of marketing of electronic cigarettes on Twitter. Tob Control. 2014;23(Suppl 3):iii26–iii30. doi:10.1136/tobaccocontrol-2014-051551 [PubMed: 24935894]

11. Noel JK, Rees VW, Connolly GN. Electronic cigarettes: a new "tobacco" industry? Tob Control. 2011;20(1):81. doi:10.1136/tc.2010.038562 [PubMed: 20930060]

12. Liu J, Vázquez-Otero C, Berman ML, Stevens EM. Youth-appealing features in popular e-cigarette brand advertising in the USA after heightened scrutiny in 2018. Tob Control. 2021. doi:10.1136/tobaccocontrol-2021-056720

13. Camenga D, Gutierrez KM, Kong G, Cavallo D, Simon P, Krishnan-Sarin S. E-cigarette advertising exposure in e-cigarette naïve adolescents and subsequent e-cigarette use: A longitudinal cohort study. Addict Behav. 2018;81:78–83. doi:10.1016/j.addbeh.2018.02.008 [PubMed: 29432916]

14. Weiland BJ, Korycinski ST, Soules M, Zubieta J-K, Zucker RA, Heitzeg MM. Substance abuse risk in emerging adults associated with smaller frontal gray matter volumes and higher externalizing behaviors. Drug Alcohol Depend. 2014;137:68–75. doi:10.1016/j.drugalcdep.2014.01.005 [PubMed: 24513182]

15. Pike JR, Tan N, Miller S, Cappelli C, Xie B, Stacy AW. The Effect of E-cigarette Commercials on Youth Smoking: A Prospective Study. Am J Health Behav. 2019;43(6):1103–1118. doi:10.5993/AJHB.43.6.8 [PubMed: 31662169]

16. Pokhrel P, Herzog TA, Fagan P, Unger JB, Stacy AW. E-cigarette Advertising Exposure, Explicit and Implicit Harm Perceptions, and E-cigarette Use Susceptibility Among Nonsmoking Young Adults. Nicotine Tob Res Off J Soc Res Nicotine Tob. 2019;21(1):127–131. doi:10.1093/ntr/nty030

17. Stevens EM, Hébert ET, Keller-Hamilton B, et al. Associations Between Exposure to The Real Cost Campaign, Pro-Tobacco Advertisements, and Tobacco Use Among Youth in the U.S. Am J Prev Med. 2021;60(5):706–710. doi:10.1016/j.amepre.2020.11.006 [PubMed: 33583677]

18. Farrelly MC, Duke JC, Crankshaw EC, et al. A Randomized Trial of the Effect of E-cigarette TV Advertisements on Intentions to Use E-cigarettes. Am J Prev Med. 2015;49(5):686–693. doi:10.1016/j.amepre.2015.05.010 [PubMed: 26163170]

19. Pierce JP, Sargent JD, Portnoy DB, et al. Association Between Receptivity to Tobacco Advertising and Progression to Tobacco Use in Youth and Young Adults in the PATH Study. JAMA Pediatr. 2018;172(5):444–451. doi:10.1001/jamapediatrics.2017.5756 [PubMed: 29582078]

20. Pu J, Zhang X. Exposure to advertising and perception, interest, and use of e-cigarettes among adolescents: findings from the US National Youth Tobacco Survey. Perspect Public Health. 2017;137(6):322–325. doi:10.1177/1757913917703151 [PubMed: 28379069]

21. Nicksic NE, Snell LM, Rudy AK, Cobb CO, Barnes AJ. Tobacco Marketing, E-cigarette Susceptibility, and Perceptions among Adults. Am J Health Behav. 2017;41(5):579–590. doi:10.5993/AJHB.41.5.7 [PubMed: 28760180]

22. Office on Smoking HP. Surgeon General's Advisory on E-cigarette Use Among Youth The E-cigarette Epidemic Among Youth. 2018. doi:10.17226/24952

23. Jensen JD, King AJ, Carcioppolo N, Davis L. Why are Tailored Messages More Effective? A Multiple Mediation Analysis of a Breast Cancer Screening Intervention. J Commun. 2012;62(5):851–868. doi:10.1111/j.1460-2466.2012.01668.x [PubMed: 26405350]

24. Moran MB, Heley K, Czaplicki L, Weiger C, Strong D, Pierce J. Tobacco advertising features that may contribute to product appeal among US adolescents and young adults. Nicotine Tob Res. December 2020. doi:10.1093/ntr/ntaa275

25. Hamilton CM, Strader LC, Pratt JG, et al. The PhenX Toolkit: get the most from your measures. Am J Epidemiol. 2011;174(3):253–260. doi:10.1093/aje/kwr193 [PubMed: 21749974]

26. Davis KC, Nonnemaker J, Duke J, Farrelly MC. Perceived effectiveness of cessation advertisements: the importance of audience reactions and practical implications for media campaign planning. Health Commun. 2013;28(5):461–472. doi:10.1080/10410236.2012.696535 [PubMed: 22812702]

27. R Team Core. R: A language and environment for statistical computing. 2020.

28. Soneji S, Knutzen KE, Tan ASL, et al. Online tobacco marketing among US adolescent sexual, gender, racial, and ethnic minorities. Addict Behav. 2019;95:189–196. doi:10.1016/j.addbeh.2019.03.015 [PubMed: 30954888]

29. Moreland-Russell S, Harris J, Snider D, Walsh H, Cyr J, Barnoya J. Disparities and menthol marketing: Additional evidence in support of point of sale policies. Int J Environ Res Public Health. 2013;10(10):4571–4583. doi:10.3390/ijerph10104571 [PubMed: 24071922]

30. Collins L, Glasser AM, Abudayyeh H, Pearson JL, Villanti AC. E-Cigarette Marketing and Communication: How E-Cigarette Companies Market E-Cigarettes and the Public Engages with E-cigarette Information. Nicotine Tob Res. 2019;21(1):14–24. doi:10.1093/ntr/ntx284 [PubMed: 29315420]

31. Smith DM, Bansal-Travers M, O'Connor RJ, Goniewicz ML, Hyland A. Associations between perceptions of e-cigarette advertising and interest in product trial amongst US adult smokers and non-smokers: results from an internet-based pilot survey. Tob Induc Dis. 2015;13(1):14. doi:10.1186/s12971-015-0039-6 [PubMed: 26180523]

32. Laestadius LI, Penndorf KE, Seidl M, Cho YI. Assessing the Appeal of Instagram Electronic Cigarette Refill Liquid Promotions and Warnings Among Young Adults: Mixed Methods Focus Group Study. J Med Internet Res. 2019;21(11):e15441–e15441. doi:10.2196/15441 [PubMed: 31763987]

33. Allem J-P, Cruz TB, Unger JB, Toruno R, Herrera J, Kirkpatrick MG. Return of cartoon to market e-cigarette-related products. Tob Control. July 2018:tobaccocontrol-2018–054437. doi:10.1136/tobaccocontrol-2018-054437

34. Padon AA, Maloney EK, Cappella JN. Youth-Targeted E-cigarette Marketing in the US. Tob Regul Sci. 2017;3(1):95–101. doi:10.18001/TRS.3.1.9 [PubMed: 28083545]

35. Liu J, McLaughlin S, Lazaro A, Halpern-Felsher B. What Does It Meme? A Qualitative Analysis of Adolescents' Perceptions of Tobacco and Marijuana Messaging. Public Health Rep. 2020.

36. Phua J, Jin SV, Hahm JM. Celebrity-endorsed e-cigarette brand Instagram advertisements: Effects on young adults' attitudes towards e-cigarettes and smoking intentions. J Health Psychol. 2018;23(4):550–560. doi:10.1177/1359105317693912 [PubMed: 28810409]

37. Soneji S, Knutzen KE, Moran MB. Reasons for engagement with online tobacco marketing among US adolescents and young adults. Tob Induc Dis. 2019;17(January). doi:10.18332/tid/99540

38. McKelvey K, Halpern-Felsher B. Youth Say Flavored E-Cigarette Ads are for Them. J Adolesc Heal. 2018;62(2):S136–S137. doi:10.1016/j.jadohealth.2017.11.278

39. Pérez A, Bluestein MA, Kuk AE, Chen B. Age of e-cigarette initiation in USA young adults: Findings from the Population Assessment of Tobacco and Health (PATH) study (2013–2017). PLoS One. 2021;16(12):e0261243. doi:10.1371/journal.pone.0261243 [PubMed: 34898629]

40. Cataldo JK, Petersen AB, Hunter M, Wang J, Sheon N. E-cigarette marketing and older smokers: road to renormalization. Am J Health Behav. 2015;39(3):361–371. doi:10.5993/AJHB.39.3.9 [PubMed: 25741681]

41. Jeong M, Zhang D, Morgan JC, et al. Similarities and Differences in Tobacco Control Research Findings From Convenience and Probability Samples. Ann Behav Med. 2019;53(5):476–485. doi:10.1093/abm/kay059 [PubMed: 30052702]

42. Rozin P, Singh L. The Moralization of Cigarette Smoking in the United States. J Consum Psychol. 1999;8(3):321–337. doi:10.1207/s15327663jcp0803_07

43. Liu J, Gaiha SM, Halpern-Felsher B. A Breath of Knowledge: Overview of Current Adolescent E-cigarette Prevention and Cessation Programs. Curr Addict Reports. 2020;7(4):520–532. doi:10.1007/s40429-020-00345-5

Table 1:

Participant Characteristics of survey sample via Prolific, stratified by age category, 2021. N(%)

	Overall N=497	Age 18–20 years n=68	Age 21–25 years n=105	Age 26+ years n=324
Age; mean (sd)	31.9 (10.6)	19.1 (0.9)	22.6 (1.4)	37.7 (8.7)
18–20 years	68 (13.7)			
21–25 years	105 (21.1)			
26+ years	324 (65.2)			
Gender; n (%)				
Female	224 (45.1)	51 (75.0)	65 (61.9)	108 (33.3)
Male	238 (47.9)	11 (16.2)	24 (22.9)	203 (62.7)
Non-binary	35 (7.0)	6 (8.8)	16 (15.2)	26 (4.0)
Sexual Orientation; n (%)				
Straight or heterosexual	270 (54.3)	23 (33.8)	29 (27.6)	218 (67.3)
Lesbian or gay	107 (11.5)	12 (17.6)	11 (10.5)	34 (10.5)
Bisexual	142 (28.6)	52 (38.2)	107 (54.3)	59 (18.2)
Other non-heterosexual	28 (5.6)	7 (10.3)	8 (7.6)	13 (4.0)
Race/ethnicity; n(%)				
Non-Hispanic White	353 (71.2)	39 (57.4)	69 (65.7)	245 (75.9)
Non-Hispanic Black	56 (11.3)	11 (16.2)	10 (9.5)	35 (10.8)
Hispanic	33 (6.7)	4 (5.9)	10 (9.5)	19 (5.9)
Other/multiple	54 (10.9)	14 (20.6)	16 (15.2)	24 (7.4)
Income; n (%)				
<$50,000	270 (54.3)	59 (86.8)	90 (85.7)	121 (37.3)
>$50,000	227 (45.7)	9 (13.2)	15 (14.3)	203 (62.7)
E-cigarette use				
Never	171 (34.1)	27 (39.7)	31 (29.5)	109 (33.6)
Ever	122 (24.4)	19 (27.9)	37 (35.2)	66 (20.4)
Current	208 (41.5)	22 (32.4)	37 (35.2)	149 (46.0)
Cigarette use				
Never	162 (32.3)	49 (72.1)	50 (47.6)	59 (18.2)
Ever	166 (33.1)	11 (16.2)	32 (30.5)	123 (38.0)
Current	173 (34.5)	8 (11.8)	23 (21.9)	142 (43.8)
Other tobacco use				
Never	177 (35.3)	49 (72.1)	53 (50.5)	71 (21.9)
Ever	203 (40.5)	15 (22.1)	41 (39.0)	147 (45.4)
Current	121 (24.2)	4 (5.9)	11 (10.5)	106 (32.7)

Table 2:

Unadjusted associations between age category, e-cigarette use status, their interaction, and perceived relevance of the ad, liking of the ad, product use intention, and perceived ad effectiveness.

	Beta	SE	p-value
Perceived relevance of the ad			
Never e-cigarette users			
18–20 years	Ref		
21–25 years	0.20[a]	0.26	0.453
26+ years	0.63[a]	0.21	**0.003**
Ever e-cigarette users			
18–20 years	Ref		
21–25 years	−0.31[a]	0.28	0.274
26+ years	−0.17[a]	0.26	0.504
Current e-cigarette users			
18–20 years	Ref		
21–25 years	−0.19[a]	0.27	0.469
26+ years	0.92[b]	0.23	**<0.001**
Liking of the ad			
Never e-cigarette users			
18–20 years	Ref		
21–25 years	0.17[a]	0.28	0.541
26+ years	0.61[a]	0.23	**0.007**
Ever e-cigarette users			
18–20 years	Ref		
21–25 years	0.02[a]	0.30	0.937
26+ years	−0.01[a]	0.27	0.964
Current e-cigarette users			
18–20 years	Ref		
21–25 years	−0.17[a]	0.28	0.537
26+ years	0.73[b]	0.24	**0.002**
Product use intention			
Never e-cigarette users			
18–20 years	Ref		
21–25 years	0.29[a]	0.28	0.298
26+ years	0.75[a]	0.23	**0.001**
Ever e-cigarette users			
18–20 years	Ref		
21–25 years	−0.44[a]	0.30	0.140
26+ years	−0.32[a]	0.28	0.246
Current e-cigarette users			

	Beta	SE	p-value
18–20 years	Ref		
21–25 years	−0.03[a]	0.29	0.923
26+ years	0.70[b]	0.24	**0.004**
Perceived ad effectiveness			
Never e-cigarette users			
18–20 years	Ref		
21–25 years	0.32[a]	0.24	0.191
26+ years	0.75[a]	0.21	**<0.001**
Ever e-cigarette users			
18–20 years	Ref		
21–25 years	−0.09[a]	0.27	0.737
26+ years	−0.11[a]	0.25	0.639
Current e-cigarette users			
18–20 years	Ref		
21–25 years	−0.05[a]	0.25	0.857
26+ years	0.93[b]	0.22	**<0.001**

[*] P-values were calculated using partial F-tests. Tukey's tests were used to assess statistical significance of pairwise comparisons. P-values that meet the criteria for statistical significance are bolded. Means without a common superscript letter differ (p<0.001). Models analyzed the interaction between e-cigarette use status and age group, but results are only stratified by age group status when the interaction was statistically significant. Stratified results are presented from models with statistically significant interactions between age group and e-cigarette use status.

Table 3:

Adjusted associations between age category, e-cigarette use status, their interaction, and perceived relevance of the ad, liking of the ad, product use intention, and perceived ad effectiveness.

	Beta	SE	p-value
Perceived relevance of the ad			
Age			
18–20 years	Ref		
21–25 years	−0.08[a]	0.14	0.554
26+ years	0.11[a]	0.14	0.410
E-cigarette use			
Never	Ref		
Ever	0.06[a]	0.11	0.610
Current	0.75[b]	0.12	**<0.001**
Liking of the ad			
Age			
18–20 years	Ref		
21–25 years	0.00[a]	0.15	0.999
26+ years	0.08[a]	0.16	0.590
E-cigarette use			
Never	Ref		
Ever	0.13[a]	0.13	0.302
Current	0.45[b]	0.13	**<0.001**
Product use intention			
Never e-cigarette users			
18–20 years	Ref		
21–25 years	0.33[a]	0.25	0.184
26+ years	0.52[a]	0.22	**0.016**
Ever e-cigarette users			
18–20 years	Ref		
21–25 years	−0.35[a]	0.27	0.188
26+ years	−0.25[a]	0.26	0.331
Current e-cigarette users			
18–20 years	Ref		
21–25 years	−0.32[a]	0.25	0.206
26+ years	−0.50[a]	0.24	**0.035**
Perceived ad effectiveness			
Age			
18–20 years	Ref		
21–25 years	0.11[a]	0.14	0.408
26+ years	0.41[b]	0.13	**0.003**
E-cigarette use			

	Beta	SE	p-value
Never	Ref		
Ever	0.11[a]	0.11	0.329
Current	0.30[a]	0.12	**0.010**

*
P-values were calculated using Wald tests. Tukey's tests were used to assess statistical significance of pairwise comparisons. P-values that meet the criteria for statistical significance are bolded. Means without a common superscript letter differ (p<0.001). Models analyzed the interaction between e-cigarette use status and age group, but results are only stratified by age group status when the interaction was statistically significant. Stratified results are presented from models with statistically significant interactions between age group and e-cigarette use status.