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Effect of e-cigarette advertisement themes on hypothetical e-cigarette purchasing in price-responsive adolescents

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Abstract

Aims: To examine the effect on adolescents of exposure to different e-cigarette advertisement themes on reported likelihood of purchasing e-cigarettes in a hypothetical scenario.

Design: Between-subjects design of four randomly-assigned thematic conditions derived from a content analysis of 350 e-cigarette ads: general, flavor- and taste-themed, people- and product use-themed, or control ads for bottled water.

Setting: Virginia, USA.

Participants: Of 1360 adolescents (13–18 years old) participating, 1063 had complete data (519 current cigarette smokers, 544 tobacco-susceptible nonsmokers).

Measurements: Participants completed an e-cigarette purchase task, reporting the likelihood of buying an e-cigarette at various prices. Indices of abuse liability included price responsiveness (whether likelihood of purchase decreased with increasing prices) and, among price-responsive adolescents, breakpoint (highest price before definitely would not buy), Omax (maximum probability-weighted expenditure), and price elasticity (how quickly willingness to purchase decreases as prices increase). Regressions controlled for demographics, prior tobacco ad exposure, tobacco/substance use, and sensation-seeking.

Findings: Prior ad exposure was positively associated with being price-responsive (OR 1.12, 95% CI 1.03, 1.22, $p<0.05$). Among price-responsive adolescents (n=579), breakpoints were 58% higher in the flavor- and taste-themed condition (β 0.46, 95% CI 0.01–0.92) and 75% higher in the people- and product use-themed condition (β 0.56, 95% CI 0.10–1.03) compared with control ($ps<0.05$). Exposure to people- and product use-themed ads was associated with a 60% higher Omax (β 0.47, 95% CI 0.01–0.93, $p<0.05$). The general and people- and product use-themed

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conditions were associated with 23% (β −0.21, 95% CI −0.38–−0.04) and 18% (β −0.24, 95% CI −0.42–−0.06) lower elasticity, respectively (*ps*<0.05).

Conclusions: E-cigarette advertising exposure may increase reported likelihood of purchasing e-cigarettes, with effects differing by advertisement content. People- and product use-themed e-cigarette advertisements increased reported likelihood of purchasing in price-responsive adolescents.

Background

E-cigarettes are the most commonly used tobacco product among United States adolescents ages 13–18; over 25% of high school students used e-cigarettes in the past month in 2019 (1). Nearly 80% of middle and high school students reported exposure to e-cigarette advertisements (ads) as of 2016 (2), and e-cigarette ad exposure is associated with e-cigarette use (3, 4) and cigarette smoking susceptibility (5). E-cigarettes typically contain nicotine, which initiates release of neurotransmitters affecting mood and pleasure (dopamine, glutamate, GABA), with repeated exposure leading to the neuroadaptation and behavioral conditioning that characterize nicotine dependence (6, 7). As effective delivery systems for nicotine (8), e-cigarettes are associated with nicotine dependence among adolescents (9, 10). Adolescents' use of nicotine-containing e-cigarettes represents a critical public health problem given nicotine's impact on adolescent brain development and mounting evidence that e-cigarette use in adolescence is associated with later cigarette smoking (11–13). Further concerns have emerged recently regarding acute lung injury following use of e-cigarette products that may contain nicotine, THC, and/or vitamin E acetate (14). As of early 2020, the Food and Drug Administration (FDA) revised its guidance to industry notifying e-cigarette manufacturers it will be prioritizing enforcement of any e-cigarette products that are targeted to minors or whose marketing is likely to promote use of these products by minors, including products marketed to resemble youth-friendly foods/drinks or resemble other non-e-cigarette products often marketed youth, marketing promoting the ease of concealment when using, and products marketed with youth-appealing characters (15). Greater restrictions on e-cigarette advertising within a comprehensive strategy could be crucial in youth prevention.

E-cigarette ads are currently free of many restrictions applicable to cigarette ads, such as bans on radio and television advertising, use of cartoons, and marketing aimed at younger audiences. Advertising restrictions for cigarettes are critical public health measures that reduce risk of youth smoking (16, 17). Currently, the only federal requirement is that the warning, "This product contains nicotine. Nicotine is an addictive chemical" must be included on e-cigarette ads (18). However, in 2019, the FDA and Federal Trade Commission took action on several groups selling e-cigarette products that resemble kid-friendly foods (19, 20). With limited evidence on how e-cigarette ad warning labels affect e-cigarette perceptions and use among youth (21, 22), another avenue for regulations is restricting the themes and content of ads. Existing e-cigarette ads often feature content that engages youth, highlighting appeals to happiness, friendship, sex and success, and using animation and non-human characters (23, 24). Yet, how e-cigarette ad content affects adolescents' intentions or susceptibility to use e-cigarettes is unclear (25).

One approach for studying the potential effects of e-cigarette advertising content is comparing indices of abuse liability after advertising exposure. Abuse liability is the likelihood for a drug to be used non-medically or lead to dependence with repeated use (26). Drug purchase tasks, which ask participants to report how much they value a substance in economic terms, can assess abuse liability and predict drug consumption (27–29). Drug purchase tasks have several advantages over traditional operant tasks used to study drug demand: they are inexpensive, simple to administer, and do not require participants to self-administer drugs (29). While purchase tasks have been used to study substances including heroin, alcohol, and cigarettes, few studies have examined e-cigarette abuse liability using purchase tasks (30–33). To date, no research has used this methodology to examine e-cigarette demand among youth or after exposure to different e-cigarette ad themes. This study aims to examine the effect of exposure to different e-cigarette ad themes on abuse liability for e-cigarettes among youth.

Methods

Participants, Recruitment and Procedure

We surveyed adolescents in Virginia, United States between September 2016 and April 2018. Participants were recruited from 212 unique zip codes across Central, Eastern, Northern, and Southern regions of Virginia and completed the survey at local community event spaces (e.g., YMCAs, schools, housing complex community rooms). Participants completed the eligibility screening and survey in person using computers or tablets provided by the study team. Eligibility was based on age (13–18 years), smoking status (past 30-day cigarette smoking or tobacco-susceptible nonsmokers), and ability to read and write in English. Youth who did not smoke cigarettes in the past 30 days and endorsed “definitely not” to all four susceptibility questions in the screener were not eligible, as non-susceptible nonsmokers were deemed unlikely to respond to e-cigarette advertising or to report any demand for e-cigarettes, which was the focus of this study. In total, 1,360 youth met these criteria out of 1,838 screened. Reasons for ineligibility were being a non-susceptible nonsmoker (n=285), not speaking English (n=2), not aged 13–18 (n=70), any combination of the preceding reasons (n=23), or not completing the eligibility survey (n=98).

Baseline survey items assessed demographics, health and health behaviors, tobacco use, and prior exposure to tobacco ads. Participants were then randomized to view one of four sets of ad conditions (described below), and subsequently completed additional questions regarding tobacco product susceptibility, ad receptivity, perceptions of tobacco product harm and addiction, and abuse liability. Participants completed the survey in community spaces including those at local YMCAs, schools, housing complex community event rooms, and at our community recruitment partner’s office. To help ensure youth felt comfortable responding truthfully, parents were generally not present when youth were completing the survey, and surveys were completed on tablets covered with privacy screens and while sitting behind a tri-fold table-level partitions. Before and during the consent process, the names of potential participants were checked against those of completers to minimize repeated participation. All participants received compensation ($5 for ineligible participants; $20 for eligible participants who completed the study) and printed materials containing

information on smoking prevention, cessation, and media literacy. A university Institutional Review Board approved the study and all participants provided informed consent (if age 18) or assent with parental consent (if ages 13–17).

Experimental Ad Conditions—Participants were randomly assigned to view one of four sets of ad conditions that differed by theme and/or product (Figure 1). All ads were static, i.e., print (newspaper, magazine, coupons), outdoor (billboard/taxi-stand/gas station pump signage), or digital (opt-in email, online banner, social media). Content and latent class analyses of 350 ads featuring e-liquid or any type of e-cigarette gathered by Competitrack, an ad tracking firm, between January 2015 and May 2016 were used to derive commonly observed e-cigarette themes (see (34) and Appendix, Tables S1–S3, for details on latent class analysis). The three e-cigarette ad conditions represented the following themes: 1) *General*, a latent class of ads with moderate probabilities of featuring flavors and references to technology (used as a positive control); 2) *Flavor and Taste*, a latent class with almost a 100% probability of featuring flavors and references to "taste," and 3) *People and Product Use*, a latent class with the highest probability of featuring people and the appearance of smoke/vapor. Three e-cigarette ads in each theme were selected for this survey (Figures S2–S4). A fourth condition featured static ads for bottled water, serving as a negative control (Figure S1). Within each condition, the three ads were viewed individually and in random order.

E-cigarette Purchase Task—After viewing ads, participants completed an e-cigarette purchase task (E-CPT) (35) using the following prompt to report how likely they were to use an e-cigarette at each individual price in a series of successively increasing prices:

> Imagine a normal day. The following questions ask how likely it is that you would use an **e-cigarette** paid for with your own money if the e-cigarette was sold at different prices.
>
> There are no "right" or "wrong" responses. Please answer all questions honestly, thoughtfully, and to the best of your understanding, as if you were actually in this situation.
>
> Lower numbers mean you would be less likely to buy the e-cigarette at that price.
>
> Higher numbers mean you would be more likely to buy the e-cigarette at that price.
>
> How likely it is that you would use an **e-cigarette** paid for with your own money if the e-cigarette was sold at the following prices?

Probability of e-cigarette use was measured on a Likert-type scale from 0, "Definitely not buy," to 10, "Definitely would buy" (36). Prices were $0, $0.01, $0.05, $0.13, $0.25, $0.50, $1, $2, $3, $4, $5, $6, $11, $35, $70 and $140 USD.

Measures

Abuse Liability Outcomes

Price Responsiveness.: Adolescents were first categorized by whether their purchasing intentions were consistent with expectations that the probability of purchasing an e-cigarette

decreases as prices increase (37). An indicator for price responsiveness was defined as whether or not adolescents' purchasing probabilities transitioned from "probably would buy" an e-cigarette (i.e., a score of ≥5 on the 10-point scale) to "probably not buy" (i.e., a score of ≤4) as prices increased.

Primary Abuse Liability Outcomes.: Three abuse liability outcomes were defined for adolescents who were categorized as price-responsive, since those who were not price-responsive would not purchase an e-cigarette at any price, even if free, and were not expected to be affected by ad exposure conditions. First, the *breakpoint* was the highest price adolescents were willing to pay before they would definitely not purchase an e-cigarette. *Omax* is typically defined as the maximum amount of money participants would spend on e-cigarettes (i.e., price multiplied by quantity consumed) (35). However, measuring the probability of purchasing e-cigarettes instead of how many e-cigarettes are purchased modifies the interpretation of Omax to reflect probability-weighted purchases of e-cigarettes across prices, where Omax is the highest probability-weighted amount youth were willing to spend on an e-cigarette (36). For comparison, we report average e-cigarette retail prices in Virginia in 2016 in the Appendix, table S4. Finally, *elasticity* was defined as the rate of decline in consumption as prices increase. Purchasing data were fit to demand curves using the following equation (38):

$$Q = \quad Q_O 10^{k\left(e^{-\alpha Q_O C} - 1\right)}$$

In this equation, Q is probability of purchase, Q_0 is probability of purchase at \$0.00, k is a scaling factor that we set equal to 4 to improve model fit, α is elasticity, and C is price. Elasticity provides a measure of price sensitivity, or how quickly demand changes in response to increases in price. For breakpoint and Omax, higher values indicate higher abuse liability; for elasticity, lower values indicate higher abuse liability.

Independent Variables—Our primary independent variable was the experimental advertising condition (general, flavor and taste, people and product use), with ads for bottled water as the referent.

Other Control Variables

Prior exposure to tobacco ads.: Youth were asked how often they recalled seeing ads or promotions for tobacco products in four contexts: online, in newspapers or magazines, outdoors, and in stores (39). Categorical responses were recoded ("never," 0; "rarely/sometimes," 1; "most of the time/always," 2) and summed across the four questions, creating a linear index (range 0–8) measuring cumulative exposure to tobacco ads (3, 40).

Smoking status.: Cigarette smokers smoked ≥1 cigarette in the past 30 days. Tobacco-susceptible nonsmokers reported no past 30-day cigarette use and responded "definitely yes," "probably yes," or "probably not" to any of four questions assessing whether participants might use tobacco products soon, in the next year, if a friend offered, or if they might experiment with tobacco products in the future (41).

Substance use and sensation seeking.: We controlled for past-month e-cigarette, alcohol, and cannabis use, defined as any e-cigarette, alcohol or cannabis use in the past 30 days. We included a mean score for the Brief Sensation Seeking Scale (42), a personality dimension that may predispose toward tobacco use.

Demographics.: Demographic covariates included age, gender, and race/ethnicity. Age was grouped as 13–14, 15–17 and 18 years. At the time of the survey, 18-year-olds could purchase tobacco products in Virginia, and youth aged 12–14 may occupy a different developmental stage than youth aged 15–17 (43). Race/ethnicity was defined as non-Hispanic Black/African American, non-Hispanic White, non-Hispanic multiracial or other race, and Hispanic. Gender was limited to male or female, as too few youth (n=6) reported any other gender identity to be included in statistical analyses.

Analysis

Data quality for the purchase task responses was assessed using criteria adapted from Stein and colleagues (37). Of the 1,360 adolescents who responded to the survey, 152 were excluded due to missing data, and 145 were excluded because their response pattern on the purchase task suggested they did not understand it (e.g., more likely to purchase as prices increased). The remaining 1,063 participants were included in our model assessing the influence of the e-cigarette ad conditions on price responsiveness. With the exception of elasticity, the remaining models examining the relationship between e-cigarette ad conditions and abuse liability outcomes used the 579 adolescents who were defined as price-responsive. Adolescents with poorly fitting demand curves, (i.e., with R^2 values <0.5 (n=31) or >0.99 (n=63)) were excluded from elasticity analyses, leaving an analytic sample of 485 for this outcome. There were no differences by experimental condition in the likelihood of being excluded due to data quality concerns (X^2=2.19, p=0.534) or due to poorly fitting demand curves (X^2=6.39, p=0.094).

Separate models were used to analyze whether adolescents were price-responsive and to assess abuse liability indices conditional on being price-responsive; similar two-part approaches have been applied to purchase task data previously (44). Logistic regression assessed odds of being price-responsive across ad themes. Next, linear regressions tested the effect of ad themes on breakpoint, Omax, and elasticity among those who were price-responsive. The e-cigarette demand data among price-responsive adolescents was highly skewed so breakpoint, Omax, and elasticity were log-transformed to improve model fit. Because outcomes are difficult to interpret on a log scale, we used the following equation to quantify the percentage change in breakpoint, Omax, and elasticity between the ad themes:

$$(e^{\beta} - 1) \times 100\%$$

All models were adjusted for control variables listed above. Individual elasticity curves were fit for each participant in Prism 7 (GraphPad, La Jolla, California). Statistical tests were conducted in STATA 15 (StataCorp LP, College Station, Texas) and used a significance threshold of p<0.05. Moderation between smoking status and ad exposure condition was formally assessed by including and testing for interactions in the models described above.

Results of these tests were inconclusive and interactions were not included in the main analytic approach. Main results were also not sensitive to conditioning the abuse liability regressions on a sample of adolescents who reported any non-zero demand for e-cigarettes instead of conditioning on price responsiveness. Furhter, as a number of participants were excluded from regressions due to missing data and data quality criteria, we used both multiple imputation and full information maximum likelihood approaches to test the sensitivity of our findings to missing and excluded data. Results indicated that the price responsiveness model was not sensitive to missing data or nonsystematic purchase task responses and the elasticity model was not sensitive to exclusion of participants with poorly fitting demand curves. Finally, as the analyses were not pre-registered and final decisions about data quality exclusions were made after data collection, the results should be considered exploratory.

Results

Sample Characteristics

Our sample included n=519 current cigarette smokers and n=544 tobacco-susceptible nonsmokers (Table 1). More than half the sample was female (52%), non-Hispanic African American or Black adolescents represented the largest racial/ethnic group (58%), and 18-year-olds were the largest age group (42%). Over one-fifth of the sample (21%) had used an e-cigarette in the past month, while 50% consumed cannabis and 53% consumed alcohol. On average, adolescents in the sample recalled seeing tobacco ads online, in newspapers or magazines, in stores, or outdoors sometimes or most of the time (mean ad exposure index score 5.48; standard deviation 1.85). Distributions of demographics, smoking status, past month e-cigarette use, and prior ad exposure were similar across experimental ad conditions, as expected with random assignment.

Associations between Experimental Ad Conditions and Measures of Abuse Liability

Price Responsiveness: Tests were not conclusive of whether experimental ad conditions were associated with price responsiveness, or the likelihood that youth in our sample transitioned from probably to probably not purchasing e-cigarettes as prices increased, after adjustment for covariates. However, higher levels of previous exposure to tobacco ads were associated with higher odds of being price-responsive (adjusted odds ratio [OR]=1.12, 95% confidence interval [95% CI] 1.03–1.21, p=0.007; Table 2). Being 15–17 years old (relative to 13–14; OR=1.50, 95% CI 1.02–2.19, p=0.037), current smoking (relative to being a tobacco-susceptible nonsmoker; OR=2.04, 95% CI 1.49–2.81, p<0.001), past-month e-cigarette use (OR=3.00, 95% CI 1.96–4.59, p<0.001), past-month cannabis use (OR=1.50, 95% CI 1.05–2.14, p=0.025), and higher sensation seeking (OR=2.19, 95% CI 1.75–2.75, p<0.001) were each associated with higher odds of being price-responsive (Table 2).

Breakpoint: Among adolescents whose e-cigarette purchasing intentions responded to increasing prices (i.e., price-responsive), exposure to the flavor and taste-themed e-cigarette ads was associated with higher breakpoint values compared to the negative control condition (β=0.46, 95% CI 0.01–0.92, p=0.049; Table 3). The highest price adolescents would pay before the probability of buying an e-cigarette dropped to zero was 58% higher in the flavor

and taste-themed e-cigarette ad condition compared to the negative control condition. Adolescents exposed to the people- and product use-themed e-cigarette ad condition had 75% higher breakpoint values than adolescents in the negative control condition (β=0.56, 95% CI 0.10–1.03, *p*=0.017).

Omax: Consistent with effects observed for breakpoint, exposure to the people and product use-themed e-cigarette ad condition was positively associated with abuse liability as indexed by Omax (Table 3). In particular, relative to the negative control condition, the people and product use-themed e-cigarette ad condition was associated with a 60% increase in the highest probability-weighted amount youth were willing to spend on an e-cigarette (β=0.47, 95% CI 0.01–0.93, *p*=0.045).

Elasticity: Among adolescents considered price-responsive as defined above, elasticity—the degree to which willingness to purchase e-cigarettes declines as prices increase—was compared across experimental ad conditions (Table 4). The general e-cigarette ad condition was associated with 19% lower elasticity relative to the negative control condition (β=−0.21, 95% CI −0.38–−0.04, *p*=0.016), meaning that exposure to general e-cigarette ads (i.e., the positive control) was associated with higher abuse liability relative to the negative control condition. The people and product use-themed e-cigarette ad condition was associated with 21% lower elasticity relative to negative control (β=−0.24, 95% CI −0.42–−0.06, *p*=0.009), indicating higher abuse liability after exposure to people and product use-themed e-cigarette ads.

Association of Demographics and Tobacco Use with Abuse Liability Indices

Among adolescents whose likelihood of purchasing e-cigarettes responded to increasing prices, several demographic and tobacco use characteristics were consistently associated with indices of abuse liability (Tables 3 and 4). Past-month e-cigarette use was positively associated with breakpoint, Omax (β=0.39, 95% CI 0.02–0.76, p=0.039), and elasticity (β=−0.25, 95% CI −0.39–−0.10, p=0.001), and being a smoker (versus a tobacco-susceptible nonsmoker) was positively associated with breakpoint and Omax (β=0.55, 95% CI 0.25–1.08, p=0.002). Specifically, being a current smoker was associated with a 62% higher breakpoint (β=0.48, 95% CI 0.06–0.90, p=0.025) and past-month e-cigarette use was associated with a 51% higher breakpoint (β=0.41, 95% CI 0.04–0.78, p=0.031). Additionally, higher sensation seeking was positively associated with e-cigarette abuse liability indices (breakpoint: β=0.29, 95% CI 0.03–0.55, p=0.026; Omax: β=0.26, 95% CI 0.00–0.52, p=0.049; elasticity: β=−0.15, 95% CI −0.25–−0.05, p=0.004).

Discussion

More than one in four high school students report past month e-cigarette use, with much of the recent increase attributable to new pod devices, specifically JUUL (1, 45, 46). In this experiment, we found consistent evidence that brief exposure to e-cigarette ads with ‘people and product use’ thematic characteristics increased multiple indices of abuse liability for e-cigarettes among adolescents considered price-responsive. This suggests that ads containing imagery of actors and product use, including the presence of young adult actors using e-

cigarettes, cartoons, and links to social media (see Supplemental Material for detail), may play a role in the likelihood that adolescents use e-cigarettes. Several of these same ad characteristics were included in a content analysis instrument developed to identify content appealing to youth for e-cigarette video ads (i.e., youth, animated characters; (23)). This association also aligns with previous work showing that youth model behaviors in ads (47) and that social factors impact youth tobacco use (48). Several e-cigarette marketing characteristics are uniquely social, such as the rise of vape shops which sometimes include a lounge-like social setting (49) and product promotion on social media. For example, JUUL, whose ads were included in the current e-cigarette ad content analysis, had a growing number of marketing campaigns using social media and featuring "influencers" as well as youthful men and women using these products (46). In 2018, FDA sent warning letters to JUUL to reassess their marketing strategies that target youth (50). We also found that exposure to e-cigarette ads with a 'general' theme—our positive control—or to ads with a flavor and taste theme was associated with at least one index of abuse liability. Thus, even brief exposure to static e-cigarette ads with a variety of common themes, and particularly ads featuring people and product use, may increase abuse liability for e-cigarettes among adolescents. Restricting specific e-cigarette ad content characteristics and reducing overall exposure to e-cigarette ads may be important policy pathways to prevent adolescent e-cigarette use.

Importantly, this study included adolescents who may be particularly vulnerable to e-cigarette ads. First, we limited the sample in our main analyses to adolescents who smoked cigarettes or who were tobacco-susceptible nonsmokers, and whose hypothetical e-cigarette demand was price-responsive. This analytic decision is relevant because youth who were not price-responsive, either due to reporting consistently high or consistently low probability of demand regardless of e-cigarette price, may have strong preferences for or against e-cigarettes that are difficult to alter through advertising. Second, the sample was racially and ethnically diverse. Understanding responses to tobacco ads among minorities is critical because tobacco industry ads are often concentrated in communities with large proportions of racial and ethnic minority residents (51, 52). Third, the sample generally reported high sensation seeking, and over half of adolescents reported past-month alcohol or cannabis use, all of which are associated with tobacco use (53, 54). While this study was not nationally representative, ads used in the content analysis were obtained from national market scans. Results highlight common e-cigarette ad characteristics associated with e-cigarette abuse liability indices for adolescents who may be especially vulnerable to tobacco use or the influences of tobacco ads, and for whom advertising regulations may therefore be the most important.

Despite evidence that flavored tobacco products appeal to youth and young adults (55, 56), we found that exposure to e-cigarette ads featuring flavors was associated with higher scores on only one abuse liability index. Similarly, previous experimental work among English youth aged 11–16 found an inconsistent effect of ads featuring candy-flavored e-cigarettes compared to no ads: exposure to flavored e-cigarette ads was associated with greater interest in trying e-cigarettes but not with increased appeal of using e-cigarettes (57). While future research may disentangle the effects of e-cigarette ads featuring flavored products, when considered alongside evidence that flavor availability is an important reason that youth try e-

cigarettes (58), ads promoting the availability of flavors are still an important regulatory target. Future studies should examine abuse liability related to brand and device-specific characteristics seen in ads.

Our assessment of abuse liability may underestimate e-cigarette demand. In our sample, a small proportion of youth who reported they would not purchase e-cigarettes even if free also reported past-month e-cigarette use. Some youth may be willing to use e-cigarettes, but not e-cigarettes 'paid for with your own money' as specified our abuse liability prompt. This is consistent with findings that youth aged 15–17 most commonly acquire e-cigarettes by asking for them or someone else offering, rather than by purchasing e-cigarettes themselves or giving someone money to buy e-cigarettes (59). Alternatively, some youth younger than 18 may have reported zero probability of purchasing an e-cigarette knowing that they could not legally purchase tobacco products. Tasks that offer a hypothetically legal purchase scenario, or measure demand in non-monetary ways (e.g., progressive ratio tasks), should be explored.

Limitations

The primary limitation is that participants viewed static ads only once and on a screen, while ads in the real world may be viewed multiple times, via multiple media channels and formats, and in various settings. Repeated ad exposure may increase ad effectiveness, and we therefore may underestimate the effects of the different ad conditions on abuse liability. We also limited this study to static ads, so results may not generalize to radio or video ads with similar themes. Additionally, retail access is associated with e-cigarette use among youth (60, 61) and participants aged 18 could legally purchase tobacco at the time of the survey. Latent factors such as perceived accessibility or knowledge of e-cigarette retail prices may have affected responding among 18-year-olds. While age did not appear to modify reported demand for e-cigarettes, evolving policies on minimum purchase age for tobacco warrant continued attention to tobacco product demand and access among older adolescents and young adults. Finally, our sample is not necessarily representative of US youth generally. As our main results are conditional on price responsiveness, estimates may overstate the effects of e-cigarette ad themes at the population level. That is, the study suggests a role for different e-cigarette ad content in influencing demand among youth who may be vulnerable to e-cigarette use (i.e., price-responsive and either current smokers or tobacco-susceptible nonsmokers). Further, most participants were racial or ethnic minorities, and rates of alcohol and cannabis use were higher than in the general US youth population (62, 63).

Conclusions

The rise in youth e-cigarette use represents a major challenge for tobacco control. Among cigarette-smoking and tobacco-susceptible nonsmoking youth who were responsive to increases in price, this study finds brief exposure to static e-cigarette ads is associated with increased abuse liability for e-cigarettes, with the most consistent effects for ads featuring people and product use. Understanding how e-cigarette ad content affects abuse liability among vulnerable youth is critical for federal and state regulations seeking to restrict e-cigarette advertising and curb tobacco use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Example advertisements in four experimental conditions.

Table 1.

Descriptive statistics, overall and by e-cigarette ad theme.

		E-cigarette Ad Theme				
	All	**Control (Bottled Water)**	**General**	**Flavor & Taste**	**People & Product Use**	***p***
	n=1063	**n=275**	**n=270**	**n=258**	**n=260**	
Price-responsive (n (%))	579 (54%)	148 (54%)	153 (57%)	140 (54%)	138 (53%)	0.854
Breakpoint (mean (SD))	23.74 (48.08)	22.90 (48.05)	20.89 (44.79)	25.25 (49.56)	26.10 (49.98)	0.591
Omax (mean (SD))	141.90 (330.14)	127.74 (310.87)	120.64 (290.40)	158.03 (355.83)	162.94 (360.65)	0.349
Elasticity (mean (SD))	0.01 (0.05)	0.02 (0.05)	0.01 (0.02)	0.02 (0.08)	0.01 (0.02)	0.085
Prior ad exposure (mean (SD))	5.48 (1.85)	5.45 (1.88)	5.36 (1.70)	5.47 (1.82)	5.64 (1.98)	0.365
Gender (n (%))						0.398
Male	505 (48%)	132 (48%)	132 (49%)	111 (43%)	130 (50%)	
Female	558 (52%)	143 (52%)	138 (51%)	147 (57%)	130 (50%)	
Age (n (%))						0.236
13–14	245 (23%)	71 (26%)	61 (23%)	51 (20%)	62 (24%)	
15–17	376 (35%)	98 (36%)	82 (30%)	100 (39%)	96 (37%)	
18	442 (42%)	106 (39%)	127 (47%)	107 (41%)	102 (39%)	
Race/ethnicity (n (%))						0.542
NH African American or Black	621 (58%)	154 (56%)	163 (60%)	151 (59%)	153 (59%)	
NH White	191 (18%)	51 (19%)	55 (20%)	46 (18%)	39 (15%)	
NH multiracial or other race/ethnicity	135 (13%)	35 (13%)	32 (12%)	34 (13%)	34 (13%)	
Hispanic	116 (11%)	35 (13%)	20 (7%)	27 (10%)	34 (13%)	
Smoking status (n (%))						0.309
Current smoker	519 (49%)	122 (44%)	132 (49%)	129 (50%)	136 (52%)	
Nonsmoker	544 (51%)	153 (56%)	138 (51%)	129 (50%)	124 (48%)	
Past-month e-cigarette use (n (%))						0.632
Yes	219 (21%)	53 (19%)	57 (21%)	49 (19%)	60 (23%)	
No	844 (79%)	222 (81%)	213 (79%)	209 (81%)	200 (77%)	
Past-month alcohol use (n (%))						0.288
Yes	563 (53%)	135 (49%)	151 (56%)	132 (51%)	145 (56%)	
No	500 (47%)	140 (51%)	119 (44%)	126 (49%)	115 (44%)	

		E-cigarette Ad Theme				
	All	**Control (Bottled Water)**	**General**	**Flavor & Taste**	**People & Product Use**	***p***
	n=1063	**n=275**	**n=270**	**n=258**	**n=260**	
Past-month cannabis use (n (%))						0.402
Yes	532 (50%)	130 (47%)	131 (49%)	130 (50%)	141 (54%)	
No	531 (50%)	145 (53%)	139 (51%)	128 (50%)	119 (46%)	
Brief sensation seeking scale (mean (SD))	3.25 (0.76)	3.25 (0.75)	3.24 (0.76)	3.24 (0.80)	3.32 (0.76)	0.372

Notes: n=frequency. SD=standard deviation. Frequency for elasticity: n=615. *p*-values are derived from bivariate tests by ad theme (ANOVAs for continuous variables and chi-squared tests for categorical variables).

Table 2.

Adjusted associations between exposure to e-cigarette advertisements and price responsiveness among adolescents (n=1,063).

	Price Responsiveness		
	OR	**95% CI**	***p***
E-cigarette ad theme			
Control (Bottled Water)	*ref*		--
General	1.14†	(0.77, 1.69)	0.507
Flavor & Taste	0.95	(0.64, 1.40)	0.789
People & Product Use	0.76†	(0.52, 1.13)	0.178
Prior ad exposure	**1.12**	**(1.03, 1.22)**	**0.007**
Female	1.14	(0.86, 1.51)	0.376
Age			
13–14	*ref*		--
15–17	**1.50**	**(1.02, 2.19)**	**0.037**
18	1.10	(0.73, 1.64)	0.654
Race/ethnicity			
NH African American or Black	*ref*		--
NH White	1.22	(0.82, 1.79)	0.326
NH multiracial or other race/ethnicity	1.54	(0.99, 2.40)	0.055
Hispanic	0.82	(0.52, 1.31)	0.415
Smoker	**2.04**	**(1.49, 2.81)**	**<0.001**
Past-month e-cigarette use	**3.00**	**(1.96, 4.59)**	**<0.001**
Past-month alcohol use	1.14	(0.79, 1.65)	0.467
Past-month cannabis use	**1.50**	**(1.05, 2.14)**	**0.025**
Brief sensation seeking scale	**2.19**	**(1.75, 2.75)**	**<0.001**

Notes: OR=Adjusted Odds Ratio. 95% CI=95% confidence interval. The price responsiveness indicator is defined as whether or not a participant's probability of purchasing e-cigarettes changes from "probably would buy" to "probably not buy" as prices increases. $p<0.05$.

†Symbols represent a significant difference between the two advertising themes, assessed using Wald tests ($p<0.05$).

Table 3.

Adjusted associations between exposure to e-cigarette advertisements and breakpoint and Omax among price-responsive adolescents (n=579).

	ln(Breakpoint)			ln(Omax)		
	β	**95% CI**	***p***	**β**	**95% CI**	***p***
E-cigarette ad theme						
Control (Bottled Water)	*ref*	--	--	*ref*	--	--
General	0.30	(−0.16, 0.75)	0.199	0.28	(−0.17, 0.74)	0.224
Flavor & Taste	**0.46**	**(0.01, 0.92)**	**0.049**	0.39	(−0.07, 0.85)	0.096
People & Product Use	**0.56**	**(0.10, 1.03)**	**0.017**	**0.47**	**(0.01, 0.93)**	**0.045**
Prior ad exposure	0.01	(−0.09, 0.11)	0.848	0.05	(−0.05, 0.16)	0.304
Female	−0.06	(−0.39, 0.27)	0.708	−0.08	(−0.40, 0.25)	0.650
Age						
13–14	*ref*	--	--	*ref*	--	--
15–17	0.25	(−0.25, 0.75)	0.331	0.23	(−0.27, 0.73)	0.360
18	−0.16	(−0.68, 0.35)	0.529	−0.14	(−0.65, 0.37)	0.592
Race/ethnicity						
NH African American or Black	*ref*	--	--	*ref*	--	--
NH White	−0.36	(−0.80, 0.09)	0.117	−0.40	(−0.84, 0.05)	0.079
NH multiracial or other race/ethnicity	−0.20	(−0.68, 0.28)	0.417	−0.36	(−0.84, 0.13)	0.148
Hispanic	−0.35	(−0.91, 0.22)	0.226	−0.35	(−0.91, 0.22)	0.227
Smoker	**0.48**	**(0.06, 0.90)**	**0.025**	**0.66**	**(0.25, 1.08)**	**0.002**
Past-month e-cigarette use	**0.41**	**(0.04, 0.78)**	**0.031**	**0.39**	**(0.02, 0.76)**	**0.039**
Past-month alcohol use	0.15	(−0.31, 0.62)	0.517	0.12	(−0.34, 0.58)	0.605
Past-month cannabis use	0.13	(−0.33, 0.58)	0.582	0.10	(−0.36, 0.55)	0.674
Brief sensation seeking scale	**0.29**	**(0.03, 0.55)**	**0.026**	**0.26**	**(0.00, 0.52)**	**0.049**

Notes: 95% CI=95% confidence interval. Breakpoint is defined as the price at which probability of demand first drops to 0 labeled “definitely NOT buy.” Omax is the highest probability-weighted amount spent on e-cigarettes. The breakpoint and Omax outcomes among those who were price-responsive were log-transformed to correct for skewness. $p<0.05$.

Table 4.

Adjusted associations between exposure to e-cigarette advertisements and elasticity among price-responsive adolescents (n=485).

	ln(Elasticity)		
	β	**95% CI**	***p***
Ad theme			
Control (Bottled Water)	*ref*		--
General	**−0.21**	**(−0.38, −0.04)**	**0.016**
Flavor & Taste	−0.12	(−0.30, 0.06)	0.178
People & Product Use	**−0.24**	**(−0.42, −0.06)**	**0.009**
Prior ad exposure	−0.01	(−0.05, 0.03)	0.755
Female	0.01	(−0.12, 0.14)	0.885
Age			
13–14	*ref*		--
15–17	−0.12	(−0.32, 0.07)	0.207
18	−0.05	(−0.25, 0.15)	0.610
Race/ethnicity			
NH African American or Black	*ref*		--
NH White	0.14	(−0.03, 0.31)	0.104
NH multiracial or other race/ethnicity	0.13	(−0.05, 0.31)	0.151
Hispanic	0.18	(−0.04, 0.40)	0.116
Smoker	−0.15	(−0.31, 0.01)	0.061
Past-month e-cigarette use	**−0.25**	**(−0.39, −0.10)**	**0.001**
Past-month alcohol use	−0.06	(−0.24, 0.12)	0.504
Past-month cannabis use	0.04	(−0.13, 0.21)	0.633
Brief sensation seeking scale	**−0.15**	**(−0.25, −0.05)**	**0.004**

Notes: 95% CI=95% confidence interval. Elasticity is defined as price sensitivity, or the slope of the curve describing how probability of purchasing an e-cigarette falls as price rises. The elasticity outcome among those who were price-responsive was log-transformed to correct for skewness. $p<0.05$.