Original investigation

An Experimental Study of Nicotine Warning Statements in E-cigarette Tweets

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Abstract

Introduction: It is unclear whether warnings on electronic cigarette (e-cigarette) advertisements required by the US Food and Drug Administration (FDA) will apply to social media. Given the key role of social media in marketing e-cigarettes, we seek to inform FDA decision making by exploring how warnings on various tweet content influence perceived healthiness, nicotine harm, likelihood to try e-cigarettes, and warning recall.

Methods: In this 2 × 4 between-subjects experiment participants viewed a tweet from a fictitious e-cigarette brand. Four tweet content versions (e-cigarette product, e-cigarette use, e-cigarette in social context, unrelated content) were crossed with two warning versions (absent, present). Adult e-cigarette users ($N = 994$) were recruited via social media ads to complete a survey and randomized to view one of eight tweets. Multivariable regressions explored effects of tweet content and warning on perceived healthiness, perceived harm, and likelihood to try e-cigarettes, and tweet content on warning recall. Covariates were tobacco and social media use and demographics.

Results: Tweets with warnings elicited more negative health perceptions of the e-cigarette brand than tweets without warnings ($p < .05$). Tweets featuring e-cigarette products ($p < .05$) or use ($p < .001$) elicited higher warning recall than tweets featuring unrelated content.

Conclusions: This is the first study to examine warning effects on perceptions of e-cigarette social media marketing. Warnings led to more negative e-cigarette health perceptions, but no effect on perceived nicotine harm or likelihood to try e-cigarettes. There were differences in warning recall by tweet content. Research should explore how varying warning content (text, size, placement) on tweets from e-cigarette brands influences health risk perceptions.

Implications: FDA's 2016 ruling requires warnings on advertisements for nicotine-containing e-cigarettes, but does not specify whether this applies to social media. This study is the first to examine how e-cigarette warnings in tweets influence perceived healthiness and harm of e-cigarettes, which is important because e-cigarette brands are voluntarily including warnings on Twitter and Instagram. Warnings influenced perceived healthiness of the e-cigarette brand, but not perceived nicotine harm or likelihood to try e-cigarettes. We also saw higher recall of warning statements for tweets featuring e-cigarettes. Findings suggest that expanding warning requirements to e-cigarette social media marketing warrants further exploration and FDA consideration.

Introduction

Electronic cigarette (e-cigarette) use is increasing among US adults,¹⁻³ and adults learn about,⁴ discuss,⁵ and purchase⁶ e-cigarettes online. The Internet is host to extensive e-cigarette advertising, including on social media (eg, Facebook, Instagram, Twitter).⁷⁻⁹ Twitter is increasingly popular; nearly one-quarter of US adult Internet users use Twitter.¹⁰ Tweets about e-cigarettes increased fivefold between 2012 and 2014,¹¹ and more than 90% of the approximately 1.7 million e-cigarette tweets posted from 2008 to 2013 were advertising.⁹ Commercial tweets for e-cigarettes focus on health, cessation, flavors, social experience, and promotions^{8,12,13} to promote products and build relationships between brands and consumers.

In their final 2016 ruling, the US Food and Drug Administration (FDA) issued a requirement that advertisements for nicotine-containing e-cigarettes bear the warning: "WARNING: This product contains nicotine. Nicotine is an addictive chemical."¹⁴ This rule is described for "print advertisements and other advertisements with a visual component (including, for example, advertisements on signs, shelf-talkers, Internet Web pages, and electronic mail correspondence)"; there is no mention of social media posts, or Twitter specifically, but tweets posted by e-cigarette brands often include images and could be subject to the requirement, particularly given the role that social media plays in selling e-cigarettes.¹⁻¹³

Researchers have explored the effect of warning statements on e-cigarette advertisements and packaging.¹⁵⁻²⁰ Among adult smokers and dual e-cigarette and cigarette users, voluntary warnings placed on e-cigarette packs elicited greater health risk perceptions than packs without warnings.¹⁸ Among adult e-cigarette users, smokers, dual users, and nonusers, warning statements placed on ads for a fictitious e-cigarette brand increased perceived addiction risk, though presence of a health claim (ie, "the healthier smoking alternative") reduced this effect.¹⁶ Among adult smokers, e-cigarette users and dual users, the warning "WARNING: Electronic cigarettes are addictive" on ads increased e-cigarette health risk perceptions and decreased willingness to try e-cigarettes.¹⁵ Among young adult nonsmokers, e-cigarette ads with warnings (voluntary warnings from the manufacturer and FDA-recommended warnings¹⁴) did not influence e-cigarette perceived harm and addictiveness (compared to ads without warnings), but warnings viewed alone increased e-cigarette perceived harm and addictiveness compared to ads alone or without warnings.¹⁹

Features of warning labels, such as size, color, and label design also influence perceptions.^{17,20} Young adults have higher visual attention for (measured via eye-tracking technology), report greater attention to, and have higher recall for warning labels with a red background. Interestingly, young adults who viewed ads with warning labels on red backgrounds reported lower perceived addictiveness for e-cigarettes than those viewing labels on a white background. E-cigarette users in the same study reported lower perceived addictiveness than nonusers, though viewing larger warnings resulted in e-cigarette users reporting similar perceived addictiveness to nonusers.²⁰ Another study found that when viewing e-cigarette ads with FDA-mandated warning labels, young adults' intentions to try e-cigarettes were mediated by warning label design and perceived risk of e-cigarette use, such that well-designed labels (in terms of readability, comprehensibility, and believability) and higher perceived risk of e-cigarettes were associated with decreased intentions to try e-cigarettes. These effects did not emerge for ads with voluntary manufacturer warnings.¹⁷

Two studies also show that varying the type of e-cigarette warning content results in differential influence on perceptions. Adult

smokers, e-cigarette users, dual users, and nonusers who viewed the FDA-mandated e-cigarette warning reported greater health and addiction risk perceptions compared to those who viewed reduced risk e-cigarette warnings.²¹ Adolescent ever e-cigarette or cigarette users who viewed e-cigarette ads with graphic warning images of fatal lung disease paired with warning text ("Warning e-cigarettes may cause fatal lung disease") reported fewer e-cigarette cravings and less use susceptibility than those who viewed the same ads with a text-only warning or no warning. On the other hand, adolescents who viewed e-cigarette ads with a text-only addiction warning ("Warning e-cigarettes are addictive") reported less e-cigarette use susceptibility than those who viewed ads without warnings and text-only warning effects did not differ from graphic warnings plus text.²² Taken together, these findings suggest the importance of tailoring warning features based on content.

Currently, there are not best practices on how to implement warnings on e-cigarette advertising on social media (eg, Twitter). In the absence of guidance, e-cigarette brands have voluntarily posted the warning specified in the 2016 FDA ruling in tweets and Instagram posts.¹⁴ For example, in October 6, 2017 the Juul e-cigarette brand (@JUULvapor) started to include FDA's statement "WARNING: This product contains nicotine. Nicotine is an addictive chemical" at the bottom of a number of tweets for their e-cigarette products. On April 29, 2016, Juul shared the same warning in the text of their @juulvapor handle's first Instagram post (and every post thereafter).

Warnings in tweets may have different effects depending on tweet content. When marketing products on Twitter, brands may use strategies such as providing information about the product and brand, providing promotional offers, building brand appeal²³ through images of product use and brand affinity through images of product use in various everyday contexts. Brands may also post compelling content that may not feature the product (eg, memes, compelling images), but is designed to enhance brand equity (ie, extent to which consumers are aware of, make associations, and identify with a brand)²⁴ and perceived credibility (ie, trustworthiness, expertise).²⁵ Studies show that e-cigarette brands, like Juul (@JUULvapor) and blu (@blucigsusa), use similar strategies on Twitter and Instagram, posting content focused on information about e-cigarette products or brands,^{9,26} promotional offers,^{8,9} and lifestyle appeal (ie, images or videos of products that portray perceived lifestyles, such as relaxation and sex appeal).²⁶ The presence of warning statements on tweets may mitigate these strategies' impact.

This study examines the effect that including nicotine warning labels in tweets posted by a fictitious e-cigarette brand has on perceived nicotine harm, perceived healthiness of the brand, intention to try the brand's e-cigarettes, and recall of warning statements among e-cigarette users. We also explored whether the effect of warnings on the aforementioned outcomes varied by tweet content (modeled after e-cigarette brands' tweet content). The study focuses on e-cigarette users; among the US adult population single tobacco product use of e-cigarettes is 1% and use of e-cigarettes and at least one other tobacco product is 4%, suggesting that uptake of e-cigarettes among nontobacco users is uncommon and studying warnings effects is most important for current users.¹

Method

Participants

US adult (aged ≥18 years) e-cigarette users (ie, ever e-cigarette use) with public Twitter accounts were recruited via social media ads to

complete questionnaires online between May and June 2017. Ads were placed on Twitter, Facebook, and Instagram. Potential participants were targeted using location (United States.), language (English), age (≥ 18 years), and e-cigarette keywords (eg, e-cigarette, e-liquid, vaping). We used the same procedures from a previous study that used Twitter to recruit this population,²⁷ but adapted procedures for use with Facebook and Instagram ads to recruit sufficient sample. Guillory et al.²⁷ provide procedures in detail. Ad content for this study was updated to be compliant with Facebook, Instagram, and Twitter requirements and featured images of people using laptops and phones and the text: “Complete a survey about social media use and health and get at \$10 gift card if you qualify!”

Participants who clicked on ads reached a screener, which included items for assessing eligibility. Eligible participants proceeded to a Twitter authentication page to ensure they had a public Twitter account and the handle provided was not a duplicate (ie, already completed survey). The Twitter authentication application requested that participants log in with their Twitter handle and password and were notified that the application would see tweets from their timeline and who they follow, which is publicly available information (only individuals with public handles were eligible). Participants whose accounts were not public or who had already participated were screened out as ineligible. Eligible participants proceeded to the main questionnaire. RTI International’s Institutional Review Board approved this study.

Procedure and Experimental Design

The experiment was embedded at the midpoint of the questionnaire, which included questions about demographic characteristics, tobacco product use, cessation, social media use, and exposure to e-cigarette advertising and content online.

The experiment used a 4×2 between-subjects design with the first factor being tweet content (e-cigarette product, e-cigarette use, e-cigarette product in social context, content unrelated to e-cigarettes) and the second being nicotine warning label (absence

or presence). Participants were randomly assigned to view one of eight manipulations (Figure 1) of a single tweet posted by the Twitter account of a fake e-cigarette brand (Vuun). Consistent with methods from previous research exploring effect of warnings on print e-cigarette ads,^{15,16} we used a fictitious brand and tweets for the experiment as Twitter user agreements prohibit the manipulation or misrepresentation of existing Twitter handles and tweets. The fictitious brand and tweets were closely modeled after brand logos and tweets from popular e-cigarette brands. This approach maximizes ecological validity by providing a logo and content similar to what one would see from a popular brand, while avoiding violation of Twitter user agreements and eliminating the influence that existing brand perceptions have on reactions to stimuli.

The first between-subjects factor was tweet content (image and text), with the following manipulations: (1) e-cigarette product image and text, (2) e-cigarette use image with vape-related text, (3) e-cigarette product in a social context image with social-themed text, and (4) unrelated image with text that does not feature e-cigarettes but is designed to engage the audience and build brand equity.

The second factor involved absence or presence of a nicotine warning label. We adapted text from FDA’s 2016 ruling.¹⁴ The label was added at the bottom of the tweet and read as follows for the first three tweet types with e-cigarette content: “WARNING: This product contains nicotine. Nicotine is an addictive substance.” For the final tweet with content unrelated to e-cigarettes, text read: “WARNING: This company sells products that contain nicotine. Nicotine is an addictive substance.”

Participants were told they would be viewing a tweet from an e-cigarette brand and asked to read and review all content in the tweet before proceeding. After viewing, participants answered questions to assess reactions to the tweet. Participants were then debriefed and told the brand was fake and created for the study. Participants received a \$10 e-gift card for participating.

	E-cigarette Product (n = 245)	E-cigarette Use (n = 253)	E-cigarette Product in Social Context (n = 247)	Content Unrelated to E-cigarettes (n = 249)
No Nicotine Warning Label (n = 501)	n = 122	n = 130	n = 126	n = 123
Nicotine Warning Label (n = 493)	n = 123	n = 123	n = 121	n = 126

Figure 1. Experimental stimuli.

Measures

Outcome Variables

Outcome variables (described later) focused on reactions to the tweet content and warning and included perceived healthiness, perceived nicotine harm, likelihood of trying Vuun e-cigarettes, and nicotine warning and tweet text recall.

Perceived healthiness of VUUN e-cigarettes was assessed by asking participants to rate the healthiness of the VUUN e-cigarette brand featured in the tweet on a 1–7 semantic differential scale (1 = unhealthy, 7 = healthy). This item was adapted from items used to assess consumer appeal of sugar-sweetened beverages.²⁸

Perceived nicotine harm was assessed on a 4-point Likert scale (1 = strongly disagree, 4 = strongly agree) with the item: “Nicotine is the main substance in tobacco that makes people want tobacco products.” Perceived nicotine harm was dichotomized for multivariable analysis as strongly agree versus agree, disagree, or strongly disagree.

Participants’ likelihood of trying Vuun e-cigarettes was assessed on a 4-point Likert scale (1 = not at all likely, 4 = very likely) using: “How likely are you to try VUUN e-cigarettes in the next 3 months?” In multivariable analyses, likelihood to try Vuun E-cigarettes was dichotomized as very likely, likely, or somewhat likely versus not at all likely.

Nicotine warning recall was assessed by identifying correct recall of warning labels (among participants who viewed warning tweets). Tweet text recall was assessed by identifying correct recall of tweet text, and was included to determine whether participants paid differing levels of attention to different types of tweet content. Nicotine warning recall and tweet message recall were assessed using the question: “Which message(s) was in the tweet you just viewed? (check all that apply)” with six multiple choice responses: the tweet text, the warning statement, and four distractor items.

Covariates

Demographic characteristics measured as covariates included age (in years), sex (male vs. female) race/ethnicity (white, non-Hispanic, black, non-Hispanic, Hispanic, other, non-Hispanic), and education (high school or less, some college, college or greater). For multivariable analyses, we dichotomized race/ethnicity (white, non-Hispanic vs. non-white) and education (high school or less vs. some college or greater).

Other variables included as covariates were current e-cigarette and cigarette use (not at all, rarely or some days, every day), social media use (Twitter: a few times a week or less, ≥daily; Facebook: daily or less, several times per day; Instagram: a few times a week or less, ≥daily), and past 30-day exposure to e-cigarette ads online.

The measures described earlier were the focus of this study. Items on other tobacco product use, cessation, social media use and exposure to e-cigarette advertising, and content online are not reported and are the focus of a separate paper.

Analyses

We used descriptive statistics to describe the sample and outcomes. Multivariable regressions explored main effects of tweet content and warning label (absence or presence) and interaction effects between the two factors on remaining outcomes (perceived healthiness, perceived nicotine harm, likelihood of trying Vuun e-cigarettes). Effect of tweet content and interactions between tweet content and warning label (absence or presence) were not significant for any outcome variables (see [Supplementary Table 2a](#) for results of multivariable analyses with interactions). A multivariable regression explored effect of

tweet content on correct recall of nicotine warning label text among participants who viewed tweets with warnings.

We ran all multivariable regression models stratifying the sample by participants who reported using e-cigarettes with nicotine versus those who used e-cigarettes without; results did not differ from analyses with the full sample. Results presented are for the full sample.

All final multivariable models included covariates (age, race/ethnicity, education, e-cigarette use, cigarette use, social media use, and past 30-day exposure to e-cigarette ads online) and were restricted to females only because the majority of the sample recruited was female (93%). All multivariable models were run with the full sample including sex as a covariate and findings did not differ from findings with models restricted to a female sample. We used Stata 14.0 for analyses.

Results

Sample Characteristics

The sample was predominantly female (93%) and white, non-Hispanic (80%). Half of participants reported having attended some college (50%). Almost one-third of participants reported using e-cigarettes on some days (31%), followed by rarely (28%), not at all (26%), and daily (15%). Most participants reported using cigarettes daily (56%). Over half reported nicotine dependence (ie, use within 30 minutes of waking) for e-cigarettes (57%) and cigarettes (65%). Most of the sample reported using Twitter a few times a week or less (56%) versus at least daily (44%). More than one-third of participants (38%) reported they had seen tweets about e-cigarettes occasionally; about one-third (32%) reported they had seen them rarely in the past 3 months. Less than one-quarter of the sample (22%) reported that they follow e-cigarette brands, retailers, or groups on Twitter to get e-cigarette information ([Table 1](#)).

Multivariable Analyses

Multivariable analyses revealed a significant effect of warning label on perceived Vuun healthiness ($p < .05$), such that people who viewed tweets with a warning were less likely to perceive the Vuun brand as healthy (vs. unhealthy) compared to people who viewed tweets without warnings ([Table 2](#)).

Multivariable analyses revealed no effects of warnings on perceived nicotine harm and likelihood to try Vuun e-cigarettes. However, there were significant effects of e-cigarette and cigarette use on likelihood to try Vuun e-cigarettes. People who use e-cigarettes ($p < .001$) or cigarettes every day ($p < .001$) or some days or rarely (e-cigarettes: $p < .001$, cigarettes: $p < .05$) were more likely to report that they were very likely, likely, or somewhat likely to try Vuun e-cigarettes than people who do not currently use e-cigarettes or cigarettes at all ([Table 2](#)).

Overall, 59% of participants who viewed warning label tweets correctly recalled warnings. Multivariable analyses exploring effect of tweet content on warning recall (among participants who viewed warning label tweets) revealed that people who viewed the e-cigarette product tweet ($p < 0.01$) and e-cigarette use tweet ($p < 0.01$) were more likely to correctly recall warning text than those who viewed the content unrelated to e-cigarettes tweet ([Table 3](#)). For descriptive data on tweet text and warning label text recall see [Supplementary Tables 1a](#) and [1b](#).

Discussion

To our knowledge, our study is the first to examine effects of e-cigarette warnings in tweets on perceptions of e-cigarettes, which

Table 1. Sample Characteristics

Characteristics	<i>n</i> (N = 994)	%
Age (M, SD)	34.58, 10.17	—
Gender		
Female	920	92.6
Male	74	7.4
Race/ethnicity		
White, non-Hispanic	790	79.5
Black, non-Hispanic	78	7.9
Hispanic	86	8.7
Other, non-Hispanic	40	4.0
Education		
High school/GED or less	367	36.9
Some college	501	50.4
College or above	126	12.7
Current e-cigarette use		
Every day	153	15.4
Some days	309	31.1
Rarely	273	27.5
Not at all	259	26.1
Current cigarette use		
Every day	552	55.5
Some days	148	14.9
Rarely	91	9.2
Not at all	203	20.4
Nicotine dependence		
Use e-cigarettes within 30 min of waking	565	57.4
Use cigarettes within 30 min of waking	515	65.1
Twitter use		
A few times a week or less	554	55.7
≥Daily	440	44.3
Facebook use		
Daily or less	225	22.6
Several times per day	769	77.4
Instagram use		
A few times a week or less	552	55.5
≥Daily	442	44.5
In the past 3 months, how often have you seen tweets about e-cigarettes on Twitter?		
Very often	99	10.0
Occasionally	373	37.5
Rarely	313	31.5
Never	209	21.0
Follow e-cigarette brands, retailers, or groups on Twitter to get information about e-cigarettes	223	22.4
Past 30-day exposure to e-cigarette ads online	727	73.1

is important given the volume of e-cigarette-related tweets and because e-cigarette brands voluntarily include nicotine warnings in tweets.^{7–9} This study can help inform FDA decision making regarding the inclusion of social media in regulations of e-cigarette marketing given that the presence of warnings in tweets influenced perceived healthiness of the fictitious e-cigarette brand Vuun. People who viewed tweets with a warning were less likely to perceive the brand as healthy (vs. unhealthy) than people who viewed tweets without warnings. This finding is consistent with research showing that warnings on e-cigarette packaging and advertising can increase health risk perceptions.^{15,17,18,20}

On the other hand, presence of a warning did not influence perceived nicotine harm. People's misperceptions about nicotine and its health effects, documented in previous research,²⁹ may have contributed to this null finding. Perceived nicotine harm as measured here focused on general harm of nicotine in tobacco products, which differs from measures related specifically to addictiveness

of e-cigarettes used in previous studies of warnings on e-cigarettes,^{16,17,20,21} suggesting that outcome measures tied directly to the product (rather than nicotine as an ingredient, which was the focus of this study) may provide a better metric for assessing warning effects.

The presence of warnings had no effect on likelihood to try Vuun e-cigarettes. The fact that having a warning in tweets did not negatively affect likelihood to try the product is consistent with one study showing warnings on e-cigarette ads did not influence thoughts about product use,¹⁷ but runs counter the argument that warning labels can hurt brand perceptions. This is a claim the sugar-sweetened beverage industry made to contest warnings on sugar-sweetened beverages and could be adapted by tobacco companies to contest FDA-mandated e-cigarette warnings. This finding should be interpreted with caution because the experiment explored the effect of exposure to a single tweet, which may not be sufficient to influence this outcome.

Table 2. Multivariable Analysis—Effect of Warning Label on Perceived Vuun Healthiness, Perceived Nicotine Harm, and Likelihood to Try Vuun E-cigarettes

	Perceived Vuun healthiness			Perceived nicotine harm			Likelihood to try Vuun e-cigarettes		
	β	<i>p</i>	95% CI	OR	<i>p</i>	95% CI	OR	<i>p</i>	95% CI
Condition									
No warning	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Warning	-.228	.039	[-0.45 to -0.01]	1.059	.677	[0.81 to 1.39]	1.150	.434	[0.81 to 1.63]
Demographics									
Age	-.001	.925	[-0.01 to 0.01]	1.005	.489	[0.99 to 1.02]	1.010	.294	[0.99 to 1.03]
White, non-Hispanic	-.050	.727	[-0.33 to 0.23]	0.901	.562	[0.63 to 1.28]	0.997	.989	[0.63 to 1.57]
Some college or above	-.007	.951	[-0.23 to 0.22]	0.943	.684	[0.71 to 1.25]	0.869	.452	[0.60 to 1.25]
E-cigarette use frequency									
Every day	.741	.000	[0.00 to 0.00]	1.202	.417	[0.77 to 1.87]	4.705	.000	[2.74 to 8.08]
Some days/rarely	.477	.001	[-0.58 to 0.05]	1.104	.575	[0.78 to 1.56]	6.366	.000	[4.25 to 9.53]
Not at all	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Cigarette use frequency									
Every day	-.085	.583	[-0.39 to 0.22]	1.112	.582	[0.76 to 1.63]	2.324	.000	[1.50 to 3.61]
Some days/rarely	-.048	.786	[-0.39 to 0.30]	0.792	.293	[0.51 to 1.22]	1.780	.026	[1.07 to 2.96]
Not at all	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Social media use frequency									
Twitter use: $\geq$ Daily	.248	.045	[0.01 to 0.49]	1.118	.465	[0.83 to 1.51]	1.351	.137	[0.91 to 2.01]
Facebook use: Several times a day	-.054	.691	[-0.32 to 0.21]	2.194	.000	[1.55 to 3.10]	1.828	.004	[1.21 to 2.76]
Instagram use: $\geq$ Daily	-.081	.515	[-0.33 to 0.16]	0.887	.440	[0.65 to 1.20]	1.542	.032	[1.04 to 2.29]
Past 30-day exposure to e-cigarette ads online	.011	.928	[-0.23 to 0.26]	0.886	.440	[0.65 to 1.21]	1.517	.034	[1.03 to 2.23]

Model includes females only as majority of the sample was female (93%). Separate models were run including men in the sample with and without gender as a covariate and results did not differ. Referent category for race is non-white. Referent category for education is high school or less. Referent category for Twitter and Instagram use is “A few times a week or less”. Referent category for Facebook use is “Daily or less”. Perceived nicotine harm dichotomized as strongly agree vs. agree/disagree/strongly disagree (Ref) for analysis. Likelihood to try Vuun e-cigarettes dichotomized as very likely/likely/somewhat likely vs. not at all likely (Ref) for analysis.

Table 3. Multivariate Analysis—Effect of Tweet Content on Warning Label Recall (Warning Tweets Only)

	Recall of nicotine warning label		
	OR	<i>p</i>	95% CI
Tweet content			
E-cigarette product	2.150	.007	[1.23 to 3.74]
E-cigarette use	2.542	.001	[1.45 to 4.47]
E-cigarette product in social context	1.540	.118	[0.90 to 2.65]
Content unrelated to e-cigarettes	Ref	Ref	Ref
Demographics			
Age	0.996	.698	[0.98 to 1.02]
White, non-Hispanic	0.894	.655	[0.55 to 1.46]
Some college or above	0.842	.401	[0.56 to 1.26]
E-cigarette use frequency			
Every day	1.509	.205	[0.80 to 2.85]
Some days/rarely	1.634	.047	[1.01 to 2.65]
Not at all	Ref	Ref	Ref
Cigarette use frequency			
Every day	0.674	.174	[0.38 to 1.19]
Some days/rarely	0.910	.769	[0.49 to 1.70]
Not at all	Ref	Ref	Ref
Social media use frequency			
Twitter use: $\geq$ Daily	1.163	.509	[0.74 to 1.82]
Facebook use: Several times a day	1.264	.330	[0.79 to 2.03]
Instagram use: $\geq$ Daily	0.476	.001	[0.30 to 0.75]
Past 30-day exposure to e-cigarette ads online	1.526	.059	[0.98 to 2.37]

Model includes females only as majority of the sample was female (93%). Separate models were run including men in the sample with and without gender as a covariate and results did not differ. Referent category for race is non-white. Referent category for education is high school or less. Referent category for Twitter and Instagram use is “A few times a week or less.” Referent category for Facebook use is “Daily or less.”

One limitation of the study is that we tested only one text warning. Research has shown that people recall graphic warnings more than text warnings,³⁰ which may explain why warning recall in our study was only 59%. Among people who viewed tweets with warnings, we saw differences in warning recall based on tweet content viewed. Warnings in tweets that featured an e-cigarette product or product use were more likely to elicit correct recall than content unrelated to e-cigarettes. This suggests that consistency between tweet content (ie, content specific to e-cigarette products containing nicotine) and warnings influences recall, which is in line with research showing that smokers were more likely to recall cigarette graphic warnings when the text and image inside the warning were congruent than when they were incongruent.³¹ Warnings on incongruent content may not be effective as people are less likely to remember warning content in this scenario, but more research is needed to determine how other factors, like varying warning content, size and placement as well as tweet content (text and images) influence perceptions. Visually grabbing warning content, like graphic warnings, may more effectively grab attention on Twitter, though the type of warning content should be carefully considered as research shows that the addition of graphic warnings has greater impact than text only for some types of warning content (fatal lung disease), but not others (addiction).²²

The nicotine warning text used in this study was adapted from warning text in FDA's 2016 ruling,¹⁴ but few studies have compared the effectiveness of different warning content in influencing perceptions of e-cigarette products, brands, and harm perceptions.^{21,32} Qualitative research shows that the FDA-mandated warning text elicits mixed reactions, with some reporting that the statement is straightforward, factual, and useful for people who may be unaware that e-cigarettes contain nicotine and others reporting that the warning was not strong because awareness of nicotine addiction is widespread and the warning does not describe serious consequences.³¹ In another study, the FDA-mandated warning elicited greater health and addiction risk perceptions and was perceived as more believable, easier to understand, and better at communicating e-cigarette health risks than reduced risk warnings.²¹ Previous studies of adult smokers and e-cigarette users show evidence that warnings similar to FDA-mandated warnings¹⁴ placed on print e-cigarette ads¹⁵ and text-heavy voluntary warnings placed on e-cigarette packages negatively influence health risk perceptions,¹⁸ which is consistent with our findings. Although two studies of young adults found that voluntary warnings from e-cigarette manufacturers placed on e-cigarette ads did not influence health risk perceptions.¹⁹

Several studies have also shown that characteristics of FDA-mandated warnings placed on e-cigarette ads, such as size, color, and label design, influence perceived addictiveness²⁰ and intention to try e-cigarettes.¹⁷ Taken together, these studies^{15-21,32} highlight the importance of examining how additional characteristics of warnings (eg, content, font size, images) and placement in e-cigarette tweets influence recall and perceptions among differing age groups and tobacco use profiles, which is timely given FDA's April 2018 announcement that they are launching new enforcement action to prevent youth access to e-cigarettes online and in stores and are examining youth appeal of these products.³³

Limitations

The study has important limitations. First, the sample, which is a convenience, nonprobability sample, may not be generalizable to

all adult e-cigarette users given that the sample was predominantly female and had higher rates of e-cigarette use than the population prevalence for everyday use.¹ The gender imbalance was likely because recruitment occurred primarily on Facebook, which has higher female (74%) than male use rates (62%)¹⁰ and research has shown women are more likely to click on Facebook ads³⁴ and respond to online surveys.³⁵ In addition, although recruitment ads are served to users of social media platforms based on targeting criteria designed to recruit a balanced sample, users can share survey links with others to complete surveys. We changed survey links every few days, but link-sharing poses a threat to keeping samples balanced and may have contributed to gender imbalance.

Second, we used a fictitious e-cigarette brand designed to be as similar as possible in name and appearance to popular brands, but was not pilot tested, which may have contributed to null effects as brand familiarity is important to influencing brand perceptions. Third, we tested only one text warning. Fourth, the experiment was embedded at the midpoint of the questionnaire. This placement was intended to reduce influence of the experiment on responses to items related to e-cigarette use, but answering these questions prior to the experiment may have had a priming effect that influenced response to the experiment.

Conclusions

This is the first study to examine warning effects on e-cigarette marketing tweets and contributes to evidence for informing FDA's decision making about the regulation of social media promotional content for e-cigarettes. Warnings led to more negative health perceptions of the brand, but did not influence perceived nicotine harm or likelihood to try e-cigarettes. There were also differences in warning recall by tweet content, such that recall was higher when tweet content was aligned with warning content (eg, content featuring e-cigarette products and use). Research is needed to explore how varying nicotine warning content, size, and placement on tweets from e-cigarette brands influences health risk perceptions. Future studies should explore effects that e-cigarette warnings placed on tweets have on perceptions among youth, who spend considerable amounts of time accessing information on social media. Understanding these effects among youth has particular importance for informing FDA regulation. Research should also explore how warnings placed on e-cigarette tweets influence perceptions among various tobacco user populations,¹⁹ which are critically important to understanding impact of warnings in tweets. Finally, future studies should explore the influence of warnings on perceptions of e-cigarette posts on other platforms, like Instagram.

Supplementary Material

Supplementary data are available at *Nicotine and Tobacco Research* online.

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Declaration of Interests

None declared.

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