Effects of a social media intervention on vaping intentions: Randomized dose-response experiment

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Abstract

Background: E-cigarette use, especially by young adults, is at unacceptably high levels and represents a public health risk factor. Digital media are increasingly used to deliver anti-vaping campaigns, but little is known about their effectiveness, or dose-response effects of content delivery.

Objective: The objectives of this study were to 1) evaluate the effectiveness of a 60-day anti-vaping social media intervention in changing vaping use intentions and beliefs related to the stimulus content, and 2) evaluate dose-response effects of varying levels of exposure to the intervention on vaping outcomes, including anti-industry beliefs, vaping intentions, and other attitudes and beliefs related to vaping.

Methods: Participants were recruited into the study, completed a baseline survey, and were then randomized to 1 of the 5 conditions: 0 (control), 4, 8, 16, 32 exposures over a 15 day period between each survey wave. Follow-up data were collected at 30 and 60 days after randomization. We conducted analyses of the full sample and in subsamples defined by baseline vaping status (never, former, and current). Stimulus through four 15-second social media videos focused on anti-industry beliefs about vaping delivered via Facebook to 18-24 year old adults in the US. The main outcomes measures reported in this study as self-reported exposure of social media intervention content, attitudes and beliefs about vaping, and vaping intentions.

Results: We found a significant effect of the social media treatment on vaping intentions and on anti-industry beliefs targeted by the intervention content among current vapers. We found no significant effects on self-reported exposure

Conclusions: Social media interventions are a promising approach to preventing vaping among young adults. More research is needed on how to optimize dosage of such interventions and the extent to which long-term exposure may affect vaping use over time. Clinical Trial: This study was registered as a clinical trial at clinicaltrials.gov under identifier NCT04867668.

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Abstract

Background: E-cigarette use, especially by young adults, is at unacceptably high levels and represents a public health risk factor. Digital media are increasingly used to deliver anti-vaping campaigns, but little is known about their effectiveness, or dose-response effects of content delivery.
Objective: The objectives of this study were to 1) evaluate the effectiveness of a 60-day anti-vaping social media intervention in changing vaping use intentions and beliefs related to the stimulus content, and 2) evaluate dose-response effects of varying levels of exposure to the intervention on vaping outcomes, including anti-industry beliefs, vaping intentions, and other attitudes and beliefs related to vaping.
Methods: Participants were 18-24 year old adults in the US. They were recruited into the study through Facebook and Instagram, completed a baseline survey, and then randomized to 1 of the 5 conditions: 0 (control), 4, 8, 16, 32 exposures over a 15-day period between each survey wave. Follow-up data were collected at 30 and 60 days after randomization. We conducted stratified analyses of the full sample and in subsamples defined by baseline vaping status (never, former, and current). Stimulus was delivered through Facebook and Instagram in four 15-second social media videos focused on anti-industry beliefs about vaping. The main outcomes measures reported in this study as self-reported exposure of social media intervention content, attitudes and beliefs about vaping, and vaping intentions. We estimated a series of multivariate linear regressions in Stata 17. In order to capture the dose-response effect, we assigned each study arm a numerical value corresponding to the number of ads (exposures) delivered to participants in each arm, and used this number as our focal independent variable. In each model the predictor was the treatment arm to which each participant was assigned.
Results: The baseline sample consisted of 1,491 participants, and the final analysis sample consisted of 854 participants retained at the 60-day follow-up. We compared the retained participants to those lost to follow-up (LTFU) and found no statistically significant differences across demographic variables. We found a significant effect of the social media treatment on vaping intentions (β -.138 (-.266, -.010), $p < .035$) and on anti-industry beliefs (β -.122 (.008, .237), $p < .036$) targeted by the intervention content among current vapers, but not among the full sample or other strata. We found no significant effects on self-reported exposure to the stimulus.
Conclusions: Social media interventions are a promising approach to preventing vaping among young adults. More research is needed on how to optimize dosage of such interventions and the extent to which long-term exposure may affect vaping use over time.
Trial registration: This study was registered as a clinical trial at clinicaltrials.gov under identifier NCT04867668.

Key Words: Randomized controlled trial; e-cigarettes; vaping; nicotine; tobacco control; social media; dose-response effects.

Introduction

Background

E-cigarettes were the most commonly used tobacco product among young adults in the US between 2014 and 2019 [1]. In 2019, current use of cigarettes and e-cigarettes were 4.5% and 14% [2], respectively. Although e-cigarette use among this population has decreased in recent years, use prevalence still remains at concerning levels. Moreover, the most popular e-cigarette brands contain high levels of nicotine, an addictive substance that may harm the developing brain of young adults [3-6]. The use of e-cigarettes has also been associated with poorer lung and mental health [7-11].

Digital media, including social media platforms, have become a part of our daily lives, particularly among young adults. The use of any social media site by 18-29-year-olds has been consistently over 80% since 2011, many people spending hours a day on these sites (Pew Research Center, 2021) [12]. Due to its ubiquity and potential for influence, digital media can be a valuable, or harmful, tool for population-level behavior change. Thus, there is a great need for more research on the relationship between digital media and health behaviors, social norms, and social networks. While research is being conducted to determine what digital media as an intervention tool would look like, how it works, and how effective it is [13-14], these studies have only scratched the surface [15].

The importance of digital media interventions is growing in many health behavior subject areas, including nicotine and tobacco use research. Mass media campaigns have been proven to be effective in creating positive change in smoking-related attitudes, intentions, and behaviors [16]. More recent research also supports the use of media campaigns to address the before mentioned rapid increase in and continued use of e-cigarettes among youth and young adults [17]. Digital strategies will be central to future campaigns. A recent systematic review of digital behavior change interventions identified 298 relevant articles (Ichimiya et al., 2022) [18]; 19 of those were for nicotine and tobacco interventions.

Prior Work

Digital media intervention research is currently a small, growing, and highly important field given the shift in nicotine behavior change campaigns from traditional mass media such as TV to digital platforms [19]. These strategies have potential to change social norms (ie, beliefs among a population about what is widespread behavior and what is socially sanctioned or required) [20] about behaviors such as vaping. Social norms may be influenced by, for example, e-cigarette companies' social media platforms [21], which normalize and effectively promote use among a peer group such as young adults [19]. At the same time, anti-vaping social media may create a new social norm that vaping is uncommon and less socially accepted among the peer group. Theoretically, the effect of such social media campaigns may be to promote a social norm such as avoidance of nicotine and tobacco products [20].

Specifically, given the relatively small numbers of studies found in the Ichimiya et al (2022) systematic review of digital tobacco behavior change interventions [18], there is a need to rigorously test the effects of anti-vaping social media content on outcomes. Many large-scale campaigns, such as those run by the Food and Drug Administration (e.g., Real Cost) and by Truth Initiative (the Truth campaign), are currently using digital content as part of their overall behavior change strategies, but little is known about their mechanisms of change and the published research does not include randomized trials [18]. Research is needed to build and test theories of change for such campaigns using randomized experimental methods.

Further, this study builds on recent studies using a social media based data collection platform for random assignment studies [14]. The use of social media recruitment, chatbots for survey delivery, and retargeting technology for intervention delivery and follow up, have been

proven feasible and to produce short-term effects on content (e.g., advertising) exposure. This study aims to test these methods in a randomized controlled dose-response experiment.

Study Aims

In this study, our goal was to determine whether a social media intervention delivered through an experimental design would have a positive effect on young adult vaping outcomes. We aimed to disseminate the intervention on participants' Facebook and Instagram News Feeds in the form of an anti-vaping campaign consisting of 4 videos, each 15 seconds in length, drawn from previous Truth Initiative content and aimed at young adults ages 18-24. Participants answered pre- and two post-intervention surveys on the same platform, Facebook Messenger. A chatbot was used to execute the surveys and keep participants engaged over the course of the 60-day study period.

Hypothesis

We tested the hypotheses that exposure to anti-vaping social media content measured through a social media based survey would reduce vaping use intentions at the 60-day follow-up (H1) and increase anti-vaping industry beliefs at the 60-day follow-up (H2). We also examined one research question: (RQ1) Would treatment assignment be associated with lower use intentions and higher anti-vaping beliefs (i.e., a dose-response effect)?

Methods

Study Design

The study design was a randomized controlled experiment with 4 treatment arms plus a no exposure control arm. Using the Virtual Lab platform, participants were recruited into the study (details below), were delivered a baseline survey, and were then randomized to 1 of the 5 conditions. The design was to achieve a specific number of impressions per arm as follows: 0 (control), 4, 8, 16, 32 over a 15 day period between each survey wave. Impressions are defined as the number of viewings of a social media post by a study participant [22].

There were three survey waves: Baseline, 30-day (FU1) follow-up, and 60-day (FU2) follow-up. The aim was to collect sufficient participants within each wave to have sufficient power to detect a treatment effect of intervention video content exposure on vaping intentions at FU2. The final baseline sample consisted of 1491 divided into the 5 study conditions, FU1 consisted of 1048, and FU2 consisted of 854 participants.

Intervention Content

The intervention content consisted of four 15-second videos drawn from a previous online Truth Initiative campaign called "Tested on Humans" (TOH). The main themes of the videos were that vaping companies don't know the health and other impacts of using e-cigarettes and that they are "testing" their products on human beings. This is consistent with an "anti-industry" countermarking approach to nicotine and tobacco campaigns, which has been used successfully in the past [23-24]. The campaign was not publicly active during the current study. We chose this content because it was designed for social media distribution, focused on preventing vaping, and was not currently active.

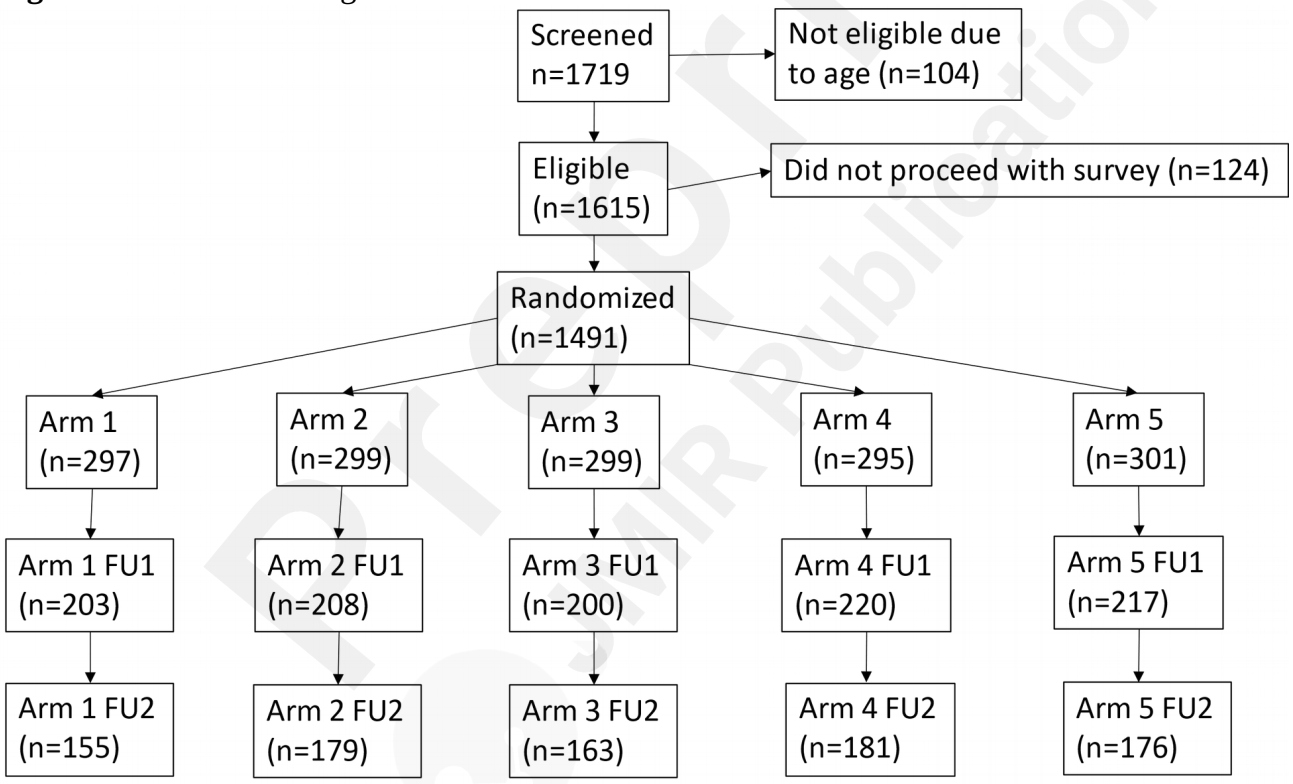
Following baseline, videos were promoted in the live Facebook and Instagram feeds of treatment arm participants in a randomized order and combinations in order to achieve the targeted impressions for each arm (i.e., an average number of impressions per condition). For example, the "low" exposure arm was designed to get 4 impressions would receive a randomly ordered assignment of each video one time, the next highest exposure arm (8 impressions) was designed to get the videos in random order two times, and so on. The actual number of impressions per group varied due to the time of the intervention delivery and was measured at the group level due to confidentiality restrictions Facebook and Instagram place on publicly available user data (i.e., the

exact number of impressions by individual user is not available, only by study condition). This resulted in the use of a 5-level variable corresponding to the 5 treatment arms of increasing intended impressions (Arm 1 = 0 impressions, Arm 2 = 4 impressions, Arm 3 = 8 impressions, Arm 4 = 16 impressions, Arm 5 = 32 impressions).

The study was implemented by Virtual Lab, a social media based data collection and intervention content delivery platform [25]. Participants were recruited via Facebook and Instagram advertising. When a potential participant clicked on a study advertisement, they were asked a series of screening questions using a Facebook Messenger (FM) chatbot. Eligible participants were 18-24 year old US residents within the stratified subgroups, with 50% of these being current vapers. Participants were asked to provide informed consent and participate in the study through a FM survey delivered by the chatbot. After completing the baseline questionnaire, participants were randomized to study condition, received any relevant content over time, and invited to complete the follow up questionnaires.

We used the CONSORT checklist when writing our report [26]. The study design and recruitment procedures are summarized in (Figure 1), CONSORT Diagram. Note that the total retained sample at follow up was 854, but sample sizes for some analyses varied due to participant response patterns.

Figure 1. CONSORT Diagram



Human Subjects Research

This study was reviewed and approved as not greater than minimal risk human subjects research by The George Washington University Institutional Research Board (IRB) on August 5, 2021. Through the FM chatbot, participants read an IRB-approved statement informing them about the purposes and nature of the research. By clicking on a button to proceed to the survey, they provided consent to participate. All data used in this study have been de-identified and stored following the IRB-approved procedure to ensure confidentiality. Participants received a $10 e-gift card as compensation for each survey completed.

Data Collection and Measures

Similar to a pilot study reported by Tulsiani and colleagues (2022), we worked with Virtual Lab to implement the study and collect data [14, 25] The study team created a Facebook business account called “Digital Health Research” to recruit participants and manage data collection, and a second account, “Consumer Consciousness,” to run the target ads on the enrolled participants’ Facebook and Instagram Newsfeeds. The recruitment ads were served to people aged 18-24 years and located in the United States. The ads used the text, “Take a 15 minute survey, get paid $10.” After participants clicked on the study’s ad, they were sent a message via FM inviting them to participate in the study.

The survey was delivered as a series of individual chats through Facebook Messenger using a Chatbot. The survey consisted of 40 items drawn from the tobacco control and campaign evaluation literature [27]. For the current study, we used a subset of the items contained in the survey, following our study objectives. All items were measured on a 5-point agreement scale except where noted (strongly agree to strongly disagree).

Our primary endpoint was future vape intentions, operationalized as the average of responses to two items, which were each answered on a 5-point agreement scale: “Thinking about the future, if one of your best friends offered you an e-cigarette/vape (even one or two puffs) in the coming year, would you smoke it?”, and “Do you think you will use an e-cigarette/vape (even one or two puffs) in the next year?” Our secondary endpoint was anti-industry sentiment, measured as the average of responses to two items, also on a 5-point agreement scale: “Vape companies make me angry” and “I am willing to stand up with others against vape companies.” Our measures of vaping intentions and anti-industry sentiment are both taken from the second follow-up survey. Lastly, we examined self-reported ad exposure. For each of the four ads, participants were asked, “Overall, about how many times to do you think you’ve seen this ad? 1-2 times; 3-5 times; more than 5 times”. Responses were recoded to approximate the average value for each category (“Never” = 0, “1-2 times” = 1.5, “3-5 times” = 4, “more than 5 times” = 6) and an average value across each of these four ads was calculated in order to generate an average value of reported ad exposure. Because we were interested in cumulative exposure, the value for both time points was averaged.

Data Analysis

In order to investigate our hypotheses, a series of multivariate linear regressions were conducted in Stata 17. In order to capture the dose-response effect, rather than treating the five study arms as five independent and nominal groups, we assigned each arm a numerical value corresponding to the number of ads delivered to participants in each arm, and used this number as our focal independent variable. In each model the predictor was the treatment arm to which each participant was assigned. The outcome variables for these regressions were: self-reported ad exposure, anti-industry attitudes/beliefs, and vape use intentions. For each of the multivariate linear regressions the following covariates were included: race/ethnicity (dummy-coded for “non-Hispanic White”, “non-Hispanic Black”, “Hispanic”, “non-Hispanic other“ – “non-Hispanic White” was used as the reference category), gender (dummy-coded for “female”, “male” ,and “another identity/non-binary/transgender” – “female” was used as the reference category), age in years, and baseline use of e-cigarettes (dummy-coded for “Never User”, “Former User”, and “Current User” – “Never User” was used as the reference category).

We included a total of 854 participants retained at FU2 in our analysis. We compared the retained participants to those lost to follow up (LTFU) and found no statistically significant

differences across demographic variables. These results are shown in the Supplemental Table.

Additionally, different efficacy of the treatment was hypothesized for participants based on their use status at baseline. Therefore, each of the above stated models was also conducted on subsamples created by e-cigarette usage at the final wave of data collection (“Never users”, “Former Users”, and “Current Users”). We note that these sub-group analyses were not among the original hypotheses of the study, and were investigated post hoc. All analyses included the full sample, including those lost to follow-up, following intent to treat principles.

Power Analysis

We conducted a statistical power analysis to determine an appropriate sample size. Because of our planned dose-responses analysis, we used correlation analysis as the basis for our calculations. Specifically, we assumed that the correlation between ads delivered in each study arm and vaping intentions at FU2 would be small, as low as 0.1, and used Stata 18 to calculate that a sample of n=783 would be needed to provide 80% power for rejecting the null hypothesis at the conventional alpha=0.05 level. Second, based on the results of some pilot studies, we assumed that up to 45% of baseline participants would be lost to follow-up prior to FU2. Thus, we concluded that the baseline sample should be n=1423, or approximately n=285 participants in each of the five study arms.

Results

(Table 1) provides descriptive statistics for the baseline sample, broken out by treatment arm. We used a Chi-square test to examine any potential differences in demographics between arms, and found no statistically significant differences. Overall, the sample is relatively evenly distributed by ages ranging from 18-24, and just under 48% of the sample is non-Hispanic White. About 8% and 17% of the sample were non-Hispanic Black and of Hispanic ethnicity, respectively. Nearly 69% of the sample was female and about 65% reported having more than enough income to support themselves. Just over 70% reported being heterosexual, with the next largest group reported being bisexual at just under 18%. At baseline, about 21% reported current, past-30 days e-cigarette use and 22% reported former (more than 30 days ago) use.

Table 1.1. Descriptive Statistics by Treatment Arm (n = 854)

	Arm 1 (n=155)	Arm 2 (n=179)	Arm 3 (n=163)	Arm 4 (n=181)	Arm 5 (n=176)
	n (%)	n (%)	n (%)	n (%)	n (%)
Age (χ^2 = .706)					
18	22 (14.19)	20 (11.17)	20 (12.27)	27 (14.92)	20 (11.36)
19	21 (13.55)	24 (13.41)	25 (15.34)	26 (14.36)	19 (10.80)
20	18 (11.61)	24 (13.41)	22 (13.50)	27 (14.92)	28 (15.91)
21	26 (16.77)	34 (18.99)	17 (10.43)	23 (12.71)	22 (12.50)
22	24 (15.48)	26 (14.53)	22 (13.50)	22 (12.15)	32 (18.18)
23	16 (10.32)	28 (15.64)	32 (19.63)	27 (14.92)	23 (13.07)
24	28 (18.06)	23 (12.85)	25 (15.34)	29 (16.02)	32 (18.18)
Race/Ethnicity (χ^2 = .488)					
White, non-Hispanic	78 (50.32)	87 (48.60)	77 (47.24)	85 (46.96)	88 (50.00)
Black, non-Hispanic	8 (5.16)	12 (6.70)	10 (6.13)	18 (9.94)	9 (5.11)
Hispanic	36 (23.23)	28 (15.64)	27 (16.56)	35 (19.34)	29 (16.48)
Other, non-Hispanic	33 (21.29)	52 (29.05)	49 (30.06)	43 (23.76)	50 (28.41)
Sex (χ^2 = .807)					
Female	109 (70.32)	125 (69.83)	117 (71.78)	127 (70.17)	121 (68.75)
Male	45 (29.03)	47 (26.26)	41 (25.15)	48 (26.52)	48 (27.27)
Another identity/Non-Binary/Transgender	1 (0.65)	7 (3.91)	5 (3.07)	6 (3.31)	7 (3.98)
Perceived Financial Situation (χ^2 = .471)					
Lives comfortably	51 (32.90)	63 (35.20)	56 (34.36)	55 (30.39)	58 (32.95)
Meets needs with a little left over	42 (27.10)	64 (35.75)	51 (31.29)	69 (38.12)	54 (30.68)
Meets basic expenses	54 (34.84)	39 (21.79)	47 (28.83)	45 (24.86)	54 (30.68)
Doesn't meet basic expenses	8 (5.16)	13 (7.26)	9 (5.52)	12 (6.63)	10 (5.68)
E-cigarette Use at Baseline (χ^2 = .672)					
Never users	81 (52.26)	108 (60.34)	91 (55.83)	105 (58.01)	102 (57.95)
Former users	40 (25.81)	35 (19.55)	42 (25.77)	41 (22.65)	33 (18.75)
Current users	33 (21.29)	35 (19.55)	30 (18.40)	34 (18.78)	41 (23.30)
Missing	1 (0.65)	1 (0.56)	0 (0.00)	1 (0.55)	0 (0.00)
Sexual orientation (χ^2 = .141)					
Heterosexual	96 (61.94)	105 (58.66)	106 (65.03)	124 (68.51)	105 (59.09)
Bisexual	25 (16.13)	38 (21.23)	25 (15.34)	18 (9.94)	34 (19.32)
Homosexual	11 (7.10)	12 (6.70)	6 (3.68)	10 (5.52)	12 (6.82)
Asexual	3 (1.94)	3 (1.68)	8 (4.91)	3 (1.66)	1 (0.57)
Another sexual orientation	7 (4.52)	6 (3.35)	1 (0.61)	5 (2.76)	6 (3.41)
Missing	13 (8.39)	15 (8.38)	17 (10.43)	21 (11.60)	19 (10.80)

(Table 2) provides a summary of the models for treatment effects with co-variates on vape use intentions by final use status (full sample, never, former, and current users). Overall, there is a significant treatment effect among current vapers on lower vaping intentions (β -.138, p < .035), but

not in the full sample or other sub-groups. We also see effects on lower vaping intentions among Black participants in the full sample and among baseline former and current vapers in the full sample.

Table 2. Treatment Effects on Vape Use Intentions

	Full Sample Analysis (n=836)		Stratified Analyses			
			Never Users (n=478)		Former Users (n=197)	
	β (95% CI)	p	β (95% CI)	P	β (95% CI)	p
Treatment	-.009 (-.059, .040)	.705	.024 (-.026, .074)	.351	.059 (-.051, .169)	.289
Race/ethnicity						
White, non-Hispanic	REF	REF	REF	REF	REF	REF
Black, non-Hispanic	**.321 (.031, .611)**	**.030**	.072 (-.221, .364)	.629	.236 (-.603, 1.07)	.580
Hispanic	.009 (-.180, .198)	.927	.090 (-.099, .280)	.350	-.272 (-.711, .167)	.223
Other, non-Hispanic	.078 (-.092, .249)	.365	.042 (-.124, .209)	.617	.158 (-.225, .541)	.417
Sex						
Female	REF	REF	REF	REF	REF	REF
Male	.099 (-.058, .256)	.217	.072 (-.085, .228)	.367	.096 (-.250, .442)	.585
Another identity / Non-binary / Transgender	.264 (-.144, .672)	.204	.216 (-.230, .663)	.342	.321 (-.414, 1.06)	.391
Age	.002 (-.033, .037)	.895	-.023 (-.058, .012)	.196	-.010 (-.089, .069)	.802
Baseline Use Status						
Never	REF	REF	N/A	N/A	N/A	N/A
Former	**.737 (.564, .910)**	**< .001**	N/A	N/A	N/A	N/A
Current	**1.70 (1.52, 1.88)**	**< .001**	N/A	N/A	N/A	N/A

Note: N for the full sample analyses was 836 due to item non-response and for the stratified analyses was 832.

(Table 3) provides a summary of the models for treatment effects with co-variates on anti-industry attitudes/beliefs, which were the main beliefs targeted by the intervention content (i.e., beliefs that the e-cigarette industry harms its customers). Overall, there is a significant treatment effect among current vapers on anti-industry beliefs (β .120, p < .046), but not in the full sample or other sub-groups. In addition, Black participants were more likely to report intention to vape than non-Hispanic White participants, and current and former vapers were more likely to report intention to vape than participants who had never vaped.

Table 3: Treatment Effects on Anti-Industry Attitudes/Beliefs

	Full Sample Analysis (n=838)	Stratified Analyses	
		Never Users (n=479)	Former Users (n=198)

	β (95% CI)	p	β (95% CI)	P	β (95% CI)	p
Treatment	.020 (-.027, .067)	.409	.007 (-.052, .067)	.811	-.065 (-.164, .033)	.191
Race/ethnicity						
White, non-Hispanic	REF	REF	REF	REF	REF	REF
Black, non-Hispanic	**-.409 (-.681, -.137)**	**.003**	-.203 (-.553, .147)	.255	-.988 (-1.673, -.303)	.005
Hispanic	.025 (-.153, .204)	.783	-.064 (-.290, .162)	.576	.120 (-.273, .512)	.549
Other, non-Hispanic	**-.245 (-.406, -.084)**	**.003**	**-.246 (-.444, -.047)**	**.015**	**-.385 (-.725, -.045)**	**.027**
Sex						
Female	REF	REF	REF	REF	REF	REF
Male	-.140 (-.288, .009)	.066	-.107 (-.294, .080)	.262	-.016 (-.325, .292)	.917
Another identity / Non-binary / Transgender	.003 (-.383, .022)	.988	-.080 (-.613, .454)	.769	.345 (-.309, .999)	.299
Age	-.011 (-.044, .022)	.507	-.009 (-.051, .032)	.667	-.031 (-.100, .039)	.388
Baseline Use Status						
Never	REF	REF	REF	REF	REF	REF
Former	**-.357 (-.520, -.193)**	**< .001**	N/A	N/A	N/A	N/A
Current	**-.622 (-.792, -.451)**	**< .001**	N/A	N/A	N/A	N/A

Note: N for the full sample analyses was 838 due to item non-response and for the stratified analyses was 834.

(Table 4) provides a summary of the models for treatment effects with co-variates on self-reported ad exposure. There is no main effect of treatment on reported ad exposure among any of the population groups of interest. Additionally, we see higher self-reported ad exposure among Black participants in the full sample and exposure of intervention content was higher among baseline never vapers and baseline current 30-day vapers. It's possible that the lack of relationship between treatment group and reported ad exposure is due to insufficient elapsed time during the intervention time period to achieve the intended number of impressions per group, which resulted in participants in the fourth and fifth group receiving similar levels of impressions. The average impressions delivered per user per treatment arm were as follows: Arm 1 = 0, Arm 2 = 2.293, Arm 3 = 7.708, Arm 4 = 12.718, Arm 5 = 14.218.

Table 4. Treatment Effects on Self-Reported Ad Exposure

	Full Sample Analysis (n=730)		Stratified Analyse			
			Never Users (n=407)		Former Users (n=18	
	β (95% CI)	p	β (95% CI)	P	β (95% CI)	
Treatment	-.004 (-.042, .034)	.826	-.020 (-.069, .030)	.437	-.006 (-.068, .055)	.8
Race/ethnicity						
White, non-Hispanic	REF	REF	REF	REF	REF	R
Black, non-Hispanic	**.312 (.087, .536)**	**.007**	.681 (.392, .969)	< .001	.143 (-.263, .549)	.4
Hispanic	-.071 (-.216, .075)	.340	-.160 (-.350, .030)	.099	.008 (-.236, .254)	.9
Other, non-Hispanic	**-.187 (-.317, -.057)**	**.005**	-.260 (-.426, -.094)	.002	-.155 (-.364, .055)	.1
Sex						
Female	REF	REF	REF	REF	REF	R
Male	.088 (-.030, .207)	.144	-.036 (-.189, .117)	.644	.106 (-.084, .296)	.2
Another identity / Non-binary / Transgender	-.064 (-.376, .028)	.688	.167 (-.308, .643)	.490	-.124 (-.512, .265)	.5
Age	.001 (-.026, .028)	.929	-.007 (-.042, .027)	.674	-.012 (-.055, .031)	.5
Baseline Use Status						
Never	REF	REF	N/A	N/A	N/A	N
Former	-.080 (-.211, .052)	.236	N/A	N/A	N/A	N
Current	.124 (-.014, .262)	.079	N/A	N/A	N/A	N

Note: N for the full sample analyses was 730 due to item non-response and for the stratified analyses was 726.

Discussion

E-cigarette use among young adults is a significant public health threat. Use rates dropped early in the COVID-19 pandemic, but have seen a resurgence in the later stages of this public health emergency [28]. Innovative strategies to deliver anti-vaping messages and reduce use intentions and behavior are needed. Given the high levels of social media use among adolescents and young adults, and especially engagement with pro-vaping content [29], interventions using social media are an important intervention channel for experimentation and population level campaigns.

Principle Results

Overall, this study found significant effects in the direction expected for intentions and anti-industry sentiment. Our H1 was partially confirmed: There was a significant treatment effect on both anti-industry beliefs and lower vaping intentions, but these effects were limited to current e-cigarette users and were not observed among never or past users or in the full sample analyses.

This study partially confirmed H2: Higher levels of treatment (i.e., from Arms 1-5) were associated with the anti-industry beliefs and vaping intentions outcomes of interest. However, we did not observe a direct or dose-response effect of the intervention on content exposure outcomes (i.e., awareness of the specific social media posts used as stimulus in the study). This is typically the most proximal outcome resulting from a campaign, the absence of these anticipated effects deserves further investigation.

One possible explanation is that the experiment did not completely achieve the intended levels of impressions intended for each study arm. In particular, the level of impression achieved at the highest exposure arms (4-5) were quite similar, whereas the intent was to double the number of impressions in each arm. This may be an artifact of the length of time our intervention was in the field, which was only 60-days. Total social media impressions are typically a function of a length of a campaign, and longer study durations may result in more closely matching intended exposure levels by study condition [30-31].

The observed effects of treatment on anti-industry beliefs are consistent with the content of the intervention content, which focused on messages exposing the mis/disinformation that e-cigarette companies use in their marketing and the idea that their products and practices are harmful to consumers. This study provides evidence to support the idea that targeted campaign messages can directly impact attitudes and beliefs focused on the content of those messages. Future studies should examine approaches to optimize these observed effects.

The observed effects on lower vape use intentions suggest that there may be a connection between anti-industry beliefs and future use among current users. If young adults believe that the industry is using mis/disinformation and selling a harmful product, they may reconsider their current use [32]. This suggests a potential mediation effect of anti-industry beliefs on intentions, and potentially on e-cigarette use. The hypothetical pathways of effects should be formally evaluated in future studies.

Future Directions

One question raised by this study's findings for vaping intentions and anti-industry beliefs is why we did not see effects among former and never vapers. Perhaps it is simply harder to shift beliefs and intentions in those other groups than among current vapers. Or perhaps messages focused on topics and persuasive content other than anti-industry sentiment may be, needed for those groups. Additionally, selective attention bias (i.e., the personal relevance of vaping-related content) suggests that vapers may be more responsive to the anti-vaping social media content used in this study [33]. Future research should examine these questions.

To fully examine dose-response effects of social media interventions, longer time durations may be needed, and larger small sample sizes per study arm may be needed, especially given attrition at follow up. Cell sizes between the study conditions were reduced at the second follow up, which may have reduced statistical power below levels needed to detect some dose-response outcomes of interest. Previous studies have shown dose response effects of anti-industry messaging on vaping related content exposure and attitudinal outcomes [14].

This study also contributes to the growing literature on public health social media interventions and theories of change [34-35]. The current research further demonstrates the potential of a social media based research and intervention delivery platform to build evidence in tobacco control. Future studies should expand on this research with longer-term longitudinal studies capable of potentially detecting treatment effects on vaping use behavior, examine diverse subgroups of interest, including high risk groups for e-cigarette use, and examine multiple types of social media content. Finally, the demonstrated effects of social media on intentions and other outcomes related to vaping should be considered in formulating tobacco control policy, including recommendations for effective comprehensive prevention and cessation interventions [36].

Limitations

Finally, this study has some limitations. First, it was conducted over a relatively short period of time (60 days), and thus only intermediate outcomes were evaluated. Additionally, the time duration may have limited our ability fully generate the intended differences in objective impressions created within each study arm. We observed substantial LTFU (over 40%) at the second followup survey. Future social media studies should make extensive efforts to limit LTFU, especially when following participants over longer periods of time. Second, our original data analysis plan did not include an explicit plan to stratify by vaping status, and relatedly, the size of our sample was based on power calculations that assumed whole-sample rather than stratified analysis. The post-hoc nature of those stratified analyses should be borne in mind when interpreting the findings of this study. Additionally, the Truth Initiative content used for the stimulus had previously aired, and prior exposure may have limited its treatment potential. Finally, while observed effects of the intervention occurred among current vapers, the study was not powered by subgroups. Finally, we made multiple comparisons in our analyses, which raises the possibility of false-positive findings. Future studies should utilize previously unaired content, where possible, and ensure sufficient sample size among specific subgroups of interest, where feasible (i.e., power at the sub-group level).

Conclusions

Social media interventions are a promising approach to preventing vaping among young adults [13]. More research is needed on how to optimize dosage of such interventions and long-term effects on vaping use over time. Social media based research platforms are a promising methodology to conduct experimental public health research among specific priority populations.

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Data Availability: A data sharing agreement is required for use of all data. Our research team does not share data with tobacco industry representatives or affiliated researchers. Investigators seeking access to data used in the study should make a written request to the corresponding author and submit a detailed research plan including the purpose of the proposed research, required variables, duration of the analysis phase, IRB approval, with FWA information and documentation of investigator training in human subjects.

Abbreviations:

FM: Facebook Messenger
TOH: Tested on Humans
LTFU: Lifetime follow-up
FWA: Federal-wide Assurance

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Supplementary Files

Untitled.
URL: http://asset.jmir.pub/assets/00e12af9bfaff9c3ae4aabaa0ba58d64.docx

Multimedia Appendixes

Untitled.
URL: http://asset.jmir.pub/assets/6cb33ffa8c79fe88f44628920101bf8c.docx

Supplemental Table. Comparison of Recruited and Retained Samples.
URL: http://asset.jmir.pub/assets/9a9cd6cd6d4b15189dc649253bf40c7f.pdf