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Evaluation of a Social Media Campaign Designed to Increase Awareness of Thirdhand Smoke among California Adults

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ABSTRACT

Despite a growing body of research outlining the harms of thirdhand smoke (THS), the public remains generally unaware of risks and exposure routes. This project built on past tobacco prevention campaigns and the tenants of McGuire's input-output model to implement and evaluate a seven-month Facebook-disseminated campaign seeking to improve THS awareness among California adults ($n = 1087$). Multilinear regression showed that THS-related knowledge ($\chi^2[6] = 19.31$, $p < .01$), attitude ($\chi^2[6] = 13.88$, $p < .05$), and efficacy ($\chi^2[6] = 13.81$, $p < .05$) significantly increased by the campaign's end, with messages highlighting children's health ($r = .110$, $p < .05$), pets ($r = .145$, $p < .01$), and dust reservoirs ($r = .144$, $p < .01$) as the most persuasive. Path analysis modeling found campaign recall to be associated with changes in knowledge ($\beta = .161$, $p < .01$), which predicated attitude change ($\beta = .614$, $p < .001$) and, in turn, behavior change ($\beta = .149$, $p < .05$). Findings suggest social media campaigns should continue to educate diverse populations about new tobacco risks and that tobacco control advocates should consider integrating educational THS messages.

For half a century, health communication campaigns have been at the forefront of efforts to reduce the burden of tobacco-related diseases (Centers for Disease Control & Prevention, 2014). Although tobacco use remains the most preventable cause of death in the United States (U.S. Department of Health and Human Services, 2014), cigarette use has steadily declined over recent decades (Creamer et al., 2019) with evidence pointing to effective communication campaigns as a substantial contributor to that success (Allen et al., 2015). Despite this accomplishment, the US is far from free of the health and economic costs associated with the tobacco epidemic.

New research suggests that decades of permissive indoor smoking norms have left a legacy of persistent toxic pollutants (Jacob et al., 2017; Matt et al., 2011). This neglected form of tobacco exposure, called thirdhand smoke (THS), perpetuates public risk of tobacco-related disease and death. THS is the toxic chemical residue left in indoor environments after the smoking stops (Matt et al., 2011). As scientific understanding of THS grows, calls for THS prevention and educational materials also increase (Escoffery et al., 2013; Jacob et al., 2017; Matt et al., 2011; Winickoff et al., 2009). Health communication campaigns are needed to bridge gaps in public awareness of THS-related risks in order to promote behavior change and implement policies to reduce exposures.

Building on past tobacco prevention campaigns and employing the tenants of McGuire's input-output model, this study tested the effects of social media-based campaign messages on improving THS-related knowledge, attitude, efficacy, and behavior in California adults. Changing these perceptions is central to reducing exposure to tobacco-related pollutants in indoor environments, thereby reducing the burden of tobacco-related disease and death.

Thirdhand smoke exposure

THS is the toxic residue left behind from the smoke of cigarettes and cigars, (Matt et al., 2011). THS sticks to surfaces, accumulates in dust, and becomes embedded in everything from carpets and furniture to toys and pillows (Matt et al., 2004, 2008). The residue, which contains a mixture of toxic chemicals, including several known to cause cancer and asthma (Jacob et al., 2017), persists in indoor environments for months to years after smoking stops (Matt et al., 2020, 2021). Humans are unintentionally exposed to these chemicals through skin absorption, breathing, and ingestion (Matt et al., 2011). Studies have found exposure to THS directly damages DNA, induces oxidative stress, and changes reproductive cell function(Hang et al., 2017; Martins-Green et al., 2014). Children are most at risk for negative health effects (Jacob et al., 2017; Northrup et al., 2016). Despite the growing evidence of the harms of THS exposure, social scientific research has found that the public is unaware of the harms of THS exposure.

People recognize THS by the odor of stale tobacco smoke or tobacco stains on walls. However, most people do not make the connection between these experiences and the term THS or the potential negative health effects of exposure. In focus group discussions of smoke-free homes, Escoffery et al. (2013) found

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that most of their participants had not heard of the term THS. Similarly, in a survey of over 1,400 US adults, Winickoff et al. (2009) found that only 65.2% of nonsmokers and 43.3% of smokers believed that THS could harm children. Given these gaps in public knowledge and the potential for harm, public health education efforts, such as health communication campaigns, are needed to increase public awareness of the presence of, and risks of exposure to, THS.

Tobacco prevention campaigns

A large body of research demonstrates the success of health communication campaigns in reducing smoking-related death and disease (Allen et al., 2015; Centers for Disease Control & Prevention, 2014; Wilson et al., 2012). More specifically, research has credited health communication campaigns with helping to lower the US smoking rate (e.g., Davis et al., 2008; Durkin et al., 2012), reduce youth initiation (e.g., Farrelly et al., 2009), increase quit attempts among smokers (e.g., Brown et al., 2014), change beliefs about smoking (e.g., Hwang, 2012), reduce the risk of smoking relapse (e.g., Wakefield et al., 2013), and increase tobacco-free policy compliance (e.g., Record et al., 2017). After many decades of successful print and traditional media-based approaches, such as television and radio spots, tobacco prevention campaign approaches have moved to online and social media platforms.

Research has supported the effectiveness of online tobacco prevention campaigns for increasing cessation-related information seeking (e.g., Kim et al., 2016), outreach and dissemination efforts (e.g., Chung, 2016), access for hard-to-reach populations (e.g., Elser et al., 2019), and perceived risk of smoking (e.g., Lee & Chen, 2017). Thus, online platforms can be effective campaign channels for reaching target audiences. As for what messages to disseminate online, best practice calls for developing persuasive approaches that follow theoretical and evidence-based guidelines (Atkin & Freimuth, 2013).

Theoretical approaches to communication campaigns

McGuire's input-output model (McGuire, 1968) was proposed as a theoretical explanation of the persuasive process surrounding mass media campaigns. The model follows a stepwise approach positing that evidence-based decisions of five key inputs (i.e., goal, source, message, channel, and receiver) will trigger ten outputs as products of the persuasive process (McGuire, 1985). More specifically, the model proposes that campaigns are most effective when evidence-based decisions guide [1] identification of a focused and tangible goal, [2] use of credible information, [3] careful message creation with the target audience, [4] audience-based channel selection, and [5] audience segmentation (McGuire, 2013). Through these five central strategies, sequential persuasive processes occur beginning with audience exposure and leading to increases in attention, interest, and knowledge. Following the occurrence of these processes, changes in attitude occur and influence outputs: memory storage and retrieval, behavior, and continued behavioral performance (McGuire, 2013).

In determining which outputs to assess, researchers typically turn to other theories or key findings in the literature to identify which outputs are most appropriate for their persuasive goals (Bull et al., 2001). In health behavior change research, the most common constructs examined to evaluate behavior change are knowledge, attitude, and efficacy. Consistent with the early presence of knowledge in McGuire's (2013) output list, Maibach and Cotton (1995) articulate the requirement of a sufficient amount of knowledge to make perception-based and behavioral changes. Logically, improving knowledge will be most important for less-known health topics, such as THS. In addition to knowledge as a key persuasive construct, theoretical reviews consistently find the constructs of attitude and efficacy are among the most common in theories and models focused on the processes surrounding health-related behavior change (see Fishbein et al., 2001; Noar, 2004; Noar et al., 2008). The theoretical emphasis on the constructs of knowledge, attitude, and efficacy is reinforced across decades of applied research.

Recent tobacco prevention research echoes the theoretical assumptions of knowledge, attitude, and efficacy as key factors in behavior change. Studies have shown knowledge of smoking-related harms is higher among nonsmokers than smokers (Ahluwalia et al., 2018) with knowledge positively associated with increased cessation (Chow et al., 2017) and reduced intention to smoke (Palipudi et al., 2012). Similarly, studies have shown attitude is a determinant of intention to smoke and active smoking (Lareyre et al., 2020; Su et al., 2015) and efficacy is a determinant of cessation (Elshatarat et al., 2016) and intention to smoke (Lareyre et al., 2020; Su et al., 2015). Such consistent findings surrounding the role of knowledge, attitude, and efficacy suggest that these variables will be key determinants of THS-related behavior. Thus, this THS awareness campaign sought to change the outputs of knowledge, attitude, and efficacy to promote positive behavior change.

Purpose

The purpose of this quasi-experimental study was to evaluate the effectiveness of a public health campaign at increasing THS awareness, as measured by knowledge, attitude, efficacy, and behavior. Two hypotheses were tested. The first hypothesis sought to evaluate the general extent to which the primary outcomes changed from the beginning until the end of the campaign.

H_1: (a) Knowledge, (b) attitude, (c) efficacy, and (d) behavioral intention related to thirdhand smoke will increase from baseline to the final posttest.

Assuming at least part of H_1 would be supported, this study also posed a research question to explore the extent to which particular campaign message were persuasive.

RQ_1: Which campaign messages will be most positively associated with changes in primary outcomes?

Finally, building on past research and theoretical expectations, the second hypothesis sought to test the role of campaign recall in the behavior change process. The tested model with hypothesized paths is displayed in Figure 1.

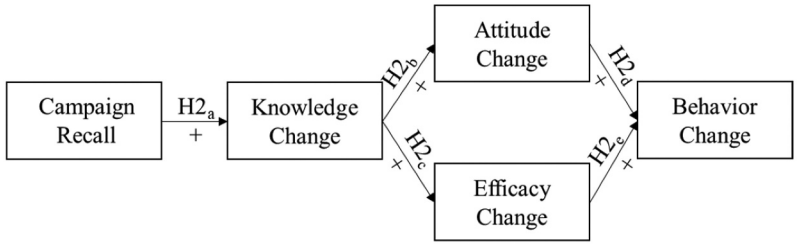

Figure 1. Hypothesis 2 Model from Campaign Recall to Behavior Change.

Method

Procedures & message development

The goal of the campaign was to increase THS awareness among California adults. Given the lack of awareness surrounding the science of THS, the target audience can be understood as an uninvolved audience that is not actively seeking information and is unlikely to be aware of the personal relevance of the topic (Parrott, 1995). Louis and Sutton (1991) suggest three persuasive approaches to engage an uninvolved audience. The most applicable to the context of THS is the presentation of content that shows a discrepancy between expectations (e.g., I am a nonsmoker therefore I am not exposed to tobacco smoke) and reality (e.g., nonsmokers can be exposed to tobacco smoke if someone else previously smoked in the environment). This discrepancy was emphasized by highlighting the unexpected reality of THS risk factors, exposure routes, and impacts on people, pets, and property through an emphasis on children, traveling, pets, and enclosed environments, such as cars, apartments, and homes. Because the majority of US adults use social media, and 69% of those use Facebook (Perrin & Anderson, 2019), campaign messages were disseminated over a seven-month period as advertisements on the Facebook platform.

Message development followed the guidelines outlined in Atkin and Freimuth (2013). Following a thorough review of the literature on effective tobacco prevention strategies for the target audience, we developed fifteen potential campaign messages that were iteratively reviewed by content and persuasion experts. The final draft messages were focus group tested with members of the target audience in the Los Angeles area; participants received a 50 USD gift card in appreciation for their time. Based on focus group feedback, the fifteen messages were reduced to seven, which can be seen in Figure 2. These messages were formatted to fit the look and advertising requirements of Facebook.

Participants

Five weeks before the campaign launched, participants were recruited via a recruitment advertisement posted to Facebook. Using Facebook algorithms for advertisement targeting, the audience was defined in the Facebook advertising system as: California adults of low to middle socioeconomic status interested in children, travel, pets, cars, apartments, or real estate. With these keywords, Facebook estimated the sampling frame at 24 million users.

Recruitment occurred during October 2019 with a 4,500 USD advertising budget. Individuals who clicked the advertisement were directed to the baseline survey. Facebook estimates the advertisement produced 283,942 impressions (i.e., number of news feeds on which the advertisement appeared) with 175,872 unique individuals reached (i.e., the advertisement fully loaded). Of those reached, Facebook recorded 2,959 advertisement clicks. Of those who clicked the advertisement, 1,755 attempted to participate in the Qualtrics baseline survey. Excluding participants who did not provide e-mail addresses for follow-up (n = 612) and duplicates (n = 56), 1,087 unique participants were included in the study. Participants agreed to a panel design study, receiving an invitation to complete one survey a month for seven months. Across the intervention, participants were incentivized as follows: five participants were randomly selected to receive a 150 USD Amazon gift card at the first and last wave; three participants were randomly selected to receive a 50 USD Amazon gift card at the other five waves.

Intervention

At the conclusion of recruitment, the seven campaign messages were posted as Facebook advertisements daily for four months (November 13, 2019 through March 13, 2020) using the same targeting terms as the recruitment advertisement (i.e., using the Facebook defined audience via the specified keywords). The advertisements were run at the same rate in Facebook, meaning each message was pushed equally by its algorithm. The budget for the campaign messages was 10,500. USD After four months, the messages recorded 1.89 million impressions, reached 679,553 users, and had 15,752 advertisement clicks. The conversion rate of advertisement clicks from reach was 2.3%. When clicked, the campaign messages directed users to pre-determined pages on the Thirdhand Smoke Resource Center website (thirdhandsmoke.org) with relevant content (see individual advertisement landing pages, impressions, and clicks in Figure 2). Each month, the 1,087 participants received an invitation (and two reminders) to complete the next survey.

Measures

All seven surveys included items to assess social media use, primary outcomes (i.e., knowledge, attitude, efficacy, and behavior), and reported THS exposure. During the campaign, surveys

Another Cold

https://thirdhandsmoke.org/news-and-updates/people/

Impressions: 52,279
Link Clicks: 346
Recall: *n*=69, *m*=.12, SD=.59

Cars

https://thirdhandsmoke.org/news-and-updates/transport/

Impressions: 507,626
Link Clicks: 3,610
Recall: *n*=19, *m*=.03, SD=.30

Dust

https://thirdhandsmoke.org/news-and-updates/things/

Impressions: 158,091
Link Clicks: 2,021
Recall: *n*=17, *m*=.02, SD=.20

Home Values

thirdhandsmoke.org/news-and-updates/places/

Impressions: 18,723
Link Clicks: 95
Recall: *n*=51, *m*=.12, SD=.71

Hotel

thirdhandsmoke.org/news-and updates/places/

Impressions: 191,062
Link Clicks: 1,400
Recall: *n*=11, *m*=.02, SD=.25

Little Hands

https://thirdhandsmoke.org/news-and-updates/people/

Impressions: 906,422
Link Clicks: 7,857
Recall: *n*=38, *m*=.07, SD=.47

Pets

https://thirdhandsmoke.org/news-and-updates/people/

Impressions: 53,451
Link Clicks: 432
Recall: *n*=72, *m*=.15, SD=.79

Figure 2. Campaign Messages as Shown on Facebook with Landing Pages, Clicks, Impressions, & Independent Message Recall.

also included items to assess message recall. Demographic characteristics were collected at baseline. Table 1 presents demographics and primary outcomes for each wave.

Knowledge

The development of the adapted eight-item knowledge measure is described in detail elsewhere (see Record et al., 2021). Response options were on a 5-point Likert-type scale from *strongly disagree* to *strongly agree*. Example items include: *Thirdhand smoke contains dangerous chemicals; Thirdhand smoke can linger in hotel rooms where guests have smoked*; and *Thirdhand smoke can make kids sick*. The scale total score means and standard deviations ranged from m = 4.38 to 4.50 and SD = 0.58 to 0.67 across the seven measurement waves.

Attitude

To assess attitude, seven attitude items were adapted from established SHS and THS measures (see Record et al., 2021 for full scale development). Example items are: *Hospitals should hire only nonsmokers; Sellers should be required to disclose if someone has smoked in their home*; and *Childcare providers should be nonsmokers*. Response options were on a 5-point Likert-type scale from *strongly disagree* to *strongly agree*. Across the seven measurement waves, the scale total score

Table 1. Demographic Characteristics & Descriptive Statistics of Outcome Measures among Participating California Adults by Wave.

	Wave 1 (Pre)	Wave 2 (During)	Wave 3 (During)	Wave 4 (During)	Wave 5 (During)	Wave 6 (Post)	Wave 7 (Post)
N(% Attrition Wave 1)	1087	326 (−68%)	315 (−69%)	278 (−73%)	253 (−75%)	238 (−77%)	301 (−71%)
Yes/No (%)							
Smoker	18%	13%	13%	14%	15%	17%	17%
Female	82%	78%	82%	83%	85%	83%	83%
White	70%	65%	68%	67%	69%	72%	70%
Employed full/part-time or retired	68%	69%	67%	68%	66%	69%	62%
Associate degree or less	65%	55%	56%	58%	56%	55%	60%
Homeowner	38%	37%	34%	37%	38%	39%	37%
Single family home	61%	59%	58%	58%	58%	58%	61%
Cat or dog in home	65%	61%	62%	60%	62%	63%	62%
Traveled past year	86%	85%	83%	85%	84%	84%	85%
Rented car past year	30%	31%	30%	30%	32%	34%	32%
M(SD)							
Age	43.09 (18.87)	41.06 (17.64)	41.90 (18.28)	42.76 (18.10)	44.59 (17.95)	44.66 (18.18)	43.08 (18.46)
Days on Facebook past month	22.02 (11.70)	22.26 (11.52)	21.75 (11.94)	22.75 (11.41)	23.53 (11.15)	23.24 (11.47)	22.93 (11.48)
Adults ≥ 18 living in home	2.79 (3.02)	2.72 (1.37)	2.72 (1.35)	2.71 (1.32)	2.61 (1.25)	2.68 (1.28)	2.67 (1.32)
Child ≤ 17 living in home	0.70 (1.41)	0.50 (1.06)	0.56 (1.15)	0.53 (1.20)	0.51 (1.07)	0.49 (1.03)	0.49 (1.02)
Knowledge Scale	4.38 (0.64)	4.47 (0.60)	4.46 (0.63)	4.48 (0.64)	4.45 (0.61)	4.43 (0.67)	4.50 (0.58)
Attitude Scale	4.04 (0.80)	4.13 (0.73)	4.12 (0.80)	4.14 (0.81)	4.17 (0.78)	4.12 (0.83)	4.20 (0.75)
Efficacy Scale	3.57 (0.90)	3.59 (0.87)	3.58 (0.91)	3.60 (0.91)	3.69 (0.89)	3.76 (0.88)	3.77 (0.85)
Behavior Scale	3.79 (0.94)	3.84 (0.95)	3.79 (0.99)	3.78 (1.01)	3.79 (0.99)	3.82 (0.97)	3.86 (0.99)

Data collected pre COVID-19 stay-at-home orders.

means and standard deviations ranged from m = 4.04 to 4.20 and SD = 0.73 to 0.83.

Efficacy

Following Bandura (1977), efficacy was conceptualized as the ability to successfully avoid THS exposure. Four items were adapted from Sherer et al. (1982). Response options were on a 5-point Likert-type scale from *strongly disagree* to *strongly agree*. All items responded to the stem, *I am able to*. Example items include: *avoid exposure to thirdhand smoke; determine if a place is smokefree*; and *ask people not to smoke around me*. Principal component factor analyses revealed high first-factor saturation at six of the seven waves, supporting single-factor loadings and explained variance above 50% (eigenvalue range: 2.14–2.40; variability range: 54–60%). Similarly, across all seven waves, Cronbach's Alpha supported low, but acceptable measure reliability (range: .70-.78). Scale score distributions were approximately normal, and the scale total score means and standard deviations ranged from m = 3.57 to 3.77 and SD = 0.85 to 0.91 across the seven measurement waves.

Behavior

Five items to assess behavior were adapted from established measures of preventative behaviors related to SHS (see Record et al., 2021 for full psychometric development). This adaptation included items that assess both behavioral intention and actual behavior. Examples include: *I would buy furniture from a smoker; I would buy a car that has been smoked in*; and *In general, I avoid places where people have smoked*. Response options were on a 5-point Likert-type scale (*strongly disagree* to *strongly agree*). Across the seven measurement waves, the scale total score means and standard deviations ranged from m = 3.78 to 3.86 and SD = 0.94 to 1.01.

Campaign recall

The approach to assessing campaign recall follows Record et al. (2017). Participants were shown all seven campaign images and asked to select which they recalled seeing over the last month and, for those they recalled seeing, how frequently they recalled having seen them from once or twice to every day (i.e., 1 = *once or twice*, 2 = *every week*, 3 = *most days*, 4 = *every day*). Participants who did not report that they recalled seeing the images were automatically coded as "never" seeing the advertisement. Thus, the final measure was a five-point scale ranging from 0 to 4 (m = 1.23, SD = 3.17) with individual message recall ranging from m = .02 (SD = .25) to m = .15 (SD = .15); see Figure 2 for individual recall for each message.

Data analysis

Participants with six or more missing item responses across the measures of knowledge, attitude, efficacy, and behavior were excluded from the within-wave analysis. Using this criterion, six participants (0.4%) had insufficient data and were excluded from a within-wave analysis. For participants with fewer than six missing responses, hot-deck imputation (Andridge & Little, 2010) in Stata (2019) was used, replacing missing values via variable matching based on within wave gender and smoking status (n = 26, 2.4%). The approach replaces the missing data with a randomly select response from the matched options. Reported regression analyses were completed in Stata; reported path analyses were run in AMOS (IBM SPSS, 2019); all other analyses were performed in IBM SPSS (2019).

To explore change over time across the primary outcomes, a mixed linear random effects model, where subjects were the random factor and time was a fixed factor, was run with all seven time points controlling for demographic factors. To account for change over time, covariance structures were modeled with an autoregressive residual structure. For all regressions in which the

omnibus effect of *time* was significant (two-tailed, $p < .05$), polynomial contrasts testing linear, quadratic, and cubic relationships were tested to probe for nonlinear associations. *D*-effect sizes were calculated comparing the means of waves 2 through 7 to wave 1 using the square root of the pooled variance across all 7 waves. Overall change in knowledge, attitude, efficacy, and behavior, was assessed by subtracting composite mean scores for the primary outcome variables at time 1 from time 7, with positive scores indicating positive change. To assess message exposure, participant recall for each message was summed across all seven timepoints. Finally, path analysis following maximum likelihood estimations was modeled to explore theoretically expected persuasive routes.

Results

Among the 1,087 participants, 124 (11%) completed all seven waves of data collection with follow-up participation ranging from 238 to 326 participants per wave. Preliminary analyses found that prior to the study, 63.5% of participants had not heard of the term THS. Compared to those without prior awareness, independent samples *t*-test did not find individuals with prior awareness of THS to differ regarding changes in attitude, knowledge, efficacy, and behavior. Select demographic data are presented in Table 1; perceptions of THS and personal exposure in the past 30 days are presented in Table 2. Regarding social media use, at each wave, participants logged into Facebook the majority of the last 30 days (m_{range} = 22.0–23.5, SD_{range} = 11.4–11.9), with most participants believing they were either just as active or more active than their peers on Facebook (range: 67.7%-73.6%). Pearson *r* correlations showed a weak nonsignificant association between Facebook use and recall of campaign messages.

The first hypothesis expected (a) knowledge, (b) attitude, (c) efficacy, and (d) behavioral intentions related to THS exposure to improve from the first wave to the last wave. For each outcome variable, a mixed linear regression model was run. As shown in Table 3, smoking history, prior awareness of THS, and age were significantly predictive across the four outcomes with race and gender predictive of efficacy and behavior (respectively). As shown in Figure 3, analyses found a significant omnibus effect of time on knowledge ($\chi^2[6] = 19.31$, $p < .01$) following a cubic relationship ($\hat{\beta} = 0.02$, SE = 0.007, $\chi^2[3] = 13.15$, $p < .01$), on attitude ($\chi^2[6] = 13.88$, $p < .05$) following a positive, although nonsignificant, linear relationship ($\hat{\beta} = 0.03$, SE = 0.02, $\chi^2[1] = 3.00$, $p = .08$), and on efficacy ($\chi^2[6] = 13.81$, $p < .05$) linearly ($\hat{\beta} = 0.06$, SE = 0.02, $\chi^2[1] = 8.33$, $p < .01$). Behaviors did not significantly change over time. Thus, $H1_{a\text{-}c}$ were supported and $H1_d$ was not supported.

To explore the extent to which each campaign message was individually persuasive, associations between individual message recall and change in the primary outcomes were examined. Recall varied between messages from *m* = .02 (*SD* = .25) to *m* = .15 (*SD* = .15). Pearson *r* correlations found changes in knowledge to be weakly but positively associated with exposure to Another Cold ($r = .110$, $p < .05$, $r^2 = .01$), Pets ($r = .145$, $p < .01$, $r^2 = .02$), and Dust ($r = .144$, $p < .01$, $r^2 = .02$). Similarly, changes in attitude were weakly but positively associated with

Table 3. Relationships between covariates and THS-Related Knowledge, Attitude, Efficacy, and Behavior.

Outcome	Covariate (*df*)	$\hat{\beta}$	SE	*z*	χ^2
Knowledge	Gender (*4*)				8.25
	Race (*7*)				9.84
	Ethnicity (*2*)				2.58
	Smoking history	−.17***	.04	−4.71	
	Prior THS knowledge	.12***	.04	3.49	
	Age	.003*	.001	2.45	
	[+]Participation (*4*)				2.81
Attitudes	Gender (*4*)				1.65
	Race (*7*)				5.02
	Ethnicity (*2*)				0.16
	Smoking history	−.35***	.05	−7.19	
	Prior THS knowledge	.09	.05	1.9	
	Age	.002	.001	1.4	
	[+]Participation (*4*)				1.11
Efficacy	Gender (*4*)				6.37
	Race (*7*)				21.27**
	Ethnicity (*2*)				0.41
	Smoking history	−.04	.05	−0.75	
	Prior THS knowledge	.15**	.05	3.16	
	Age	.01***	.001	7.86	
	[+]Participation (*4*)				1.53
Behavior	Gender (*4*)				9.83*
	Race (*7*)				5.50
	Ethnicity (*2*)				0.31
	Smoking history	−.49***	.06	−8.35	
	Prior THS knowledge	.13*	.06	2.35	
	Age	.01***	.002	4.67	
	[+]Participation (*4*)				1.47

*$p < .05$; **$p < .01$; ***$p < .001$; [+]Number of waves completed (min 1, max 7); Unstandardized coefficients from the mixed linear regression models.

Table 2. Reactions to THS and Self-Reported Exposure to Tobacco Smoking and Vaping in Past 30 Days by Wave.

	Pre	Intervention				Post	
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5[a]	Wave 6 [a]	Wave 7 [a]
*Select your level of agreement, m(SD)							
I find the smell of stale tobacco smoke unpleasant.	4.48 (1.06)	4.60 (0.87)	4.61 (0.88)	4.59 (0.81)	4.63 (0.87)	4.58 (0.91)	4.63 (0.80)
Stale cigarette smoke makes me feel ill.	3.96 (1.21)	3.95 (1.12)	4.07 (1.09)	4.07 (1.08)	4.01 (1.09)	3.97 (1.13)	4.07 (1.06)
[+]In the last month … (%)							
No one smoked inside my home.	86%	88%	89%	89%	91%	88%	88%
No one vaped inside my home.	84%	87%	87%	87%	89%	89%	89%
I was in a place that smelled of stale tobacco smoke once or twice.	56%	51%	50%	45%	37%	36%	36%
I have not spent time with a family member, friend, or coworker who smokes cigarettes.	45%	51%	51%	54%	60%	70%	66%
I have not spent time with a family member, friend, or coworker who vapes.	65%	71%	70%	75%	78%	83%	83%

Wave sample sizes are provided in Table 1. Questions asked each wave; *Response options on a 5-point scale from strongly disagree to strongly agree; [+]Response options yes or no; [a]Data collected when the COVID-19 stay-at-home orders were in effect.

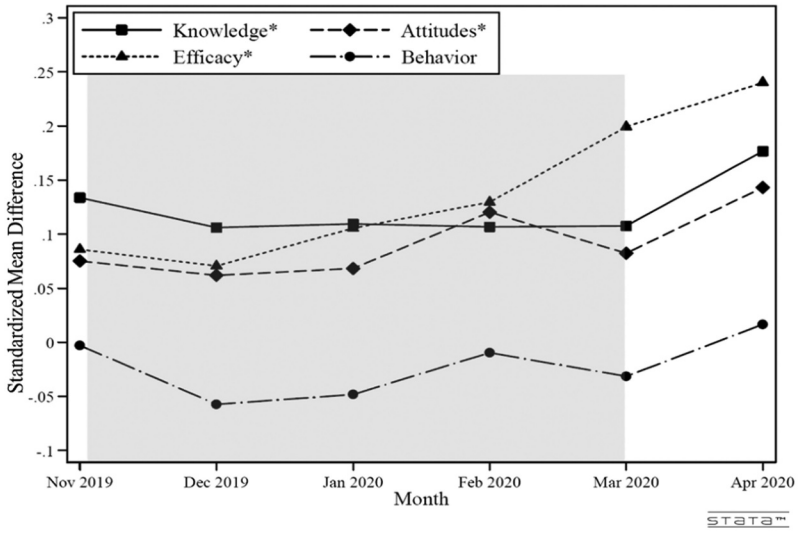

Figure 3. Changes from Baseline in THS-Related Knowledge, Attitudes, Efficacy, and Behavior Over Time. *Significantly improved from beginning until end ($p < .05$); Standardized mean difference reported in Cohen's D comparing the means of waves 2–7 to wave 1; shadow marks duration of campaign messages

exposure to the messages Another Cold (r = .119, $p < .05$, r^2 = .01), Pets (r = .216, $p < .001$, r^2 = .05), and Dust ($r = .160$, $p <$ .01, r^2 = .03). Changes in efficacy and behavior were not positively associated with exposure to any particular message. Thus, messages featuring THS impacts on the frequency of colds in children, negative health effects for pets, and the presence of THS in dust were more persuasive in promoting knowledge and attitude change than the other four messages.

Finally, the second hypothesis tested a model that expected campaign recall to predict changes in knowledge; changes in knowledge would predict changes in attitude and efficacy; changes in attitude and efficacy would predict changes in behavior. To accurately test expected persuasive routes, campaign recall was used for the three most persuasive advertisements (i.e., Another Cold, Pets, & Dust; $m = .30$, $SD = 1.29$). Five fit indices were evaluated following Kline (2005). Three fit indices supported satisfactory model fit compared to a worst fitting (CFI = .905) or no model (GFI = .968) with expected covariance residuals (SRMR = .057). The overall chi-square model fit statistic was statistically significant ($\square^2[5] = 23.38$, $p < .001$) indicating poor model fit with respect to a best possible fitting model. Similarly, the RMSEA suggest poor fit (RMSEA [CI: .068, .159] = .111, $p = .01$). Parameter estimates (see Figure 4) found all expected relationships to be statistically significant except that efficacy did not predict behavior. Thus, $H2_{a\text{-}d}$ were supported and $H2_e$ was not supported.

Discussion

This quasi-experimental study evaluated the effectiveness of a public health campaign on improving THS awareness, as measured by knowledge, attitude, efficacy, and behavior (including intention) in a sample of 1087 California adults. The campaign design built on past tobacco prevention materials and was evaluated following theoretical expectations of the persuasive process. Results demonstrated significant change over time (from baseline to post-intervention) in THS-related knowledge, attitude, and efficacy but did not show a significant change in behavior. However, behavior change, which included measures of intention, was indirectly associated with participant recall of campaign messages: recall of the most persuasive messages predicted change in knowledge, which in turn predicted change in attitude and efficacy, and change in attitude ultimately predicted change in behavior. The intervention producing positive change in knowledge is consistent with past meta-analytic findings of the effectiveness of mass-media health campaigns; however, the positive change in efficacy and finding a lack of significant change in behavior is counter to the findings from the meta-analysis (see Anker et al., 2016). The difference in these findings could be due to their analysis including all health-related campaign topics. The findings from the present investigation have numerous implications for practice and theory.

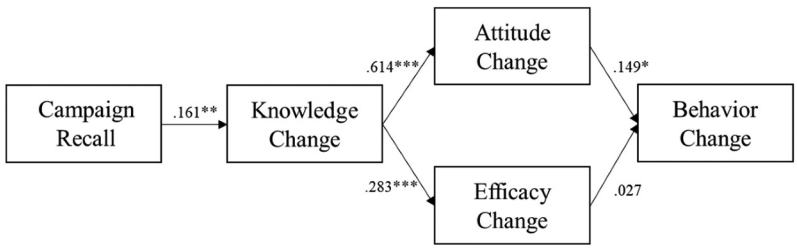

Figure 4. Tested Model (hypothesis 2) with Parameter Estimates. Standardized estimates reported; *p < .05; **p < .01; ***p < .001

Tobacco control advocates and researchers, particularly those in areas with lower tobacco use prevalence such as California, are working toward the "tobacco endgame," which envisions a world free of the commercial tobacco epidemic (Malone, 2016). Bringing smoking prevalence to near-zero levels and removing all forms of exposure to toxic tobacco residue will require substantial behavior change and intensified regulations. This would include expanding existing tobacco control policies that fail to protect the public from THS exposure in private settings associated with real estate transactions, rental contracts, used car sales, and other personal property transactions. Implementation of new policies that extend to such settings will necessarily require widespread public knowledge of the persistent risks of tobacco use and high levels of public support for regulatory action. In this context, communication campaigns attempting to change public awareness of THS are a critical area of tobacco research.

Findings from this study suggest that progressive tobacco prevention can benefit from using strategic communication approaches from past tobacco prevention campaigns (Allen et al., 2015; Centers for Disease Control & Prevention, 2014; Wilson et al., 2012), especially those that leverage the persuasive topics of children's health, pets, and dust. As technology evolves, campaign approaches need to adapt to trends in mediated communication platforms (Capurro et al., 2014; Rice & Atkin, 2009). Consistent with recent approaches to tobacco prevention campaigns (Chung, 2016; Elser et al., 2019; Kim et al., 2016; Lee & Chen, 2017), the present campaign leveraged the modern social media platform of Facebook, and the results support Facebook as a successful dissemination platform. Campaign recall was generally low for participants, which is not unexpected in mass-media campaigns. Although low campaign recall suggests that the Facebook algorithms did not perfectly reach the recruitment group, targeting was efficient enough to support persuasive outcomes. Relying on corporate social media algorithms can be risky, especially in unstable political climates where advertising regulations can change with little notice. However, flexible campaign designs should continue to engage social media platforms as a means to effectively reach large target audiences.

Consistent with theoretical expectations for health-related behavior change (Fishbein et al., 2001; Noar, 2004; Noar et al., 2008) and past research (Ahluwalia et al., 2018; Chow et al., 2017; Lareyre et al., 2020; Palipudi et al., 2012), findings from this study support that changing knowledge and attitude is a key factor in changing behavior. Interestingly, efficacy was not found to be significantly related to THS prevention behaviors. Although past tobacco prevention research has found efficacy to be a central construct in tobacco control (Elshatarat et al., 2016; Su et al., 2015), the context of THS has a lower degree of personal agency. For instance, deciding to stop smoking is in our personal control, whereas avoiding environments that have been formerly smoked in might feel out of the control of individuals. Thus, the lack of support for efficacy in the persuasive process is more likely a product of the THS context than a misguided theoretical expectation. However, future campaigns that promote greater awareness of personal and public steps that could be taken to reduce exposure may shift perceptions of efficacy and increase support for THS control policies. Such personal behaviors could include washing hands and changing potentially contaminated clothes before holding a baby, while policies could include mandatory disclosure of THS to prospective buyers or tenants within real estate law or expansion of housing code violations to include THS.

As a final implication, current tobacco control toolkits, such as those available from the CDC, lack THS-related resources. Given the results of this study, tobacco control toolkits should include THS educational components that leverage the negative impacts of THS exposure, in particular, persuasive messages that emphasize the impact of THS on children and pets as well as the prevalence of THS in dust. Comprehensive tobacco control toolkits that include THS educational materials help move public perceptions in the direction of the tobacco endgame.

Limitations

A few limitations need to be acknowledged. First, the dissemination channel relied heavily on Facebook algorithms. According to Facebook's advertising and algorithm guides, the participants recruited from baseline would be priority targets for future advertisements from the Thirdhand Smoke Resource Center. However, there was no way for the Center to ensure that participants were being prioritized with the advertised messages. Recall measures supported that the messages were appearing on many participant's newsfeeds, although much lower than initially assumed. For participants who reported no recall, it is possible that the messages never appeared on their newsfeed. Second, findings reflect perspectives and behaviors of California adults. As a state with low smoking rates and high tobacco control efforts, these findings might not be the same in other states or regions of the world where smoking rates are higher and tobacco prevention is more challenging. Finally, because participants engaged in monthly testing, the attribution of the observed changes to the media campaign could be threatened via a testing effect. Although this is important to note, the risk is deemed low as only a small portion of the sample (i.e., 11%) completed all seven surveys and were at risk of such an effect.

Conclusion

Future research should build on the findings reported here to continue to educate the public on THS risks, both on and off social media platforms. As technology changes, platforms that allow greater control over audience targeting will strengthen the validity of future intervention findings. Tobacco prevention advocates should consider including information on THS risks and exposure routes in their educational materials as well as provide resources for preventing and removing THS. Finally, advocates working toward the tobacco endgame of eliminating the commercial tobacco epidemic should include THS educational materials in their campaigns, promotional materials, and briefs. Preparing the public to recognize and remove THS pollutants in their personal environments will be a last important step in creating a world free of toxic tobacco toxicants.

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