Reactions to messages about smoking, vaping and COVID-19: two national experiments

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ABSTRACT

Introduction The pace and scale of the COVID-19 pandemic, coupled with ongoing efforts by health agencies to communicate harms, have created a pressing need for data to inform messaging about smoking, vaping, and COVID-19. We examined reactions to COVID-19 and traditional health harms messages discouraging smoking and vaping.

Methods Participants were a national convenience sample of 810 US adults recruited online in May 2020. All participated in a smoking message experiment and a vaping message experiment, presented in a random order. In each experiment, participants viewed one message formatted as a Twitter post. The experiments adopted a 3 (traditional health harms of smoking or vaping: three harms, one harm, absent) × 2 (COVID-19 harms: one harm, absent) between-subjects design. Outcomes included perceived message effectiveness (primary) and constructs from the Tobacco Warnings Model (secondary: attention, negative affect, cognitive elaboration, social interactions).

Results *Smoking* messages with traditional or COVID-19 harms elicited higher perceived effectiveness for discouraging smoking than control messages without these harms (all $p < 0.001$). However, including both traditional and COVID-19 harms in smoking messages had no benefit beyond including either alone. Smoking messages affected Tobacco Warnings Model constructs and did not elicit more reactance than control messages. Smoking messages also elicited higher perceived effectiveness for discouraging vaping. Including traditional harms in messages about *vaping* elicited higher perceived effectiveness for discouraging vaping ($p < 0.05$), but including COVID-19 harms did not.

Conclusions Messages linking smoking with COVID-19 may hold promise for discouraging smoking and may have the added benefit of also discouraging vaping.

INTRODUCTION

The COVID-19 pandemic has created urgent and unprecedented global public health challenges. These challenges may be exacerbated by the persistently high rates of smoking cigarettes and using electronic cigarettes (e-cigarettes), also known as vaping. Research on COVID-19 is rapidly evolving. Currently available evidence suggests smoking could increase risk of becoming infected with SARS-CoV-2, the virus that causes COVID-19, by weakening the immune system.[1–3] Smoking could also lead to worse outcomes among those with COVID-19. Systematic reviews and meta-analyses have found that smoking is associated with worse outcomes among those with COVID-19, including severe symptoms and death.[4–6] One meta-analysis found no association between smoking and worse COVID-19 outcomes,[7] but the findings have since been called into question.[8] While potentially less harmful than smoking, vaping has some risks. For example, a survey of US adolescents and young adults (ages 13–24) conducted in May 2020 found that those who had ever vaped were more likely to report having been diagnosed with COVID-19 compared with never vapers, though no association was observed between recent (past 30 days) vaping and COVID-19 diagnosis.[9] Studies of patients with COVID-19 have not yet reported vaping status; however, vaping could worsen COVID-19 outcomes by weakening the immune system,[3 10–13] lung function[10 12–16] or the circulatory system.[11 17 18] Beyond potential direct associations between smoking, vaping and COVID-19, smoking and vaping (perhaps to a lesser extent) also contribute to chronic diseases including heart disease, type 2 diabetes, emphysema and chronic obstructive pulmonary disease,[2 11] which contribute to worse COVID-19 outcomes[19–22] and represent significant public health challenges even in the absence of the COVID-19 pandemic.

The COVID-19 pandemic presents an opportunity to discourage smoking and vaping. Communication efforts, such as mass media campaigns, social media messaging and product warnings, are effective tools for discouraging smoking and vaping.[23–25] Even as research on COVID-19 risk evolves, public health agencies worldwide are already communicating about the potential risks of smoking and vaping in the context of the COVID-19 pandemic. Globally, the World Health Organization (WHO) launched a social media campaign about the potential for smoking and vaping to worsen COVID-19 morbidity and mortality (figure 1).[26] In the USA, entities such as the National Cancer Institute and state authorities have communicated to the public about the risks of smoking, vaping and COVID-19 via press releases and social media.[26–28]

The rapid pace and global scale of the COVID-19 pandemic, coupled with ongoing efforts by health agencies to communicate harms to the public, have created a pressing need for data to inform messaging campaigns to discourage smoking and vaping. If research finds that smoking or vaping increase COVID-19 risks, agencies need to know whether messages describing these associations are likely to discourage these behaviours. Even in the absence of the COVID-19 pandemic, addressing the continued burden of smoking and vaping requires developing generalisable principles on how to maximise the

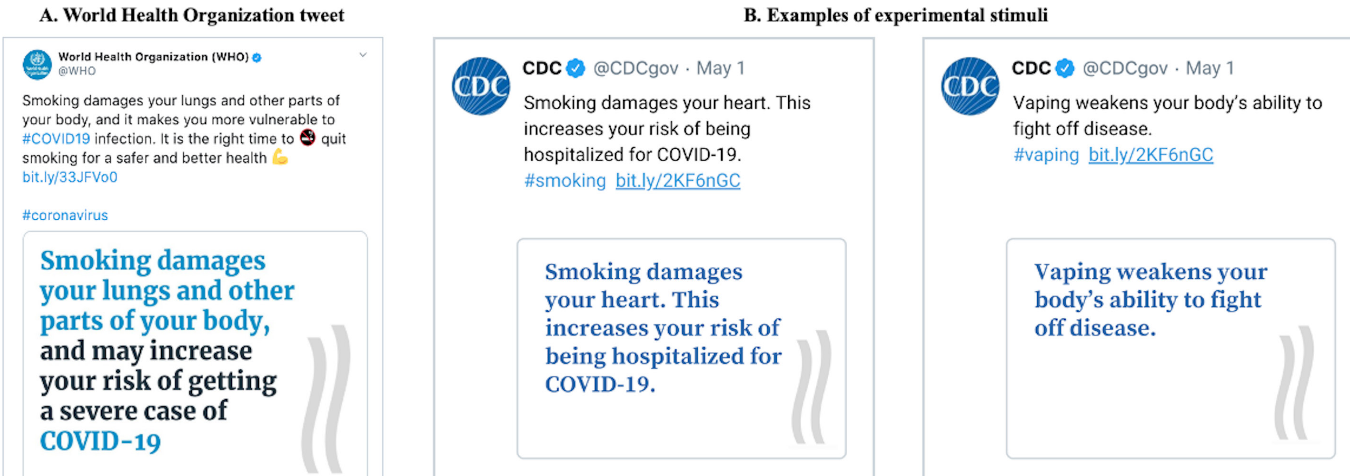

Figure 1 Tweets with messages about COVID-19, smoking and vaping from (A) the World Health Organization and, (B) examples of experimental stimuli.

impact of antismoking and antivaping messages. Prior research suggests two principles to examine. First, the optimal number of harms to include in messages remains unknown. Cigarette pack warnings typically include only one harm, but some research suggests more harms could boost impact.[29–31] Second, only a small number of studies have examined whether particular harms may have more impact than others, so the specific harms most likely to motivate cessation remain largely unknown.[31–33] As research on the links between smoking, vaping and health harms (including both traditional and COVID-19 harms) develops further, forward-looking evidence on reactions to messages about particular harms can guide swift dissemination of effective messages.

To inform tobacco control efforts, this study examined the extent to which messages about traditional health harms and COVID-19 harms were perceived to discourage smoking and vaping. We focused on perceived message effectiveness (PME) because it is a brief, reliable and valid measure that is commonly used for message development and selection, and because it is predictive of messages' actual effectiveness.[34–36] We also assessed warnings' impacts on constructs from the University of North Carolina (UNC) Tobacco Warnings Model[37] (TWM), an empirically driven model explaining how cigarette and e-cigarette warnings influence behaviour change, because these outcomes are also good proxies for actual message effectiveness.[38–41] Finally, we examined smoking and vaping warnings' effects on discouragement and thinking about harms of the non-focal behaviour (eg, smoking warnings' impact on discouragement from vaping) to evaluate whether messages about one product spill over to affect perceptions of the other product.

METHODS

Prior to data collection, we preregistered the sample size, hypotheses and analysis plan (https://aspredicted.org/ek4rk.pdf).

Participants

In May 2020, we recruited an online convenience sample of 810 US adults (ages 18 or older) through the Qualtrics Online Panel platform. Online convenience samples are an efficient way to study message reactions and can yield highly generalisable findings for experiments like those used in this study.[42] Participants were eligible if they were established current smokers (smoked at least 100 cigarettes and now smoking every day or some days),[43 44] current e-cigarette users (currently vaping every day or some days),[45] or dual users (current smoker and current e-cigarette user).

Procedures

Design

We conducted two independent experiments, one to test smoking messages and one to test vaping messages. Both experiments used the same 3 × 2 between-subjects factorial design, randomising participants to one of six message conditions (see online supplemental figures 1 and 2). The first factor varied the *traditional health harms* included in the message: three harms, one harm, or absent. Within the one traditional health harm condition, participants were randomised to view messages about immune function, lung damage, or heart disease. These harms were combined for the three traditional health harms condition. The second factor varied the *COVID-19 harm* included in the message (present or absent). Within the COVID-19 harm present condition, participants were randomised to see messages about COVID-19 infection, hospitalisation or death. We integrated these message elements to create 40 messages (20 for each experiment; online supplemental tables 1 and 2 show the smoking and vaping messages, respectively) based on our prior experience developing cigarette and e-cigarette risk communications.[31 33 37 46 47] Messages in the two experiments were identical except for the behaviour (smoking vs vaping). Online supplemental table 3 provides additional details and rationale underlying the experimental design.

Stimuli

We developed the smoking and vaping messages guided by existing scientific evidence and by messages currently in use by agencies such as the WHO and US Centers for Disease Control and Prevention (CDC). Research on the links between smoking, vaping, and COVID-19 harms is rapidly developing; the messages we used had varying levels of scientific evidence supporting them at the time of survey launch (see online supplemental table 4). Given the extraordinary pace of COVID-19 research, we elected to create forward-looking messages (ie, that may have lacked strong scientific support at the time of the survey) so that data on messages' effectiveness is readily available as clarity emerges in research on smoking and vaping harms. Control messages presented generic text about cigarette and e-cigarette products adapted from Wikipedia to be neutral and similar in length to intervention messages (eg, 'A regular cigarette is a narrow cylinder that usually contains tobacco. It is rolled into thin paper and smoked by lighting the end of it'.).

We presented each message as a tweet from the CDC to provide realism and context for participants. We chose to create tweets because Twitter is a commonly used social media platform,[48] news media often embed tweets in their stories, and many health organisations (including the CDC) actively use Twitter to disseminate information. Twitter posts commonly include an image; thus, we added an image of the experimental message to the tweet, following the approach used by the WHO. A graphic designer created these images to closely mirror formatting from a WHO tweet (figure 1).[26] The designer developed the 40 tweets with the message text and relevant image into visuals matched for layout, size, and colour.

Approach

Participants each completed two experiments: one for smoking and one for vaping. Half of participants were randomly assigned to complete the smoking experiment first and the other half to complete the vaping experiment first. Experiment order did not interact with the message element variables (all $p>0.05$). In each experiment, participants viewed a smoking or vaping message randomly assigned from one of the six conditions, then answered questions about that message. Message condition assignment in one experiment was independent of assignment in the other. At the conclusion of the survey, we debriefed participants, informed them that the messages they viewed were developed by the research team, and directed them to online resources with cessation support and up-to-date information about smoking, vaping, and COVID-19 (see online supplemental table 5 for debriefing language). Participants received incentives in a reward type and amount set by the survey vendor (eg, cash, reward points).

Measures

Participants rated messages on the primary outcome of PME, assessed using the three-item UNC PME Scale (eg, 'How much does this message discourage you from wanting to smoke?', Cronbach's alpha=0.91 for smoking items and 0.92 for vaping items).[49] Secondary outcomes from the TWM were: attention,[50] cognitive elaboration (ie, thinking about quitting vaping/smoking and health problems caused by vaping/smoking),[51–53] negative affective reactions to the messages (ie, fear, anxiety, sadness),[50 54 55] and anticipated social interactions about the messages.[56–58] The survey also assessed message reactance (ie, oppositional reaction to the message),[59 60] perceived harm[61] (ie, how harmful is vaping/smoking to your health), PME for discouraging the non-focal behaviour (eg, discouraging vaping in response to the smoking message)[49] and cognitive elaboration about the harms of the non-focal behaviour. Finally, the survey assessed participants' beliefs about the risks of smoking and vaping, including beliefs about the harms discussed in the experimental messages (eg, how smoking affects immune function). All measures used 5-point response scales (coded as 1 (low) to 5 (high)). The survey also assessed standard demographics, smoking, and vaping. Survey measures appear in online supplemental table 5.

Data analysis

We made three predictions for both the smoking and vaping experiments. First, we predicted that messages that describe one traditional health harm would elicit higher PME than messages that describe no traditional health harms, and lower PME than messages that describe three traditional health harms, based on a study of cigarette warnings.[31] Second, we predicted that messages that describe COVID-19 would elicit higher PME than messages without discussion of COVID-19. Finally, we predicted that the combined effects of a traditional health harms message and a COVID-19 message would be less than additive (ie, diminishing returns from additional message elements), based on studies of cigarette and sugary drink warnings.[62 63]

We used linear models to test these predictions, assessing how the manipulated message elements affected the primary outcome of PME. The initial models included indicators for the manipulated message elements and their interactions. To ease interpretation, the final model retained only statistically significant interactions from the initial model. We used *post hoc* tests to compare the effect of 1 traditional harm to three traditional harms, applying a Bonferroni-adjusted critical alpha to account for multiple comparisons. We used the same approach to examine the effects of message elements on secondary and other outcomes. We probed interactions by calculating average differential effects at each level of the moderating factors.

We also examined whether messages discussing immune function, lung damage, or heart damage elicited higher PME among those randomised to view messages with one traditional health harm. These analyses used linear regression with indicator variables for each type of traditional health harm and compared effects of specific harms using postestimation commands. We used the same approach to examine whether messages discussing COVID-19 infection, hospitalisation, or death elicited higher PME among participants randomised to see messages with a COVID-19 harm.

Exploratory analyses examined whether eight participant characteristics moderated the impact of message elements on PME: Twitter use (ever vs never); political party identification (Republican vs Democrat, Independent, or other); frequency of smoking or vaping (every day vs less often); type of user (smoker only, vaper only, or dual user); negative affective reactions to COVID-19 (average of three items, alpha=0.70); COVID-19 deaths per capita in respondents' state on 6 May 2020 (day of survey launch, coded continuously in deaths per 100 000 residents[64]); presence of a health condition considered high risk for severe COVID-19 infection (eg, heart disease); and educational attainment (some college or less vs college degree or more). These moderation analyses used a Bonferroni-adjusted critical alpha.

To allow for comparisons of effects across outcomes, we standardised all dependent variables prior to analysis and report the resulting regression coefficients (B). Analyses used Stata MP V.16.1 (StataCorp LLC). Statistical tests were two tailed and used a critical alpha of 0.05.

RESULTS

Participants

Participants' average age was 41.9 years (table 1). About 71% reported smoking every day, compared with 23% who reported vaping every day. Nearly one-third (29%) lived in poverty (ie, income <150% of the 2020 Federal Poverty Level). About 11% reported they probably or definitely had COVID-19 before or currently. Sample characteristics did not differ by experimental conditions in either the smoking or vaping experiments (all $p>0.05$).

Table 1 Participant characteristics, n=810

Characteristic	N	%
Demographic Characteristics		
Age		
18–29 years	159	20%
30–39 years	251	31%
40–54 years	204	25%
55+ years	187	23%
Mean (SD)	41.9	(14.6)
Gender identity		
Man	365	45%
Woman	430	53%
Neither man nor woman or prefer to self-describe	13	2%
Transgender	40	5%
Gay, lesbian or bisexual	94	12%
Hispanic ethnicity	81	10%
Race		
White	620	77%
Black or African American	97	12%
Asian or Pacific Islander	34	4%
American Indian or Alaskan Native	15	2%
Other race or multiracial	44	5%
Education		
High school diploma or less	220	27%
Some college	201	25%
Bachelor's or associate's degree	274	34%
Graduate degree	114	14%
Household income, annual		
US $0–24 999	200	25%
US $25 000–49 999	195	24%
US $50,000–74 999	148	18%
US $75 000–99 999	85	10%
US $100 000+	182	22%
Low income (≤150% of FPL)	236	29%
Political party identification		
Democrat	357	44%
Republican	277	34%
Independent or other	176	22%
Behaviours and Health Status		
Cigarette smoking frequency		
Not at all	58	7%
Some days	174	21%
Every day	578	71%
Vaping frequency		
Not at all	351	43%
Some days	276	34%
Every day	183	23%
Ever used Twitter	499	62%
Have health condition that increases COVID-19 risk	450	56%
Probably or definitely had COVID-19	93	11%
Knew someone who had COVID-19	328	40%

Characteristics did not differ by experimental conditions in either the vaping or smoking experiments (all p>0.05). Missing demographic data ranged from 0.0% to 1.6%. Health conditions that increase COVID-19 risk included heart disease or history of heart attack; stroke; hypertension or high blood pressure; asthma; cancer; chronic lung disease including chronic obstructive pulmonary disease; emphysema or chronic bronchitis; obesity (body mass index ≥30 kg/m^2); diabetes; liver disease including cirrhosis; chronic kidney disease; or autoimmune disease including lupus, multiple sclerosis, rheumatoid arthritis, psoriasis, Crohn's disease, and inflammatory bowel disease.
FPL, US Federal Poverty Level for 2020.

Smoking experiment

Perceived message effectiveness

Compared with control messages, messages with one (B=0.73, p<0.001) or three (B=0.86, p<0.001) traditional health harms elicited higher PME for discouraging smoking (table 2). Messages that included a COVID-19 harm also elicited higher PME compared with control messages (B=0.82, p<0.001). Three traditional health harms did not have a stronger impact on PME than one harm (p=0.45), contrary to our prediction.

Traditional health harms interacted with COVID-19 harms, showing diminishing returns from adding a new message element (p for interactions <0.001, table 2). Adding a COVID-19 harm to smoking messages led to higher PME only when messages did not include any traditional health harms (B=0.82, p<0.001) (figure 2). The addition of a COVID-19 harm had no benefit when messages already included one traditional health harm (B=0.06, p=0.68) or three traditional health harms (B=−0.04, p=0.77). (online supplemental table 6 provides means and SDs for each condition for all outcomes).

Of the 24 interactions between participant characteristics and experimental factors examined, none were statistically significant at the Bonferroni-adjusted critical alpha (online supplemental table 7).

Smoking messages about immune function, lung damage, and heart damage elicited similar PME ratings (all p for pairwise comparisons>0.05, online supplemental figure 3). Smoking messages about dying from COVID-19 were perceived to be more effective than smoking messages about being hospitalised for COVID-19 (p=0.03, online supplemental figure 4), but were not different from messages about COVID-19 infection.

Secondary outcomes

The same pattern of results, including diminishing impact of additional message elements, emerged for attention, cognitive elaboration, negative affect and anticipated social interactions, our secondary outcomes from the TWM (table 2). For these outcomes, messages with one or three traditional health harms or with a COVID-19 harm generally outperformed control messages. Including additional types of harms once messages described either traditional health harms or a COVID-19 harm showed diminishing returns (ie, negative interactions).

Other outcomes

Messages with traditional health harms or COVID-19 harms generally led to greater perceived harm of smoking (table 2). The smoking messages also led to higher perceived effectiveness for discouraging vaping and cognitive elaboration about the harms of vaping, despite the smoking messages not mentioning vaping. None of the manipulated message elements led to more reactance than control messages.

Beliefs that smoking affects COVID-19 risks (eg, infection, hospitalisation) did not differ across experimental conditions (online supplemental table 8). Message elements also did not affect beliefs about smoking's effects on the immune system, lungs or heart. Exploratory analyses comparing participants who did and did not receive messages corresponding to the topic of the survey item showed a similar pattern of results.

Vaping experiment

Perceived message effectiveness

Messages that included one (B=0.24, p=0.005) or three (B=0.18, p=0.033) traditional health harms were perceived to be more effective for discouraging vaping than messages without

Table 2 Smoking message elements' impact, n=810

	Primary outcome	Secondary outcomes from Tobacco Warnings Model				Other outcomes			
	Perceived effectiveness	Attention	Cognitive elaboration	Negative affect	Social interactions	Perceived harm	Perceived effectiveness, vaping	Cognitive elaboration, vaping	Reactance
Message element	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Traditional harms									
1 harm versus absent	**0.73*** **	0.33	**0.67*** **	**0.49** **	0.08	**0.44* **	**0.60*** **	**0.54** **	0.02
3 harms versus absent	**0.86*** **	**0.43* **	**0.81*** **	**0.58*** **	**0.40* **	**0.61*** **	**0.57*** **	**0.64*** **	0.09
COVID-19 harm									
1 harm versus absent	**0.82*** **	**0.55*** **	**0.78*** **	**0.66*** **	**0.56*** **	**0.46** **	**0.55*** **	**0.63*** **	0.19
Traditional 1 harm × COVID-19	**−0.77*** **	−0.30	**−0.57** **	**−0.53** **	−0.09	**−0.41* **	**−0.64** **	**−0.49* **	−0.03
Traditional 3 harms × COVID-19	**−0.86*** **	**−0.50* **	**−0.76*** **	**−0.66*** **	**−0.47* **	**−0.61** **	**−0.52** **	**−0.60** **	−0.13

Bs are unstandardised regression coefficients on standardised dependent variables. Bold indicates statistically significant effects. *p<0.05, **p<0.01, ***p<0.001.

traditional health harms (table 3, figure 2; see also online supplemental table 9 for mean outcomes by condition). Three traditional health harms did not have a stronger impact on PME than one harm (p=0.48). Vaping messages with a COVID-19 harm did not elicit higher PME ratings compared with messages without a COVID-19 harm (B=0.08, p=0.33). In addition, traditional and COVID-19 harms did not interact with one another in initial models (p>0.05), so final models removed the interaction terms for ease of interpretation.

None of the 16 interactions between participant characteristics and experimental factors were statistically significant at the Bonferroni-adjusted critical alpha (online supplemental table 10).

Vaping messages about immune function, lung damage, and heart damage were perceived to be similarly effective (all p for pairwise comparisons>0.05,online supplemental figure 5). Likewise, vaping messages about COVID-19 infection, hospitalisation, and death elicited similar PME ratings (all p>0.05,online supplemental figure 6).

Secondary outcomes

Three of our four secondary outcomes from the TWM (ie, attention, cognitive elaboration, and negative affect) showed a similar pattern of results as the primary outcome (table 3). For these outcomes, messages with one or three traditional health harms generally outperformed messages without traditional health harms, while messages with COVID-19 harms did not outperform messages without this message element. Vaping message elements did not affect anticipated social interactions.

Other outcomes

A similar pattern of results again emerged for vaping message elements' effects on perceived harm of vaping, PME at discouraging smoking and cognitive elaboration about smoking (table 3). Likewise, a similar pattern emerged for beliefs about the risks of vaping (eg, how vaping affects immune function, online supplemental table 11). None of the manipulated message elements led to more reactance (table 3).

DISCUSSION

Public health agencies are communicating about how cigarette smokers may experience greater harm from COVID-19. Our national experiments show that US adults perceived these health messages as likely to discourage smoking. Further, they also perceived cigarette messages describing traditional health harms (whether one or three) to be effective. Because PME is predictive of actual message effectiveness,[36] our findings offer preliminary support for using COVID-19-related smoking harms as a new topic in antismoking communication efforts. Further, three different COVID-19 harms (infection, hospitalisation, and death) all had similar impact to traditional health harms (whether one or three), indicating that health agencies have many viable options for topics to use in anti-smoking messages. Moreover, agencies could rotate among the varying topics in their communications to add novelty and prevent messages from becoming stale over time.[65 66]

In contrast to the findings for smoking messages, only traditional harms (and not COVID-19 harms) were perceived as effective for vaping messages, suggesting that health agencies focus their vaping communications on traditional harms[32] rather than COVID-19 harms. The lack of effect of COVID-19 messages on PME in the vaping experiment could be due to the vaping control message being more 'active' (see figure 2), potentially reflecting that any information on vaping—even neutral information—is relatively novel for many adults. While we did not assess believability of messages, it is also possible that participants found the vaping messages about COVID-19 less believable than the smoking messages about COVID-19, and that this explains the lack of effect of the COVID-19 vaping messages.

The messages affected the main constructs of the TWM. The messages that were perceived to be effective in discouraging smoking and vaping also increased attention, thinking about the message content, negative affective reactions, and expectations of talking to others about the messages, consistent with previous studies of messages about smoking,[67] chemicals in cigarettes,[53] and sugary drinks.[68] The constructs in the TWM have been shown to be predictive of behavioural intentions and behaviour change,[38–41 47 58] suggesting that the messages in our study hold promise for decreasing actual cigarette and e-cigarette use.

Some have raised concerns that antismoking and antivaping messages and product warnings that discourage one harmful behaviour (eg, vaping) might inadvertently *encourage* another harmful behaviour (eg, smoking).[69] Alternatively, messages about one product may exert a *tarnishing* effect on other products. Importantly, we found evidence to support the tarnishing hypothesis: in our study, messages discouraging smoking also discouraged vaping and vice versa, suggesting that antismoking and antivaping messages may make both products unappealing. This finding builds on a prior study showing e-cigarette warnings discouraged both vaping and smoking.[47] Future research

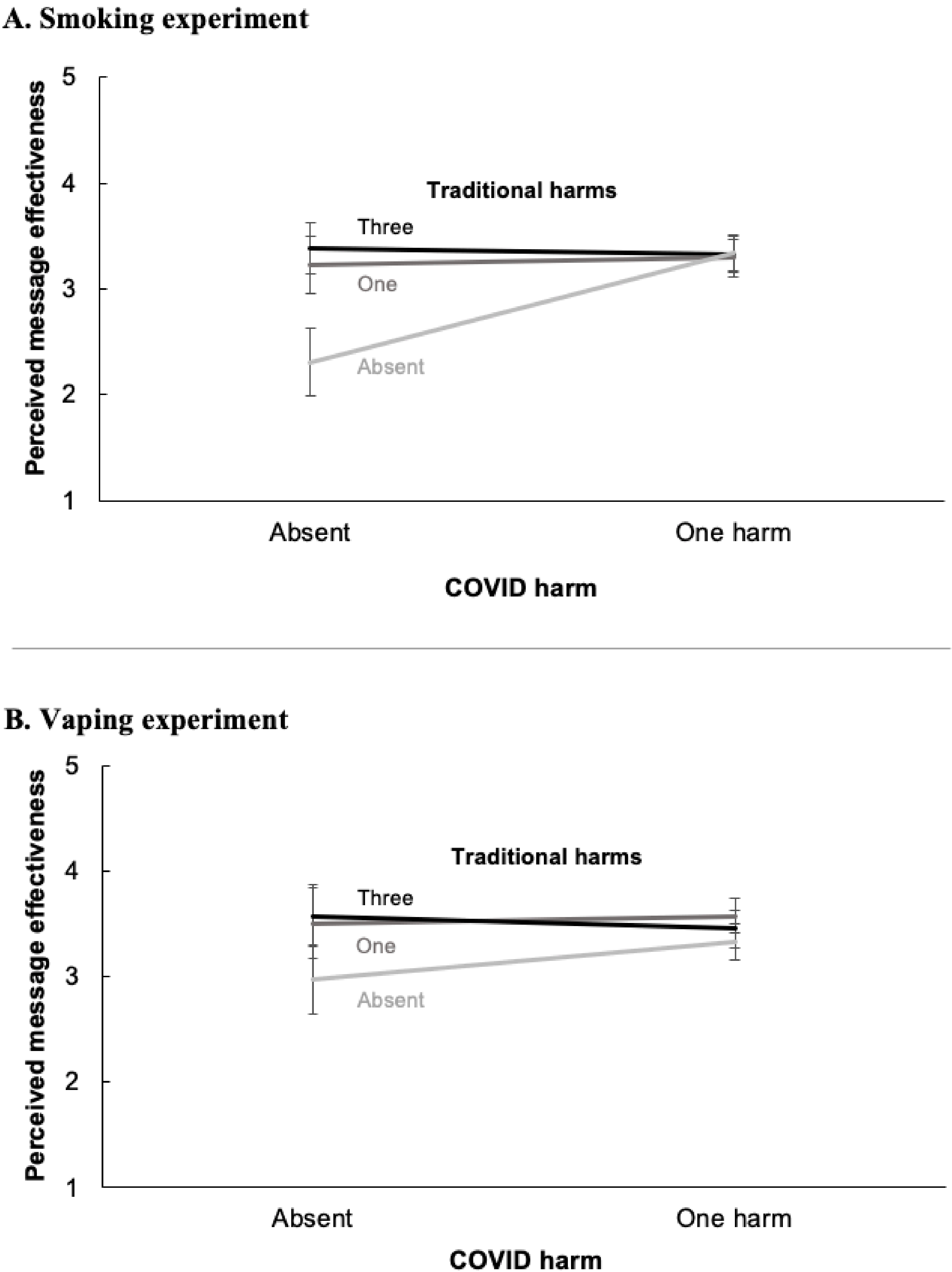

Figure 2 Perceived message effectiveness by condition in (A) the smoking experiment and, (B) the vaping experiment. Error bars show 95% CIs.

Table 3 Vaping message elements' impact, n=810

	Primary outcome	Secondary outcomes from Tobacco Warnings Model				Other outcomes			
	Perceived effectiveness	Attention	Cognitive elaboration	Negative affect	Social interactions	Perceived harm	Perceived effectiveness, smoking	Cognitive elaboration, smoking	Reactance
Message element	B	B	B	B	B	B	B	B	B
Traditional harms									
1 harm versus absent	**0.24****	**0.20***	**0.25****	**0.25****	0.14	**0.27****	**0.28****	**0.25****	0.17
3 harms versus absent	**0.18***	0.11	**0.19***	**0.20***	0.10	**0.26****	**0.19***	**0.20***	0.13
COVID-19 harm									
1 harm versus absent	0.08	0.06	0.01	0.04	−0.01	−0.03	0.09	−0.03	0.14

Bs are unstandardised regression coefficients on standardised dependent variables. Two-way interactions between traditional health harms and COVID-19 harm were not statistically significant in initial models and so were removed from the final models. **Bold** indicates statistically significant effects. *p<0.05, **p<0.01, ***p<0.001.

will clarify the extent to which messages have beneficial spill-over effects on behavioural outcomes, as well as whether there are any circumstances in which these messages have unintended consequences.

Strengths of our experiments include the use of a randomised design, measurement of a primary outcome with strong psychometric properties,[49] and creation of realistic stimuli mirroring actual messages from public health organisations. Limitations include the brief exposure to stimuli in an online study, precluding assessment of behaviour. We did not assess underlying beliefs about smoking or vaping harms or measure believability of messages. Additionally, we surveyed a convenience sample, so results' generalisability remains to be established, though online convenience samples provide results for experiments that closely match population-based samples.[42] Finally, we fielded our survey in early May 2020, when 'stay-at-home' and 'shelter-in-place' orders were active for most US states, and additional research will clarify whether our findings hold later in the pandemic.

Our results have actionable implications for public health communicators and the tobacco control field. First, our findings indicate that messages linking smoking cigarettes with COVID-19-related harms could have an impact. If and when the link between smoking and COVID-19 is confirmed, our findings provide forward-looking evidence that health agencies can use to rapidly deploy prevetted messages leveraging COVID-19 to discourage smoking. Second, our findings suggest that messages linking vaping with traditional health harms such as lung damage could discourage vaping. As evidence of vaping's harms continues to emerge, public health communications should include information about these harms in vaping messages, particularly because studies suggest vaping risk communication is effective at discouraging e-cigarette use.[32 47] The lack of differences between messages with different traditional health harms suggests that those designing vaping messages have several promising options in terms of which harms to highlight. Third, our findings suggest a general principle of simplicity for public health messages. We observed diminishing returns from including additional message elements in smoking messages, similar to previous studies of warnings for cigarettes and sugary drinks.[31 47 62 63] This 'less is more' finding[70] supports use of brief messages. Given the pressing public health need to reduce smoking and vaping, these findings provide timely evidence that brief smoking and vaping messages may effectively discourage these behaviours.

What this paper adds

- ► Smoking causes many health harms, and evidence is accumulating that vaping also causes harms.
- ► Early studies suggest that smoking may exacerbate health harms caused by COVID-19, but this remains a contested area as of this writing. Patient-level data on vaping and COVID-19 harms is not yet available.
- ► Public health agencies globally are messaging on the potential harms of smoking, vaping, and COVID-19.
- ► Our study found benefits of messages linking smoking with both COVID-19 and traditional health harms.
- ► Messages linking vaping and COVID-19 had limited effects, but messages linking vaping and traditional health harms (eg, lung damage) were beneficial.

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Contributors AHG had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: AHG, MGH, SMN, KMR and NTB. Acquisition, analysis or interpretation of the data: AHG, MGH, CGM, JRM, SMN, KMR and NTB. Drafting of the manuscript: AHG, MGH, JRM, SMN and NTB. Critical revision of the manuscript for important intellectual content: all authors. Statistical analysis: AHG and CGM. Obtained funding: KMR. Administrative, technical, or material support: AHG, JRM and NTB. Study supervision: AHG and NTB.

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Competing interests None of the authors have received funding from tobacco product manufacturers. NTB, SMN, and KMR have served as paid expert consultants in litigation against e-cigarette and tobacco companies. JMS has served as a paid consultant in government litigation against tobacco companies.

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REFERENCES

1 Scott A, Lugg ST, Aldridge K, *et al*. Pro-Inflammatory effects of e-cigarette vapour condensate on human alveolar macrophages. *Thorax* 2018;73:1161–9.
2 US Department of Health and Human Services. *The health consequences of smoking - 50 years of progress: A report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014.
3 Strzelak A, Ratajczak A, Adamiec A, *et al*. Tobacco smoke induces and alters immune responses in the lung triggering inflammation, allergy, asthma and other lung diseases: a mechanistic review. *Int J Environ Res Public Health* 2018;15:1033.
4 Patanavanich R, Glantz SA. Smoking is associated with COVID-19 progression: a meta-analysis. *Nicotine Tob Res* 2020;22:1653–6.
5 Vardavas CI, Nikitara K. COVID-19 and smoking: a systematic review of the evidence. *Tob Induc Dis* 2020;18:20
6 Alqahtani JS, Oyelade T, Aldhahir AM, *et al*. Prevalence, severity and mortality associated with COPD and smoking in patients with COVID-19: a rapid systematic review and meta-analysis. *PLoS One* 2020;15:e0233147.
7 Lippi G, Henry BM. Active smoking is not associated with severity of coronavirus disease 2019 (COVID-19). *Eur J Intern Med* 2020;75:107–8.
8 Guo FR. Active smoking is associated with severity of coronavirus disease 2019 (COVID-19): an update of a meta-analysis. *Tob Induc Dis* 2020;18:37
9 Gaiha SM, Cheng J, Halpern-Felsher B. Association between youth smoking, electronic cigarette use, and coronavirus disease 2019. *J Adolesc Health* 2020.
10 Gotts JE, Jordt S-E, McConnell R, *et al*. What are the respiratory effects of e-cigarettes? *BMJ* 2019;366:l5275.
11 NAoSEa M. *Public health consequences of e-cigarettes*. Washington, DC: The National Academies Press, 2018.
12 Gómez A-C, Rodríguez-Fernández P, Villar-Hernández R, *et al*. E-Cigarettes: effects in phagocytosis and cytokines response against Mycobacterium tuberculosis. *PLoS One* 2020;15:e0228919.
13 Madison MC, Landers CT, Gu B-H, *et al*. Electronic cigarettes disrupt lung lipid homeostasis and innate immunity independent of nicotine. *J Clin Invest* 2019;129:4290–304.
14 Bals R, Boyd J, Esposito S, *et al*. Electronic cigarettes: a task force report from the European respiratory Society. *Eur Respir J* 2019;53. doi:10.1183/13993003.01151-2018. [Epub ahead of print: 31 Jan 2019].
15 Polosa R, O'Leary R, Tashkin D, *et al*. The effect of e-cigarette aerosol emissions on respiratory health: a narrative review. *Expert Rev Respir Med* 2019;13:899–915.
16 National Academies of Sciences Engineering and Medicine. *Public health consequences of e-cigarettes*. Washington, DC: The National Academies Press, 2018.
17 Darville A, Hahn EJ. E-Cigarettes and atherosclerotic cardiovascular disease: what clinicians and researchers need to know. *Curr Atheroscler Rep* 2019;21:15.
18 Bhatnagar A. Environmental determinants of cardiovascular disease. *Circ Res* 2017;121:162–80.
19 Guan W-J, Liang W-H, Zhao Y, *et al*. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. *Eur Respir J* 2020;55:2000547.
20 Coronavirus disease 2019 (COVID-19): people who are at higher risk. Available: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-at-higher-risk.html [Accessed 23 May 2020].
21 Richardson S, Hirsch JS, Narasimhan M, *et al*. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the new York City area. *JAMA* 2020;323:2052.
22 Yang J, Zheng Y, Gou X, *et al*. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. *Int J Infect Dis* 2020;94:91–5.
23 Institute of Medicine. *Ending the tobacco problem: A blueprint for the nation*. Washington, DC: Institute of Medicine, 2007.
24 US Department of Health and Human Services. *E-cigarette use among youth and young adults: A report of the Surgeon General*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 2016.
25 Noar SM, Hall MG, Francis DB, *et al*. Pictorial cigarette pack warnings: a meta-analysis of experimental studies. *Tob Control* 2016;25:341–54.
26 WHO. Using tobacco products can increase your chance of getting #COVID19. Available: https://twitter.com/who/status/1252879486606913536?lang=en [Accessed 22 Apr 2020].
27 Smoking cigarettes can leave you more vulnerable to respiratory illnesses such as #COVID19. There's never been a better time to quit smoking. Available: https://twitter.com/NCICancerCtrl/status/1257665358498009089 [Accessed 23 May 2020].
28 Ag Healey Warns public about increased risks associated with smoking and Vaping during COVID-19 crisis. Available: https://www.mass.gov/news/ag-healey-warns-public-about-increased-risks-associated-with-smoking-and-vaping-during-covid [Accessed 23 May 2020].
29 Cappella JN. Perceived message effectiveness meets the requirements of a reliable, valid, and efficient measure of Persuasiveness. *J Commun* 2018;68:994–7.
30 Kim M, Reliable CJN. Valid and efficient evaluation of media messages: developing a message testing protocol. *J of Com Mana* 2019;23:179–97.
31 Noar SM, Kelley DE, Boynton MH, *et al*. Identifying principles for effective messages about chemicals in cigarette smoke. *Prev Med* 2018;106:31–7.
32 Rohde JA, Noar SM, Mendel JR, *et al*. E-Cigarette health harm awareness and discouragement: implications for health communication. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2019.
33 Kelley DE, Boynton MH, Noar SM, *et al*. Effective message elements for disclosures about chemicals in cigarette smoke. *Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco* 2017.
34 Bigsby E, Cappella JN, Seitz HH. Efficiently and effectively evaluating public service announcements: additional evidence for the utility of perceived effectiveness. *Commun Monogr* 2013;80:1–23.
35 Noar SM, Rohde JA, Prentice-Dunn H, *et al*. Evaluating the actual and perceived effectiveness of e-cigarette prevention advertisements among adolescents. *Addict Behav* 2020;109:106473.
36 Noar SM, Barker J, Bell T, *et al*. Does perceived message effectiveness predict the actual effectiveness of tobacco education messages? A systematic review and meta-analysis. *Health Commun* 2020;35:148–57.
37 Brewer NT, Parada Jr H, Hall MG, *et al*. Understanding why pictorial cigarette pack warnings increase quit attempts. *Ann Behav Med* 2018.
38 Li Y, Yang B, Owusu D, *et al*. Higher negative emotions in response to cigarette pictorial warning labels predict higher quit intentions among smokers. *Tob Control* 2020;29:tobaccocontrol-2019-055116.
39 Brennan E, Maloney EK, Ophir Y, *et al*. Potential effectiveness of pictorial warning labels that feature the images and personal details of real people. *Nicotine Tob Res* 2017;19:1138–48.
40 Noar SM, Francis DB, Bridges C, *et al*. Effects of strengthening cigarette pack warnings on attention and message processing: a systematic review. *Journal Mass Commun Q* 2017;94:416–42.
41 Morgan JC, Golden SD, Noar SM, *et al*. Conversations about pictorial cigarette pack warnings: theoretical mechanisms of influence. *Soc Sci Med* 2018;218:45–51.
42 Jeong M, Zhang D, Morgan JC, *et al*. Similarities and differences in tobacco control research findings from convenience and probability samples. *Annals of behavioral medicine : a publication of the Society of Behavioral Medicine* 2018.
43 Centers for Disease Control and Prevention (CDC). State-specific prevalence and trends in adult cigarette smoking--United States, 1998-2007. *MMWR Morb Mortal Wkly Rep* 2009;58:221–6.
44 Arrazola RA, Singh T, Corey CG, *et al*. Tobacco use among middle and high school students - United States, 2011-2014. *MMWR Morb Mortal Wkly Rep* 2015;64:381–5.
45 Population Assessment of Tobacco and Health Study. Path: population assessment of tobacco and health, Published 2018. Available: https://www.icpsr.umich.edu/icpsrweb/NAHDAP/series/606
46 Brewer NT, Morgan JC, Baig SA, *et al*. Public understanding of cigarette smoke constituents: three us surveys. *Tob Control* 2016;26:592–9.
47 Brewer NT, Jeong M, Hall MG, *et al*. Impact of e-cigarette health warnings on motivation to vape and smoke. *Tob Control* 2019.
48 Share of U.S. Adults using social media, including Facebook, is mostly unchanged since, 2018. Available: https://www.pewresearch.org/fact-tank/2019/04/10/share-of-u-s-adults-using-social-media-including-facebook-is-mostly-unchanged-since-2018/ [Accessed 20 May 2020].
49 Baig SA, Noar SM, Gottfredson NC, *et al*. Unc perceived message effectiveness: validation of a brief scale. *Ann Behav Med* 2019;53:732–42.
50 Nonnemaker J, Farrelly M, Kamyab K, *et al*. *Experimental study of graphic cigarette warning labels: Final results report*. Research Triangle Park, NC: RTI International, 2010.
51 Moodie C, Mackintosh AM, Hastings G, *et al*. Young adult smokers' perceptions of plain packaging: a pilot naturalistic study. *Tob Control* 2011;20:367–73.
52 Hammond D, Fong GT, McDonald PW, *et al*. Impact of the graphic Canadian warning labels on adult smoking behaviour. *Tob Control* 2003;12:391–5.
53 Brewer NT, Jeong M, Mendel JR, *et al*. Cigarette pack messages about toxic chemicals: a randomised clinical trial. *Tob Control* 2019;28:tobaccocontrol-2017-054112.
54 Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. *J Pers Soc Psychol* 1988;54:1063–70.
55 Keller PA, Block LG. Increasing the persuasiveness of fear appeals: the effect of arousal and elaboration. *Journal of Consumer Research* 1996;22:448–59.
56 Hall MG, Peebles K, Bach LE, *et al*. Social interactions sparked by pictorial warnings on cigarette packs. *Int J Environ Res Public Health* 2015;12:13195–208.
57 Morgan JC, Southwell BG, Noar SM, *et al*. Frequency and content of conversations about pictorial warnings on cigarette packs. *Nicotine Tob Res* 2018;20:882–7.
58 Grummon AH, Brewer NT. Health warnings and beverage purchase behavior: mediators of impact. *Ann Behav Med* 2020;54:691–702.
59 Hall MG, Sheeran P, Noar SM, *et al*. Reactance to health warnings scale: development and validation. *Ann Behav Med* 2016;50:736–50.
60 Hall MG, Sheeran P, Noar SM, *et al*. A brief measure of reactance to health warnings. *J Behav Med* 2017;40:520–9.
61 Noar SM, Rohde JA, Horvitz C, *et al*. Adolescents' receptivity to e-cigarette harms messages delivered using text messaging. *Addict Behav* 2019;91:201–7.

62 Baig SA, Byron MJ, Boynton MH, *et al*. Communicating about cigarette smoke constituents: an experimental comparison of two messaging strategies. *J Behav Med* 2017;40:352–9.
63 Grummon AH, Hall MG, Taillie LS, *et al*. How should sugar-sweetened beverage health warnings be designed? A randomized experiment. *Prev Med* 2019;121:158–66.
64 Coronavirus locations: COVID-19 map by County and state. Available: https://usafacts.org/visualizations/coronavirus-covid-19-spread-map/ [Accessed 23 May 2020].
65 Hitchman SC, Driezen P, Logel C, *et al*. Changes in effectiveness of cigarette health warnings over time in Canada and the United States, 2002-2011. *Nicotine Tob Res* 2014;16:536–43.
66 Swayampakala K, Thrasher JF, Yong H-H, *et al*. Over-Time impacts of pictorial health warning labels and their differences across smoker subgroups: results from adult smokers in Canada and Australia. *Nicotine Tob Res* 2018;20:888–96.
67 Brewer NT, Hall MG, Noar SM, *et al*. Effect of pictorial cigarette pack warnings on changes in smoking behavior: a randomized clinical trial. *JAMA Intern Med* 2016;176:905–12.
68 Grummon AH, Taillie LS, Golden SD, *et al*. Sugar-Sweetened beverage health warnings and purchases: a randomized controlled trial. *Am J Prev Med* 2019;57:601–10.
69 Wackowski O, Hammond D, O'Connor R, O'Connor RJ, *et al*. Considerations and future research directions for e-cigarette Warnings—Findings from expert interviews. *Int J Environ Res Public Health* 2017;14. doi:10.3390/ijerph14070781. [Epub ahead of print: 14 Jul 2017].
70 Peters E, Dieckmann N, Dixon A, *et al*. Less is more in presenting quality information to consumers. *Med Care Res Rev* 2007;64:169–90.