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# Independent and combined effects of very low nicotine cigarette messages and e-cigarette messages: a randomised clinical trial

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## ABSTRACT

**Background** USA is considering reducing nicotine in cigarettes to non-addictive levels, coupled with promoting alternative nicotine delivery products (eg, e-cigarettes). However, effective communication is needed to reduce misperceptions about very low nicotine cigarettes (VLNCs) being less harmful than regular cigarettes.

**Methods** In 2022–2023, we conducted a four-group randomised clinical trial with a national probability sample from an online panel (971 adults who smoked cigarettes exclusively, 472 adults who dual used cigarettes and e-cigarettes and 458 adults aged 18–29 who had never smoked). Participants were randomised (parallel assignment) to one message condition: (1) VLNCs as harmful but easier to quit than regular cigarettes (n=468), (2) those who are not ready to quit should consider switching to e-cigarettes as less harmful alternatives (n=484), (3) combined VLNC and e-cigarette messages; n=476 or (4) control condition (ie, water ads), n=473. The primary outcome was perceived absolute harm of VLNCs.

**Results** Perceived harm of VLNCs was higher in the VLNC condition compared with the e-cigarette and control conditions, and higher in the combined condition compared with the e-cigarette condition (adjusted  $p<0.05$ ). Among adults who dual used, intention to switch to e-cigarettes was higher in the VLNC condition than the e-cigarette, combined or control conditions (adjusted  $p<0.05$ ).

**Conclusions** VLNC messages reduced the misperception that VLNCs are less harmful than cigarettes, but adding messages about e-cigarettes did not enhance desired outcomes. These VLNC messages can be considered during the rollout of a reduced nicotine policy.

**Trial registration** NCT05506046

## INTRODUCTION

Although most people who smoke want and have tried to quit,<sup>1</sup> the addictive nature of nicotine in tobacco products makes quitting extremely difficult. Several countries have developed novel regulatory strategies that target nicotine. New Zealand, for example, is the first country that passed a law to reduce nicotine in smoked tobacco products to very low levels (although the new government repealed this legislation).<sup>2,3</sup> Similarly, in 2022, the United States Food and Drug Administration (FDA)

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Past research on messages about very low nicotine cigarettes (VLNCs) found that these messages can sometimes reduce the misperception that VLNCs are less harmful than regular cigarettes. No studies so far have examined the effects of VLNC messages in combination with messages about e-cigarettes, even though both are components of nicotine-focused regulatory approaches.

## WHAT THIS STUDY ADDS

⇒ Our VLNC messages reduced the misperception that VLNCs are less harmful than cigarettes. However, adding messages about e-cigarettes did not significantly improve the desired outcomes.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The Food and Drug Administration may consider prioritising the VLNC messages during the rollout of a reduced nicotine policy.

announced its intention to develop a reduced nicotine standard that would make cigarettes and, potentially, other combustible tobacco products minimally or non-addictive.<sup>4</sup>

This nicotine-focused regulatory approach is based on evidence that very low nicotine cigarettes (VLNCs; that is, cigarettes that contain around 0.4 mg nicotine per gram of tobacco) can reduce nicotine dependence, craving and cigarette consumption, which, in turn, reduces biomarkers of exposure to harmful chemicals among people who smoke.<sup>5–7</sup> Reduced nicotine would also facilitate cessation efforts.<sup>8,9</sup> For people who do not already smoke, minimally addictive cigarettes would likely prevent the progression to regular use.

An essential component of the FDA's nicotine-focused regulatory approach concerns providing people who are not ready to quit nicotine with an option to obtain nicotine from less harmful alternative nicotine delivery products, such as electronic cigarettes (e-cigarettes).<sup>8,10</sup> The primary risks of smoking pertain to inhaling the harmful constituents of combustion.<sup>11</sup> Although the long-term health risks of e-cigarette use remain unknown,

they have the potential to deliver nicotine with reduced risk compared with smoking.<sup>12–14</sup>

This comprehensive approach is compelling. However, effectively communicating about VLNCs to the public can be challenging. Misperceptions exist surrounding the health effects of nicotine in tobacco products.<sup>15–16</sup> Many people incorrectly believe that nicotine is the primary cause of most smoking-related diseases, which may lead them to perceive VLNCs as less harmful than regular cigarettes.<sup>16–18</sup> More accurate perceptions of the health effects of VLNCs are promoted by messages that use percentage descriptions of VLNCs (eg, remove 95% of the nicotine from cigarettes), highlighting that VLNCs are as harmful as regular cigarettes, or showing the specific harms and chemicals of VLNCs.<sup>19–21</sup> These previous studies have predominantly evaluated textual statements rather than fully developed advertisements typically used in communication campaigns. Furthermore, no research has examined the effects of VLNC messages in combination with messages about e-cigarettes, even though both are components of nicotine-focused regulatory approaches.<sup>8</sup> To address this research gap, our randomised clinical trial (RCT) assessed the effects of messages about VLNCs, e-cigarettes and their combination on perceptions, behavioural intentions and subsequent behaviours.

## METHODS

We conducted an RCT between October 2022 and February 2023. This study follows the Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines for RCTs.<sup>22</sup> Trial protocol is available in online supplemental file 2.

### Participants

Participants from the Ipsos KnowledgePanel were pre-identified based on internal data on age (aged 18+) and smoking status: *adults who smoked exclusively* had smoked at least 100 cigarettes in their lifetime, currently smoked cigarettes every day or some days and did not use e-cigarettes; *adults who dual used* had smoked at least 100 cigarettes in their lifetime, currently smoked cigarettes every day or some days and had used e-cigarettes at least once in the past 30 days; *young adults who never smoked* were individuals aged 18–29 years who had not smoked 100 cigarettes in their lifetime. The KnowledgePanel sample (probability sample) included 971 adults who smoked exclusively, 240 adults who dual used cigarettes and e-cigarettes and 458 young adults (18–29 years old) who never smoked. To augment the sample of adults who dual used, additional participants were recruited from the opt-in, non-probability sample (n=232), bringing the total sample size to 1901.

### Procedure and design

A soft launch with 162 participants was conducted prior to the trial to test the procedures. The study was a four-group RCT with parallel assignment that was delivered through an online self-administered questionnaire, consisting of two sessions over 2 weeks. Participant enrollment, random allocation sequence and participants' assignments were implemented by Ipsos. In session 1, after consenting, participants were asked about their smoking status, quit intentions and attempts (adults who smoked exclusively and adults who dual used), e-cigarette use, other tobacco product use and health literacy. After stratification by smoking status group, participants were randomised into one of four conditions: (1) VLNC messages; (2) e-cigarette messages; (3) a combination of VLNC and e-cigarette messages or (4) control messages. A least-fill method was used, with participants

assigned to the condition with the lowest filled count. If the counts for the conditions were equal, the survey would assign the condition sequentially.

In the VLNC, e-cigarette and control message conditions, participants viewed two messages drawn at random from a pool of five messages corresponding to the assigned condition. In the combined condition, they were randomly shown one message from the pool of five VLNC messages and one from the pool of five e-cigarette messages. The study used a single-blind design, with participants unaware of the condition assignments or the content of the messages. The research team was not blinded, as the trial was administered online. To ensure that all participants knew about the VLNC policy before evaluating VLNC-related outcomes, after their exposure to the messages, all participants were presented with a description of the hypothetical VLNC policy scenario, which entailed that 'all cigarettes for sale are reduced nicotine cigarettes—cigarettes from which most (95%) of nicotine has been removed.' Participants then answered questions assessing the perceived harm of VLNCs (primary outcome), as well as other perceptions and behavioural intentions. Two weeks after session 1, participants from the KnowledgePanel were asked to complete a session 2 follow-up survey to assess message recall, perceived harm of VLNCs and smoking behaviours since session 1. At the end of the first session, participants were debriefed of the research purposes and provided with a Quitline number and a link to a smoking cessation website. Participant flow diagram is shown in online supplemental Appendix 1. Ipsos implemented additional checks for quality in the opt-in sample, including verifying answer consistency for a pair of questions expected to yield similar responses, cross-referencing zip code with state of residence and reviewing answers to open-ended responses.

### Message stimuli

Based on previous research,<sup>23–24</sup> we developed five VLNC messages and five e-cigarette messages, each with pictures and text (see figure 1). VLNC messages focused on the harms of VLNCs, explaining that VLNCs would still have the harmful chemicals and disease risks of regular cigarettes, but that they would be easier to quit. E-cigarette messages communicated that people who smoke and are not ready to quit could benefit from switching to e-cigarettes to reduce risks to their health. The control messages were bottled water ads with no smoking-related content (a 'placebo message control').<sup>25</sup>

### Measures

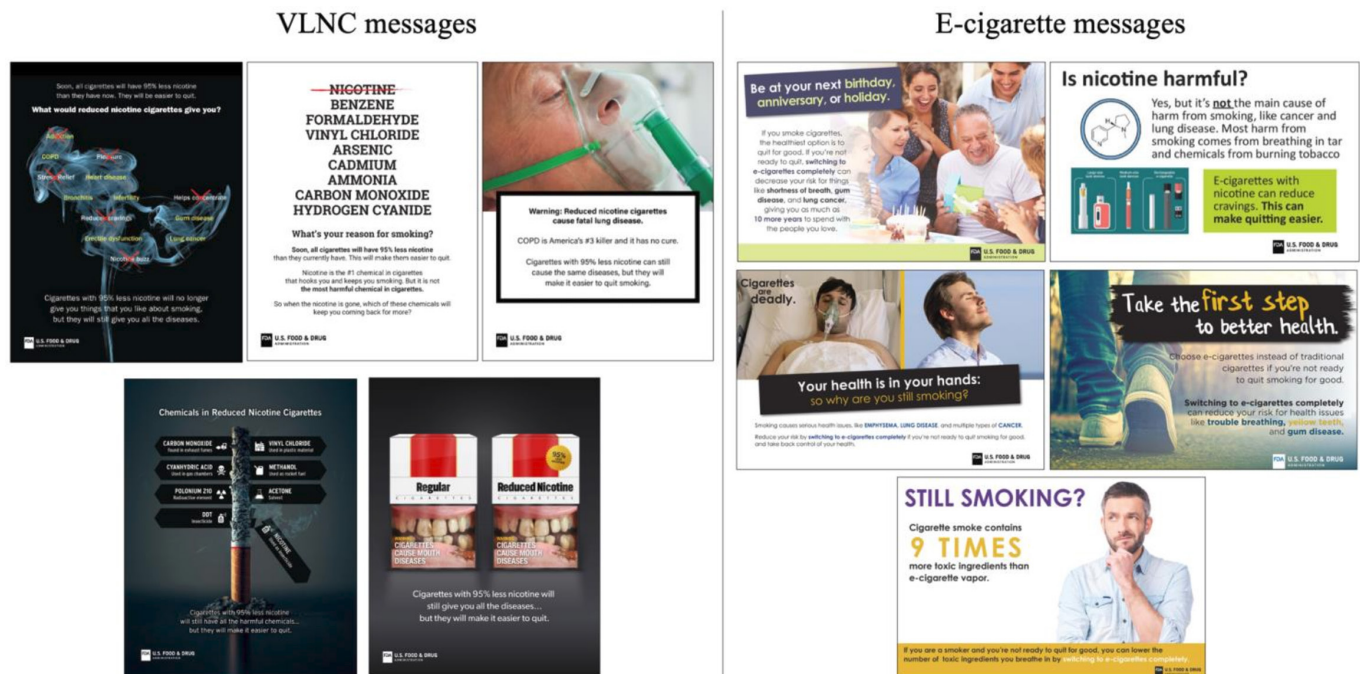
#### Primary outcome

The primary outcome was perceived absolute harm of VLNCs: "If you were to smoke reduced nicotine cigarettes every day, how likely is it that they would harm your overall health?" (1—not at all to 5—extremely, plus 'don't know'), measured immediately after exposure to the two messages and at session 2.

#### Secondary outcomes

Perceived comparative harm of VLNCs was measured immediately after exposure to the two messages and at session 2 via a single item: 'Compared to smoking regular cigarettes, how harmful is smoking reduced nicotine cigarettes?' (1—much less harmful; 5—much more harmful, and 'don't know').

The following outcomes were measured immediately after exposure. *Perceived absolute addictiveness of VLNCs* was measured with a single item: 'If you were to smoke reduced nicotine cigarettes every day, how likely is it that you would get



**Figure 1** Messages about very low nicotine cigarettes and e-cigarettes. VLNC, very low nicotine cigarettes.

addicted?’ (1—not at all likely; 5—extremely likely, plus ‘don’t know’). *Perceived comparative addictiveness of VLNCs* was measured with a single item: ‘Compared to regular cigarettes, reduced nicotine cigarettes are...’ (1—much less addictive; 5—much more addictive, plus ‘don’t know’). *Interest in trying VLNCs* was measured with a single item: ‘How interested are you in trying reduced nicotine cigarettes?’ (1—not at all; 7—extremely, plus ‘don’t know’). *Support for the VLNC policy* was measured with a single item: ‘Think about the policy to reduce nicotine by 95% in all cigarettes. How much do you support or oppose this policy?’ (1—strongly oppose; 5—strongly support, plus ‘don’t know’). Intention to switch completely to e-cigarettes was only asked and analysed for people who smoked (exclusively and dual used with e-cigarettes). Participants responded to the question, ‘At any time during the next 6 months, do you think you will switch completely from cigarettes to electronic nicotine products?’ (1—not at all likely; 7—extremely likely, plus ‘don’t know’).

In addition to the outcomes that were registered in ClinicalTrials.gov, we also measured additional outcomes including perceived risk of nicotine and intention to quit smoking. *Perceived risk of nicotine* was measured by asking, ‘How much do you agree or disagree that nicotine in cigarettes is the substance that causes most of smoking-related health problems, such as cancer and lung disease?’ (1—strongly disagree; 7—strongly agree, plus ‘don’t know’). *Intention to quit smoking* was only asked and analysed for people who smoked with three items: ‘How interested are you in quitting smoking in the next 6 months?’, ‘How likely are you to quit smoking in the next 6 months?’, ‘How much do you plan to quit smoking in the next 6 months?’ (1—not at all; 7—extremely, plus ‘don’t know’). A composite score was calculated by averaging the responses to these items ( $\alpha=0.94$ ).

At session 2, smoking behaviour was measured with a single item asking the average number of cigarettes participants smoked per day in the past 2 weeks.

#### Covariates

We included standard demographic measures as potential covariates, including sex (male, female), age, race/ethnicity (white, non-Hispanic; black, non-Hispanic; other, non-Hispanic; Hispanic; multiracial, non-Hispanic), education (no high school or General Educational Development (GED), high school or GED, some college or associate degree, bachelor degree or higher), employment status (full-time, part-time, not currently employed) and smoking status (adults who smoked exclusively, adults who dual used cigarettes and e-cigarettes and young adults who never smoked).

Additional factors that might influence outcomes were measured before message exposure, including intention to quit smoking in the next 6 months (yes vs no among adults who smoke exclusively and adults who dual use), e-cigarette use (ever vs never used) and health literacy (‘how confident are you filling out medical forms by yourself?’ 1—extremely to 5—not at all).

#### Statistical analysis

The target sample size was 1800, with 450 participants per condition (balanced for smoking status) and accounting for an 80% retention rate at the 2-week follow-up survey. With power fixed to 80%, alpha 0.05, the trial had adequate power to detect close to small effects, with standardised effect sizes between  $d=0.13$ – $0.28$  for continuous outcomes (where  $0.2$ =small effects;  $0.5$ =large effects) and, for binary outcomes, ORs between 1.4 and 3.5.<sup>26 27</sup>

$\chi^2$  tests assessed differences in baseline characteristics by message condition. To examine the effects of message condition, we conducted univariate analyses of covariance for continuous outcomes (including the primary outcome) and logistic regressions for dichotomous outcomes. ‘Don’t know’ responses were treated as missing values, and percentages of ‘don’t know’ are presented separately. Only covariates that significantly correlated with the outcomes at  $r \geq 0.3$  were included.<sup>28</sup> To test moderation of message condition effects by

smoking status, we added interaction terms to the covariate-adjusted models. If the interactions were significant, differences by smoking status were tested. False Discovery Rate was applied to account for multiple testing while balancing the risks of Type I and II errors.<sup>29</sup>

Sensitivity analyses were conducted after excluding opt-in participants. The results remained consistent with those presented in the paper regarding statistical significance, valence and interpretation (results available on request). All analyses were conducted using unweighted data with SPSS V.28.

## RESULTS

### Sample characteristics

A total of 1901 participants completed session 1 (see table 1). Retention rate for those who received the session 2 invitation (ie, KnowledgePanel only) was 90.5% (N=1510). The condition was not associated with participant characteristics, missing data or attrition. Among session 1 participants (table 1), 46.6% were men, 69.0% were white, non-Hispanic, 40.4% had a high school degree or less and 43.6% were working full-time.

**Table 1** Sample characteristics overall and by message condition

Sample characteristics/ conditions	Overall (%), N=1901	VLNC message (%), n=468	E-cigarette message (%), n=484	Combined message (%), n=476	Control (%), n=473
Sex					
Male	46.6	45.5	45.9	45.6	49.3
Female	53.4	54.1	54.4	50.7	53.4
Age					
18–29	28.9	27.4	29.1	28.2	31.1
30–44	23.2	22.4	22.7	23.9	23.7
45–59	23.4	25.4	23.1	22.3	22.8
60+	24.5	24.8	25.0	25.6	22.4
Race/ethnicity					
White, non-Hispanic	69.0	70.1	64.9	73.1	67.9
Black, non-Hispanic	11.8	10.5	13.0	10.9	12.9
Other, non-Hispanic	3.7	4.3	3.9	2.3	4.4
Hispanic	11.5	11.8	13.0	9.7	11.4
2+ races, non-Hispanic	4.0	3.4	5.2	4.0	3.4
Education					
No high school or GED	9.8	12.2	9.3	7.6	10.4
High school or GED	30.6	32.1	27.7	30.0	32.8
Some college or associate degree	35.3	31.8	38.6	36.8	34.0
Bachelor degree or higher	24.2	23.9	24.4	25.6	22.8
Employment status					
Working full-time	43.6	41.9	44.0	44.7	43.8
Working part-time	16.6	17.9	17.8	15.8	15.0
Not working	39.8	40.2	38.2	39.5	41.2
Smoking status					
Adults who smoked exclusively	51.1	52.6	50.6	51.5	49.7
Adults who dual used	24.8	24.4	24.6	24.8	25.6
Young adults who never smoked	24.1	23.1	24.8	23.7	24.7
Quit intention at pre-test*					
Not in the next 6 months	65.1	63.1	64.9	69.1	63.2
Sometime in the next 6 months	34.9	36.9	35.1	30.9	36.8
E-cigarette use					
Ever used	61.7	60.3	62.4	61.1	62.8
Never used	38.3	39.7	37.6	38.9	37.2

$\chi^2$  test results suggest there were no significant differences in baseline characteristics between message conditions.

\*Only tested among adults who smoked exclusively and adults who dual used (n=1443).

GED, General Educational Development; VLNC, very low nicotine cigarettes.

**Table 2** Estimated marginal means, SEs, univariate F statistics and % of 'don't know' of each message condition

Session 1 outcomes/ conditions	VLNC message, N=468	E-cigarette message, n=484	Combined message, n=476	Control, n=473	Univariate F statistics	Adjusted P value
Perceived absolute harm of VLNCs* (1–5 scale)						
EMM (95% CI)	<b>4.09 (3.99 to 4.19)<sup>a</sup></b>	<b>3.81 (3.71 to 3.90)<sup>b</sup></b>	<b>4.03 (3.93 to 4.13)<sup>ac</sup></b>	<b>3.87 (3.78 to 3.97)<sup>bc</sup></b>	F(3, 1687)=7.33, p<0.001, $\eta_p^2=0.013$	0.008
% of 'don't know'	10.3	11.4	11.4	9.5		
Perceived absolute addictiveness of VLNCs (1–5 scale)						
EMM (95% CI)	3.68 (3.58 to 3.78)	3.74 (3.64 to 3.84)	3.65 (3.55 to 3.75)	3.71 (3.61 to 3.82)	F(3, 1633)=0.64, p=0.59, $\eta_p^2=0.001$	0.70
% of 'don't know'	12.9	14.0	13.7	13.4		
Interest in trying VLNC* (1–7 scale)						
EMM (95% CI)	3.09 (2.89 to 3.28)	2.95 (2.76 to 3.14)	3.08 (2.90 to 3.27)	3.15 (2.95 to 3.34)	F(3, 1755)=0.77, p=0.51, $\eta_p^2=0.001$	0.70
% of 'don't know'	7.1	8.5	5.0	6.4		
Intention to switch completely to e-cigarettes† (1–7 scale)						
EMM (95% CI)	3.15 (2.96 to 3.33)	2.97 (2.79 to 3.15)	2.91 (2.73 to 3.09)	2.86 (2.68 to 3.05)	F(3, 1324)=2.08, p=0.10, $\eta_p^2=0.005$	0.40
% of 'don't know'	9.5	5.6	7.5	6.5		
Perceived risk of nicotine (1–7 scale)						
EMM (95% CI)	4.81 (4.64 to 4.99)	4.87 (4.69 to 5.04)	4.75 (4.58 to 4.93)	4.94 (4.76 to 5.11)	F(3, 1807)=0.75, p=0.52, $\eta_p^2=0.001$	0.70
% of 'don't know'	5.6	4.1	4.1	2.5		
Intention to quit smoking*† (1–7 scale)						
EMM (95% CI)	3.94 (0.08)	3.69 (0.08)	3.86 (0.08)	3.87 (0.08)	F(3, 1390)=1.52, p=0.21, $\eta_p^2=0.003$	0.56
% of 'don't know'						
'How interested are you in quitting smoking in the next 6 months?'	4.2	6.1	4.2	2.3		
'How much do you plan to quit smoking in the next 6 months?'	7.8	6.3	5.0	6.2		
'How likely are you to quit smoking in the next 6 months?'	9.4	8.0	6.9	6.2		
Session 2 Outcome/ conditions	VLNC message, N=379	E-cigarette message, n=383	Combined message, n=374	Control, n=374	Univariate F statistics	
Perceived absolute harm of VLNCs at Session 2 (1–5 scale)						
EMM (95% CI)	3.68 (3.57 to 3.80)	3.62 (3.51 to 3.74)	3.68 (3.56 to 3.79)	3.62 (3.50 to 3.73)	F(3, 1198)=0.36, p=0.78, $\eta_p^2=0.001$	0.78
% of 'don't know'	20.8	20.4	20.1	21.1		
Number of cigarettes smoked per day in the past 2 weeks at Session 2*						
EMM (95% CI)	12.40 (11.88 to 12.91)	11.98 (11.46 to 12.50)	12.27 (11.75 to 12.79)	12.00 (11.47 to 12.52)	F(3, 1132)=0.61, p=0.61, $\eta_p^2=0.002$	0.70
Results from analyses of covariance (ANCOVAs). Bold indicates significance at adjusted p<0.05. P values were adjusted using the False Discovery Rate method. <sup>29</sup> Estimates with different superscripts in each row were significantly different at adjusted p<0.05. *Covariates were those that correlated at $r$ or $r_{(s)} \geq 0.30$ with outcomes: smoking status was controlled for perceived harm of VLNCs; age, e-cigarette use and smoking status were controlled for interest in trying VLNC; age, e-cigarette use and smoking status were controlled for intention to switch to e-cigarettes; the number of cigarettes smoked per day at session 1 was controlled for the number of cigarettes smoked per day at session 2. No covariates were controlled for the other outcomes. †Only tested among adults who smoked exclusively and adults who dual used (n=1443). EMM, Estimated Marginal Means; VLNC, very low nicotine cigarettes.						

### Primary outcome

The effect of message condition on perceived absolute harm of VLNCs was significant,  $F(3, 1687)=7.33$ ,  $p<0.001$ ,  $\eta_p^2=0.013$  (table 2). Pairwise comparisons showed that perceived absolute harm of VLNCs was significantly higher in the VLNC message

condition (Estimated Marginal Means (EMM)=4.09) compared with the e-cigarette message condition (EMM=3.81) and the control condition (EMM=3.87, adjusted  $p<0.05$ ). Participants in the combined message condition reported higher perceived absolute harm of VLNCs (EMM=4.03, adjusted  $p<0.05$ )

**Table 3** Logistic regressions of message condition on perceived comparative harm, comparative addictiveness of VLNCs, and support for VLNC policy

Outcomes/conditions	VLNC message, N=468	E-cigarette message, n=484	Combined message, n=476	Control, n=473
Perceived VLNCs as less harmful than regular cigarettes*				
OR	<b>0.40 (0.29–0.57)</b>	0.85 (0.63–1.14)	0.68 (0.50–0.93)	Reference
% of 'less harmful'	13.3	23.3	20.8	27.1
% of 'don't know'	15.7	17.1	13.2	14.4
Perceived VLNCs as less addictive than regular cigarettes*				
OR	1.05 (0.79–1.40)	0.84 (0.63–1.12)	1.01 (0.76–1.35)	Reference
% of 'less addictive'	32.1	29.0	32.7	33.0
% of 'don't know'	20.1	17.2	17.1	15.6
Support for VLNC policy†				
OR	1.09 (0.83–1.42)	0.98 (0.75–1.29)	1.14 (0.87–1.48)	Reference
% of 'support'	39.1	35.5	39.3	37.7
% of 'don't know'	4.5	7.6	6.3	4.7
Session 2 Outcome/conditions	VLNC message, N=379	E-cigarette message, n=383	Combined message, n=374	Control, n=374
Perceived VLNCs as less harmful than regular cigarettes at Session 2*				
OR	0.81 (0.57–1.14)	1.06 (0.76–1.48)	0.94 (0.67–1.32)	Reference
% of 'less harmful'	23.5	28.3	26.3	27.1
% of 'don't know'	20.8	20.5	20.2	21.2

Bold indicates significance at adjusted  $p < 0.05$ .  
The correlations between the outcomes and potential covariates were consistently below 0.30. Therefore, the models were unadjusted for covariates, and only ORs were presented.  
\*Perceived comparative harm/addictiveness of VLNCs was dichotomised as 1='equally or more harmful/addictive' (equally harmful/addictive, more harmful/addictive and much more harmful/addictive) versus 2='less harmful/addictive' (much less harmful/addictive and less harmful/addictive).  
†Support for VLNC policy was dichotomised as 1='support' (strongly support, support) versus 2 'oppose or neutral' (strongly oppose, oppose, neither support nor oppose).  
VLNC, very low nicotine cigarettes.

compared with those in the e-cigarette message condition. Perceived absolute harm of VLNCs at session 2 was not significantly different at the univariate level or in pairwise comparisons between conditions.

### Continuous secondary outcomes

All the continuous secondary outcomes measured at session 1 (perceived absolute addictiveness of VLNCs, interest in trying VLNCs, intention to switch completely to e-cigarettes, perceived risk of nicotine, intention to quit smoking) and session 2 outcomes (number of cigarettes smoked in the past 2 weeks) were not significantly different at the univariate level or in pairwise comparisons between conditions.

### Dichotomous secondary outcomes

Compared with control condition, exposure to the VLNC messages was associated with lower odds of believing that VLNCs are less harmful than regular cigarettes (OR=0.40, adjusted  $p < 0.05$ , table 3). Message condition was not significantly associated with perceived comparative harm of VLNCs at session 2 or perceived comparative addictiveness of VLNCs and support for VLNC policy at session 1.

### Interaction between message condition and smoking status

After correcting for multiple testing, we observed a significant interaction between message condition and smoking status only for intention to switch to e-cigarettes in the next 6 months,  $F(3, 1322)=4.50$ , adjusted  $p=0.028$ . For adults who dual used, intention to switch to e-cigarettes were significantly higher in the VLNC condition (EMM=4.93) than the e-cigarette (EMM=4.29), combined (EMM=4.30) and control conditions (EMM=4.00, adjusted  $p < 0.05$ ;

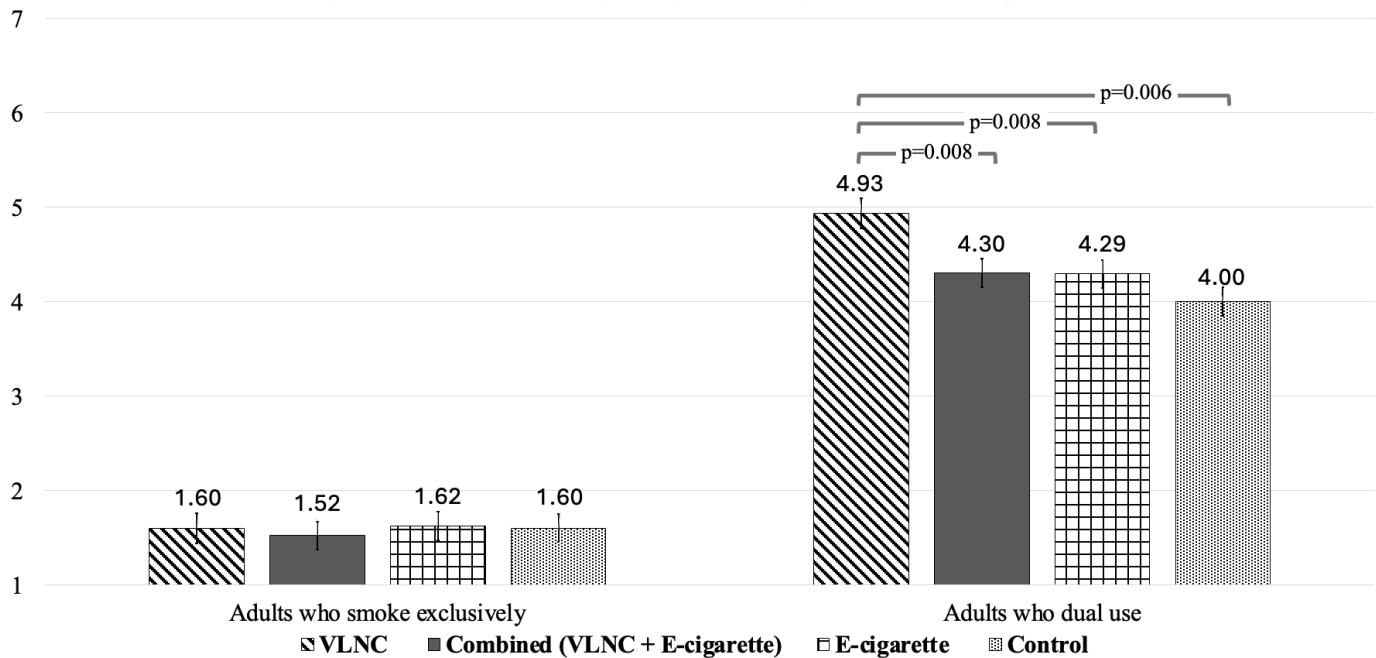
figure 2). The effect of message condition on intention to switch to e-cigarettes was not significant for adults who smoked exclusively.

## DISCUSSION

In light of pending FDA regulations to reduce nicotine in combusted cigarettes to minimally addictive levels,<sup>4,8</sup> this RCT assessed the effects of messages about VLNCs, messages about e-cigarettes and the combination of VLNC and e-cigarette messages in three key populations: adults who smoked cigarettes exclusively, adults who used both cigarettes and e-cigarettes and young adults who never smoked. The VLNC messages were developed based on previous research,<sup>21,23</sup> which involved participants sharing in-depth feedback on VLNC messages with different themes. These messages elucidated that VLNCs would be easier to quit, but they still contain all the harmful chemicals found in regular cigarettes and would still cause diseases. Exposure to VLNC messages increased perceived absolute harm of VLNCs and reduced the likelihood of perceiving VLNCs as less harmful than regular cigarettes. These findings indicate the potential of these VLNC messages to effectively communicate about the harms of VLNCs, as well as correct the misperception that VLNCs are less harmful than regular cigarettes. Although some effects we found were small, small effects are typical in communication research,<sup>30,31</sup> though the impact can still be meaningful if the message reach and, hence, exposure is broad.

Message effects on intention to switch completely to e-cigarettes in the next 6 months varied by smoking status. Following exposure to VLNC messages, adults who dual used reported significantly higher intention to make a complete switch compared with those who viewed the e-cigarette, combined and control messages. Additionally, for adults who dual used, no

## Estimated marginal means of "At anytime during the next 6 months, do you think you will switch completely from cigarettes to e-cigarettes?"



**Figure 2** Interaction effect of message condition and smoking status on intention to switch to e-cigarettes. Intention to switch was only tested among adults who smoke exclusively and adults who dual use. Covariates were those that correlated at  $r \geq 0.30$  with intention to switch to e-cigarettes: age and e-cigarette use. VLNC, very low nicotine cigarettes.

significant difference in intention to switch was seen between the e-cigarette condition and the control condition, as well as between the combined condition and the control condition. No difference in intention to switch was observed between message conditions among adults who smoked exclusively. This finding suggests that messages conveying the harm reduction of switching completely from cigarettes to e-cigarettes did not have the expected impact on intention to switch for adults who smoked exclusively. This observation remained consistent with previous focus group studies, where participants showed hesitancy and, at times, adverse responses to messages that advised people who smoke to switch from cigarettes to alternative tobacco products.<sup>23 32</sup> In the case of adults who dual used, they were already familiar with e-cigarettes and possibly the harm reduction aspect of these products, as existing studies have shown that one commonly cited reason for initiating e-cigarette use among people who smoke is the perception of reduced harm.<sup>33 34</sup> Consequently, the content in the e-cigarette messages did not motivate them to change their current product use patterns. On the other hand, our VLNC messages highlighted the harms of smoking in general, whether traditional or VLNC products. This reinforced awareness of the overall detrimental health risks associated with smoking and promoted intention to switch completely to the alternative nicotine delivery product that they were already using and familiar with.

We found no significant differences across message conditions either in perceived absolute addictiveness of VLNCs or in the perception that VLNCs are less addictive than regular cigarettes. Although our VLNC messages included the statement that reduced nicotine would make VLNCs easier to quit compared with regular cigarettes, they did not explicitly describe how addictive VLNCs with the remaining 5% nicotine might be, nor did they provide comprehensive information about nicotine's role in smoking addiction. Previous research suggests that

people often attribute cigarette addiction to ingredients beyond just nicotine.<sup>35</sup> Given that the pictorial content of our VLNC messages primarily focused on the harms of VLNCs and did not directly address the nicotine-related misperceptions, participants might have overlooked the brief statement about VLNCs being easier to quit or might not have associated ease of quitting with nicotine levels. This could explain why the VLNC messages did not significantly influence perceptions of their addictiveness.

Analyses of session 2 outcomes showed that message condition was not significantly associated with smoking behaviour in the past 2 weeks. Furthermore, the previously observed significant effect of message condition on perceived harm of VLNCs immediately after exposure also dissipated in the follow-up survey. The proportion of participants in all message conditions who selected 'don't know' when asked about the harm of VLNCs increased from 9.5% to 11.4% at session 1 to 20.1% to 21.1% at session 2. Given that participants were exposed to the messages only once, it is likely that the effects were not as powerful as they could have been with more frequent message exposure and for a longer duration, as suggested by previous research.<sup>36-38</sup> Actual experience with VLNCs also may have reinforce message content if these were properly coordinated. Future studies should consider exploring the effects of VLNC messages using a longitudinal design where participants view messages repeatedly for an extended period, accompanied by actual use of VLNCs.

Our results suggested that compared with VLNC messages only, combined messaging about VLNCs and e-cigarettes did not yield significant improvements in the outcomes either overall, including perceived harm of VLNCs and intention to switch to e-cigarettes, or when evaluating outcomes by smoking status groups. Therefore, combining message content about alternative products along with the harms of VLNCs may not improve message outcomes. Additional ways to communicate about e-cigarettes in the context of the VLNC policy need to be explored.

## Strengths and limitations

This study relied on self-reported quitting behaviour, and people who smoke are less likely to report short and/or unsuccessful quit attempts.<sup>39 40</sup> However, self-report of quitting and other outcomes appears unlikely to have been systematically different across conditions. Participants may have responded in the manner perceived as socially desirable. Furthermore, participants were exposed to each message only once during the study; however, certain effects manifest only after repeated exposure during an extended period, as sometimes seen in real-world campaigns.<sup>36–38</sup> Not finding effects of messages might be due to the specific execution of these messages. Future research can explore alternative executions. VLNC messages were accompanied by messages on e-cigarettes consistent with the FDA's comprehensive nicotine-focused strategy. However, future research should evaluate the messages about nicotine replacement therapy, which would likely also play a role in the implementation of the policy.

Several strengths contributed to our study's scientific rigour. The inclusion of a nationally representative sample spanning different smoking status groups enhanced the generalisability of our findings. The randomised design allowed comparison of message effects while reducing the influence of potential confounding factors. We used full-colour print ads that resemble real-world campaign materials. These messages can be used in future paid campaigns with minimal edits either in their current form or serve as foundation for other campaign messages (eg, social media ads).

## Conclusion

Reducing nicotine levels in combusted tobacco products to minimal or non-addictive levels, while addressing the availability of alternative nicotine delivery systems such as e-cigarettes, represent two parallel strategies of the FDA's nicotine-focused regulatory approach.<sup>8 10</sup> However, our results suggested that combining VLNC messages with messages advising people who smoke to switch to e-cigarettes as a reduced risk product did not significantly improve the desire outcomes of either more accurate perception of the harm of VLNCs or increased intention to switch to e-cigarettes. Given that messages emphasising the harms of VLNCs while highlighting their ease of quitting were effective in increasing perceived harm of VLNCs and reducing perceptions that VLNCs are less harmful than regular cigarettes, the FDA may consider prioritising the VLNC messages.

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