



# Correcting misperceptions about very low nicotine cigarettes for cigarette-only smokers, dual/poly smokers, other tobacco users, and non-tobacco users

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## ABSTRACT

**Background:** The U.S. Food and Drug Administration authorized the sale and marketing of two very low nicotine cigarettes (VLNC) as modified risk tobacco products. The misperception that VLNC are healthier than regular cigarettes is common. This study explores effective message strategies to inform the public about health risks associated with VLNC use, encourage cigarette smokers to try VLNC, and prevent other tobacco users and non-users from product initiation.

**Methods:** Following the Reasoned Action approach, a VLNC educational message was developed based on the salient beliefs associated with behavioral intention. The message was tested in an online survey conducted in 2018, where 410 participants were randomly assigned to one of the two message conditions (no-message, VLNC message). Message effects were assessed across four tobacco-use groups (non-tobacco users, cigarette-only smokers, cigarette dual/poly smokers, other tobacco users).

**Results:** Compared to the no-message control, the VLNC message condition showed lower nicotine risk perception for all participants, lower misbelief in VLNC safety for non-users and cigarette-only smokers, higher belief in VLNC carcinogenicity for other tobacco users, stronger belief in second-hand smoke harm for cigarette dual/poly smokers and other tobacco users, and higher VLNC intention for cigarette-only smokers.

**Conclusions:** Different messages are needed for different types of tobacco users. Both cigarette smokers and other tobacco users could benefit from messages that acknowledge the non-addictiveness but emphasize the health risks of VLNC. Regulators could consider making physical harm statements a requirement for VLNC packaging and marketing. New strategies need to be explored to inform cigarette dual/poly smokers.

## 1. Introduction

In June 2022, the U.S. Food and Drug Administration (FDA) announced a plan to develop a product standard that would eventually reduce nicotine in combustible cigarettes to non-addictive levels (U.S. Food and Drug Administration, 2022). Very low nicotine cigarettes (VLNC) are a promising tool for reducing nicotine dependence and the daily consumption of cigarettes (Berman and Glasser, 2019). A simulation study predicted that five million smokers would quit smoking within the first year if the FDA were to implement the nicotine reduction policy. By 2060, this policy could reduce smoking prevalence to just 1.4% in the U.S. (Apelberg et al., 2018). Although the FDA has the long-term goal of eventually making VLNC the only combustible cigarettes

available on the market, there is likely a period when VLNC and regular cigarettes coexist. The FDA authorized the sale of “VLN King” and “VLN Menthol King” in 2019. By the end of 2022, VLNC were available to two test markets in the U.S.; thus, most smokers in the U.S. have yet to experience this new product. To prepare for the implementation of the nicotine reduction policy and to minimize unintended consequences, researchers have been calling for extensive education of the public on nicotine and the VLNC (Byron et al., 2018; Villanti et al., 2019a).

### 1.1. Nicotine and VLNC misperceptions

Most smokers in the U.S. have not formed any decisive intentions toward their use of VLNC. In a 2019 study, three-quarters of cigarette

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smokers reported some intention to smoke VLNC if they were the only available cigarettes, but 62.5 % of the same sample of smokers also reported they might just quit tobacco completely (M. Patel et al., 2019). The misperception that VLNC are healthier than regular cigarettes was a contributing factor in smokers' decision to smoke VLNC or to quit (Byron et al., 2018). This false belief in the relative low harm of VLNC is usually explained as a result of people's lack of understanding of the health risk of nicotine per se (Villanti et al., 2019b). A large proportion of the public incorrectly sees nicotine as the primary carcinogen in cigarettes (O'Brien et al., 2017) so when evaluating the VLNC, smokers may reason "Nicotine causes cancer; VLNC contain a very low level of nicotine; Thus VLNC are healthier than regular cigarettes".

Previous research has demonstrated that correcting misperceptions of nicotine per se (e.g., educating smokers that nicotine does not cause cancer) had limited effects on people's product-specific perceptions (Shi et al., 2021). Therefore, in this study, a product-specific message is developed to correct nicotine misperceptions, explain the role nicotine plays in cigarettes, and address the most salient health beliefs associated with VLNC use among tobacco users.

### 1.2. Tobacco use status

The FDA's plan to reduce nicotine in cigarettes will primarily benefit current cigarette smokers as the VLNC could potentially make it easier for them to quit smoking. However, once on the market, the VLNC will be available to people of various tobacco use statuses. Ideally, VLNC would only appeal to cigarette smokers rather than non-smokers, electronic cigarette users, cigar smokers, or smokeless tobacco users.

Cigarettes remain the most popular tobacco product among adult tobacco users in the U.S. (Cornelius et al., 2020), and about 40 % of cigarette smokers also use other tobacco products (Kasza et al., 2017). The most common product combination for dual/poly users is the cigarettes plus electronic cigarettes combo. The cigarette/e-cigarette dual smokers are different from cigarette-only smokers on three dimensions: dual smokers tend to have higher intentions to quit cigarettes and make more quitting attempts than cigarette-only smokers; dual smokers are more concerned with the health risks of cigarettes for themselves and the second-hand smoking harm for others; dual smokers also show higher nicotine dependence symptoms than cigarette-only smokers (D. Patel et al., 2016; Rutten et al., 2015; Sung et al., 2018). Therefore, with the correct belief that VLNC can help them quit cigarettes and the misperception that VLNC are safer than cigarettes, cigarette dual/poly smokers may be even more motivated to smoke VLNC than cigarette-only smokers.

Although VLNC have not been made widely available in the U.S., and data from the test markets are limited, some insights into its potential adoption pattern can be drawn from the recent release of heat-not-burn tobacco products. These products contain a heating source that heats a cigarette to a high temperature without burning it. Both VLNC and heat-not-burn tobacco are FDA-authorized modified risk tobacco products new to the U.S. market. VLNC are authorized to be marketed as less addictive than regular cigarettes, while heat-not-burn tobacco is promoted as a safer alternative to regular cigarettes. Ideally both products would only be used by cigarette smokers. A recent study, however, shows that heat-not-burn tobacco may encourage concurrent use among e-cigarette-only users and cigarette/e-cigarette dual smokers (Pokhrel et al., 2021). Specifically, relative to non-users, baseline cigarette/e-cigarette dual users are nine times more likely to initiate heat-not-burn tobacco use in six months, and baseline e-cigarette-only users are three times more likely to initiate use in six months (Pokhrel et al., 2021). Therefore, it is reasonable to speculate that VLNC may appeal not only to cigarette smokers but also to other tobacco product users.

It is urgent to educate people of various tobacco use statuses on the meaning of VLNC as a modified risk tobacco product in terms of addictiveness and health risks. Based on the discussion above, in this study tobacco users are categorized as cigarette-only smokers, cigarette

dual/poly smokers, and other tobacco users who do not smoke cigarettes.

### 1.3. The current study

The Reasoned Action approach (Fishbein and Ajzen, 2011) serves as a theoretical framework for message development and testing. This theoretical model proposes that behavioral intention is the strongest predictor of human behavior, and intention is in turn determined by people's attitude, perceived norm, and perceived behavior control. This study mainly follows the attitude-intention path to predict VLNC use because the VLNC are not readily available to the national market, and people may have difficulty forming any perception of norm or behavior control. Attitude alone has been shown to be strongly associated with health behavioral intentions in a meta-analysis (McEachan et al., 2016).

This study aims to develop and test a VLNC education message. The message would inform the public about the health risks associated with VLNC use, encourage cigarette smokers to try VLNC, and prevent other tobacco users and non-users from product initiation.

## 2. Methods

### 2.1. Message development

To facilitate message development, we conducted a cross-sectional pilot survey first with an online sample of 614 adult tobacco users in the U.S. recruited through the research company SSRS using the SSRS Online Probability Panel. Tobacco users responded to five behavioral beliefs regarding the consequences of using VLNC and their intentions to use VLNC. Measurement details are described in the section below. As shown in Table 1, results from the pilot survey indicated the VLNC message should address addictiveness, second-hand smoke, cancer, and relative harm. We then developed a VLNC message based on the layout of the New York State Smokers' Quitline's Facts and Myths webpage with a Q&A format. The message clarifies that nicotine does not cause cancer and explains that VLNC are as cancerous as regular cigarettes. The answers provided in the Q&A were extracted from official websites of public health agencies, including CDC, FDA, Smokefree.gov, and nysmokefree.com. Fig. 1 shows the appearance and wording of the VLNC message.

### 2.2. Experiment design and procedure

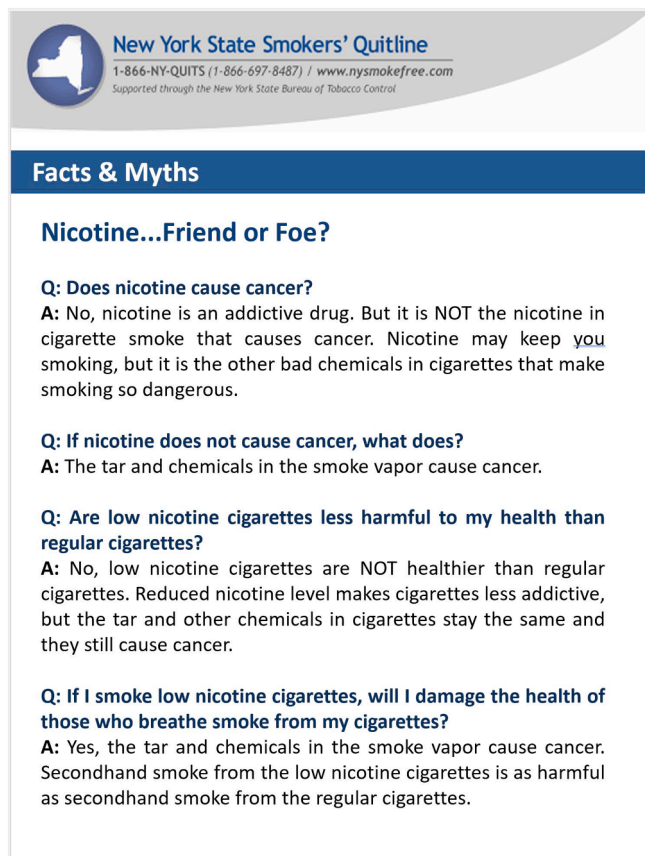
We conducted an online experiment in 2018 to test the effectiveness of the VLNC educational message. The experiment took a post-only between-subject design. Study participants were randomly assigned to one of the two conditions (no-message, VLNC message). Message effects were assessed across four tobacco-use groups (non-tobacco users, cigarette-only smokers, cigarette dual/poly smokers, other tobacco

**Table 1**

Pilot: tobacco users' beliefs about very low nicotine cigarettes (VLNC) and their zero-order correlations with VLNC intention.

VLNC behavioral beliefs	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	r
I will become addicted.	10.9	36.2	<b>52.9</b>	−0.10**
I will damage the health of those who breathe smoke from my cigarettes.	<b>10.6</b>	27.9	61.6	−0.11**
I will get a heart attack.	<b>11.2</b>	57.7	31.1	−0.07
I will get cancer.	<b>8.2</b>	52.4	39.5	−0.08*
It will be less harmful to my health than if I smoke regular cigarettes.	32.3	34.3	<b>33.4</b>	0.34**

Note.  $N = 614$ . Bold texts indicate the proportion of respondents with misbeliefs. \* $p < 0.05$ . \*\* $p < 0.01$ .



**New York State Smokers' Quitline**  
1-866-NY-QUITS (1-866-697-8487) / www.nysmokefree.com  
Supported through the New York State Bureau of Tobacco Control

## Facts & Myths

### Nicotine...Friend or Foe?

**Q: Does nicotine cause cancer?**  
A: No, nicotine is an addictive drug. But it is NOT the nicotine in cigarette smoke that causes cancer. Nicotine may keep you smoking, but it is the other bad chemicals in cigarettes that make smoking so dangerous.

**Q: If nicotine does not cause cancer, what does?**  
A: The tar and chemicals in the smoke vapor cause cancer.

**Q: Are low nicotine cigarettes less harmful to my health than regular cigarettes?**  
A: No, low nicotine cigarettes are NOT healthier than regular cigarettes. Reduced nicotine level makes cigarettes less addictive, but the tar and other chemicals in cigarettes stay the same and they still cause cancer.

**Q: If I smoke low nicotine cigarettes, will I damage the health of those who breathe smoke from my cigarettes?**  
A: Yes, the tar and chemicals in the smoke vapor cause cancer. Secondhand smoke from the low nicotine cigarettes is as harmful as secondhand smoke from the regular cigarettes.

Fig. 1. The very low nicotine cigarettes message.

users). Participants in the VLNC message condition were kept on the message screen for at least 20 s before the “next” button appeared. Their responses to nicotine and VLNC were then assessed in a survey.

### 2.3. Study sample

We recruited a convenience sample of U.S. adults from an online research company, Critical Mix. The company’s research panel members received a standardized e-mail request containing a study link, and panelists self-enrolled through the link. To be eligible, panelists must be above 18 years old and reside in the U.S. Both tobacco users and non-users were recruited out of the concern that non-users may develop some interest in smoking initiation with VLNC. A stratified sampling strategy was used to recruit an equal number of tobacco users and non-tobacco users. Tobacco users were defined as those who reported using any tobacco product in the past 30 days. All participants were recruited before VLNC were released to the test markets, and none of them had any experience with the product. This study was approved by the University of Maryland Institutional Review Board (No. 1004845-3) with a consent waiver.

### 2.4. Measures

*Tobacco use status* was measured with seven dichotomous questions that asked about their use of regular cigarettes, electronic cigarettes, cigars, smokeless tobacco, roll-your-own, pipe, and hookah in the past 30 days. Participants were coded as “non-user” if they answered “no” to all seven products, as “cigarette-only smokers” if they exclusively smoked regular cigarettes, as “cigarette dual/poly smokers” if they used any products in addition to cigarettes, and as “other tobacco users” if they used any products other than cigarettes.

*Nicotine risk perception* was measured with the question: “In addition

to the risk of causing addiction, how much of the health risks in smoking come from the nicotine?”. Options included “1-none”, “2-very small part”, “3-relatively small part”, “4-relatively large part”, “5-very large part”, and “6-All” (Hamilton et al., 2004; Mooney et al., 2006; Wikmans and Ramström, 2010).

To measure *Behavioral beliefs of VLNC*, participants were told, “The next set of questions are about Reduced Nicotine Content Cigarettes. Reduced nicotine content cigarettes are similar to regular cigarettes except that they contain A VERY LOW level of nicotine compared to regular cigarettes. Currently you cannot buy reduced nicotine content cigarettes, that is, they are not on the market.” (Benowitz et al., 2017; Mercincavage et al., 2016). Five behavioral beliefs regarding the consequences of using VLNC were measured using a five-point scale with options ranging from “1-Strongly disagree” to “5-Strongly agree”. The five beliefs addressed concerns over addiction, heart attack, cancer, second-hand smoke, and relative harm (McQueen et al., 2011; Tan et al., 2016) (See Table 1 for item wording).

*VLNC Attitude* was measured with a 7-point semantic differential scale. Participants were asked to evaluate their use of VLNC in the next three months on five dimensions: Good-Bad, Enjoyable-Unenjoyable, Wise-Foolish, Pleasant-Unpleasant, and Beneficial-Harmful, Cronbach’s  $\alpha = 0.98$ .

*VLNC Intention* was measured with three items on a Likert scale with options ranging from “1-Strongly disagree” to “5-Strongly agree”. The three statements are “If reduced nicotine cigarettes are currently available, I intend to buy some reduced nicotine cigarettes in the next 3 months”, “...I will try some reduced nicotine cigarettes in the next 3 months”, and “...I plan to start using reduced nicotine cigarettes on a regular basis in the next 3 months”, Cronbach’s  $\alpha = 0.98$ .

*Covariates*. Sociodemographic information including age, gender, race, household income, and education level were measured. As shown in Table 2, significant differences were observed in participants’ age, gender, race, and income across the tobacco use status groups. Therefore, these four variables served as covariates in all the analytical models.

### 2.5. Statistical analysis

A two-way MANCOVA was first performed to examine the overall effects of the VLNC message (two levels: no-message control, VLNC message) and tobacco use status (four levels: non-users, cigarette-only smokers, cigarette dual/poly smokers, other tobacco users,) on all the outcome variables. A series of two-way ANCOVA were then conducted to detect message effects on every individual outcome across four tobacco use status groups. Heteroskedasticity-consistent standard errors were used in models where the Levene’s test indicated a violation of the assumption of homogeneity of variance.

## 3. Results

The analytical sample consisted of 410 participants who had completed the survey. Table 2 reports the demographic characteristics of the sample. As a natural result of stratified sampling, about half of the participants reported no past 30-day tobacco use and thus were labeled as non-users of tobacco products ( $n = 209$ ). Among the tobacco users ( $n = 201$ ), regular cigarettes are the most used product (77.6 %), followed by electronic cigarettes (27.4 %), cigars (25.9 %), smokeless tobacco (15.9 %), roll-your-own (14.4 %), hookah (11.9 %), and pipe (8.5 %).

The two-way MANCOVA indicated a significant main effect of the VLNC message on all the outcome variables, Wilks’  $\Lambda = 0.85$ , multivariate  $F(7, 392) = 10.22, p < 0.001$ , and a significant main effect of tobacco use status on all the outcome variables, Wilks’  $\Lambda = 0.61$ , multivariate  $F(21, 1126.16) = 10.05, p < 0.001$ . The interaction term between message and tobacco use status is also significant, Wilks’  $\Lambda = 0.92$ , multivariate  $F(21, 1126.16) = 1.61, p = 0.04$ . Univariate tests were then performed (reported in Table 3).

**Table 2**  
Mean (SD) and Column Percentage of Participant Characteristics by Tobacco use status.

Characteristics	Non-user (n = 209)	Cigarette-only smoker (n = 74)	Cigarette dual/poly smoker (n = 72)	Other tobacco user (n = 55)	Total (n = 410)	P*
Age (Mean, SD)	50.95 (16.47)	48.74 (12.79)	41.53 (13.1)	45.22 (15.34)	48.13 (15.53)	<.01
Household Income (in thousands; Mean, SD)	68.35 (50.58)	45.65 (28.95)	70.36 (57.31)	73.11 (62.49)	65.06 (51.42)	<.01
Gender-Male (%)	49.3	31.7	50.0	61.8	47.8	<.01
Hispanic/Latino (%)	16.3	13.5	13.9	12.7	14.9	0.88
Race (%)						
White	68.4	83.8	75.0	67.3	72.2	0.05
Black	14.8	14.9	13.9	16.4	14.9	0.99
Native American	1.9	1.4	4.2	0.0	2.0	0.38
Asian	6.2	0.0	4.2	7.3	4.9	0.15
Other	2.9	1.4	0.0	0.0	1.7	0.27
Education (%)						0.18
Some high school	0.5	4.1	0.0	1.8	1.2	
High school/GED	25.4	25.7	29.2	29.1	26.6	
Some college	27.3	33.8	33.3	16.4	28.0	
College graduate	31.6	28.4	29.2	38.3	31.5	
Postgraduate	15.3	8.1	8.3	14.5	12.7	

Note: \*for age and income this is the p-value of the overall ANOVA test; for the rest of the table this is the p-value of the Pearson Chi-square test.

**Table 3**  
Analysis of Covariance of People’s Nicotine and VLNC Responses by Message and Tobacco Use Status.

	VLNC Behavioral Beliefs													
	Nicotine risk perception		Become addicted		Second-hand smoke harm others		Get cancer		Less harmful than regular cigarettes		VLNC attitude		VLNC intention	
	F	$\eta^2$	F	$\eta^2$	F	$\eta^2$	F	$\eta^2$	F	$\eta^2$	F	$\eta^2$	F	$\eta^2$
Tobacco use status (T)	0.80	0.01	1.27	0.01	3.07*	0.02	0.87	0.01	4.50**	0.03	47.96**	0.26	57.00**	0.31
VLNC Message (V)	42.34**	0.10	0.23	0.00	8.84**	0.02	1.64	0.00	12.52**	0.03	0.00	0.00	0.20	0.00
T × V	2.66*	0.02	1.37	0.01	2.67 <sup>†</sup>	0.01	1.56	0.01	0.43	0.00	0.30	0.00	2.13 <sup>†</sup>	0.02
Adjusted R <sup>2</sup>		0.19		0.00		0.04		0.03		0.07		0.27		0.38

Note: N = 410. All models included age, gender, race-white, and income as covariates.  $\eta^2$ : eta squared. <sup>†</sup> p < 0.10, \* p < 0.05, \*\* p < 0.01.

**Table 4**  
Means (SD) of Nicotine and VLNC Responses by Experiment Conditions.

Outcomes	Non-user			Cigarette-only smoker			Cigarette dual/poly smoker			Other tobacco user		
	No Message (n = 105)	VLNC Message (n = 104)	$\eta_p^2$	No Message (n = 37)	VLNC Message (n = 37)	$\eta_p^2$	No Message (n = 41)	VLNC Message (n = 31)	$\eta_p^2$	No Message (n = 24)	VLNC Message (n = 31)	$\eta_p^2$
Nicotine risk perception	4.37 (1.24)	2.60 (1.69)	0.16**	4.19 (1.2)	2.97 (1.72)	0.03**	3.98 (1.29)	3.16 (1.59)	0.02*	3.71 (1.46)	2.84 (1.95)	0.01
VLNC behavioral beliefs												
I will become addicted	3.65 (0.97)	3.57 (1.00)	0.00	3.59 (0.83)	3.41 (0.87)	0.00	3.59 (0.84)	3.90 (0.75)	0.01	3.38 (1.06)	3.52 (1.24)	0.00
I will damage the health of those who breathe smoke from my cigarettes	3.86 (1.00)	4.03 (1.07)	0.00	3.59 (1.04)	3.73 (0.93)	0.00	3.73 (0.84)	4.19 (0.95)	0.01*	3.04 (1.16)	4.10 (1.04)	0.04**
I will get cancer	3.64 (0.91)	3.57 (1.02)	0.00	3.38 (0.83)	3.35 (0.86)	0.00	3.61 (0.74)	3.71 (0.94)	0.00	3.29 (0.86)	3.77 (1.09)	0.01*
It will be less harmful to my health than if I smoke regular cigarettes	2.92 (1.13)	2.35 (1.25)	0.03**	3.22 (1.11)	2.51 (1.04)	0.02*	3.37 (0.94)	3.13 (1.41)	0.00	3.21 (1.14)	2.71 (1.47)	0.01
VLNC attitude	2.02 (1.54)	2.07 (1.72)	0.00	3.91 (1.65)	4.18 (1.42)	0.00	4.50 (1.59)	4.40 (1.89)	0.00	3.66 (1.78)	3.37 (2.2)	0.00
VLNC intention	1.50 (0.93)	1.38 (0.85)	0.00	2.24 (1.21)	2.73 (0.99)	0.01*	3.36 (1.07)	3.19 (1.21)	0.00	2.76 (1.32)	2.27 (1.5)	0.01

Note: VLNC, Very low nicotine cigarettes.  $\eta_p^2$ : partial eta squared. \*two means differ at p < 0.05. \*\* two means differ at p < 0.01.

Participants' estimation of nicotine risk is significantly lower in the VLNC message condition ( $M = 2.79$ ,  $SD = 1.72$ ) than in the no message control condition ( $M = 4.18$ ,  $SD = 1.28$ ). As shown in Table 4, the message had a stronger impact on non-tobacco users than tobacco users, but overall the direction of the message's effect on nicotine risk perception is consistent across people of various tobacco use statuses, that is, the message tend to lower nicotine risk perception.

Two out of the four VLNC behavioral beliefs were affected by the VLNC message. As reported in Table 3 and Table 4, the VLNC message strengthened people's belief in the danger of second-hand smoke from VLNC. This effect is mainly manifested among other tobacco users ( $\Delta M = 1.06$ ,  $p < 0.01$ ) and cigarette dual/poly smokers ( $\Delta M = .46$ ,  $p < 0.05$ ) but not among non-users ( $\Delta M = .17$ ,  $ns$ ) or cigarette-only smokers ( $\Delta M = .14$ ,  $ns$ ). The VLNC message also corrected people's misbelief that VLNC are healthier than regular cigarettes. Across the four tobacco use statuses, people in the VLNC message condition consistently showed less agreement to this misbelief ( $M = 2.55$ ,  $SD = 1.29$ ) than the control condition ( $M = 3.1$ ,  $SD = 1.1$ ).

VLNC attitude differs across the tobacco use status groups. Cigarette dual/poly smokers ( $M = 4.46$ ,  $SD = 1.72$ ) and cigarette-only smokers ( $M = 4.04$ ,  $SD = 1.52$ ) showed the most positive attitude toward VLNC use. Other tobacco users had a moderate attitude ( $M = 3.49$ ,  $SD = 2.01$ ), while non-users had the least favorable attitude ( $M = 2.04$ ,  $SD = 1.62$ ). The attitude of cigarette dual/poly smokers was significantly higher than that of other tobacco users ( $p < 0.05$ ), and non-users' attitudes were significantly lower than those of all other groups ( $p < 0.01$ ).

VLNC intention also differs by tobacco use status. Cigarette dual/poly smokers ( $M = 3.29$ ,  $SD = 1.13$ ) expressed significantly higher intention to use VLNC than cigarette-only smokers ( $M = 2.49$ ,  $SD = 1.12$ ) and other tobacco users ( $M = 2.48$ ,  $SD = 1.43$ ,  $p < 0.01$ ), whose intentions were higher than the non-users ( $M = 1.44$ ,  $SD = .9$ ,  $p < 0.01$ ). A significant interaction effect between the message condition and the tobacco use status is also detected. Planned contrast showed the VLNC message only increased VLNC intention for cigarette-only smokers (Table 4).

#### 4. Discussion

This study developed a message strategy to correct misperceptions and raise awareness of health risks associated with very low nicotine cigarettes. The experiment found this message could effectively lower people's nicotine risk perception, weaken people's misbelief that VLNC are healthier than regular cigarettes, strengthen belief in second-hand smoke harm among cigarette dual/poly smokers and other tobacco users, increase VLNC intention for cigarette-only smokers, and marginally decrease VLNC intention for all other groups.

##### 4.1. Message tailoring for different types of tobacco users

The FDA approved the very low nicotine cigarettes with an intended user group in mind: the addicted cigarette smokers. When creating communication materials about this product, however, it is necessary to consider other types of tobacco product users and non-users. The educational messages on VLNC should always carry the dual responsibility of encouraging VLNC use among cigarette smokers so they can quit and discouraging VLNC use among the rest of the population. Overall the message has shown potential to serve this goal as it moved attitudes and intentions toward the "correct" direction, such that it fostered favorable attitude and higher intention in cigarette-only smokers but unfavorable attitude and lower intentions in all other groups.

Cigarette-only smokers responded well to the VLNC message. By clarifying the carcinogenicity of nicotine per se and the risk of smoking VLNC, the message successfully generated a lower estimate of nicotine harm, a lower misbelief that VLNC are healthier, and a higher intention to use VLNC than the control group for cigarette-only smokers. The

results indicate those who smoke cigarettes exclusively would be more likely to try VLNC after they are informed of the full consequences.

We separated cigarette dual/poly smokers from cigarette-only smokers because the latter could benefit from VLNC while the former may not. Dual/poly smokers have other sources of nicotine intake, and thus switching from regular cigarettes to VLNC may not decrease their nicotine dependence. In the current experiment, cigarette dual/poly smokers showed the most favorable attitude and the highest intention to use VLNC, even higher than cigarette-only smokers. Research on dual/poly smokers' cigarette use pattern suggest that dual/poly cigarette smokers at baseline largely remain cigarette smokers one year later (Miller et al., 2020). It is, therefore, quite concerning that dual/poly smokers may use VLNC merely as a "safer" alternative to regular cigarettes rather than a quitting tool. Future research needs to examine dual/poly cigarette smokers' use pattern of VLNC, as this population may be at higher risk than exclusive cigarette smokers. Future research that explores messaging strategies for dual/poly smokers can focus on other VLNC-related beliefs such as explicitly stating that VLNC could be used as a quitting tool.

Other tobacco users will not benefit from smoking VLNC at all, but among the participants in the no-message control condition, other tobacco users showed the second highest intention to try VLNC. Other tobacco users may try VLNC under the misperception that VLNC are healthier than cigarettes. The VLNC message heightened their belief in second-hand smoke harm and the belief in getting cancer. The message condition also showed a lower VLNC intention ( $M = 2.27$ ,  $SD = 1.5$ ) than the control condition ( $M = 2.76$ ,  $SD = 1.32$ ), but the difference is not statistically significant. Given the effect size of this comparison, we believe the lack of significance can be largely explained by the lack of power. Therefore it is concluded that for other tobacco users, an educational message would have great potential to discourage VLNC use by emphasizing physical harm to self and others.

Non-tobacco users have a very low interest in VLNC. Their attitude and intention to use VLNC are low and are not affected by the VLNC message. They could still benefit from the educational message in the sense that they would hold fewer misbeliefs about nicotine harm and VLNC risk.

##### 4.2. Implications for regulation and public communication

Under the FDA's regulation, the VLNC are allowed to be marketed as "95 % less nicotine", "Helps reduce your nicotine consumption", and "... Greatly reduces your nicotine consumption". This study shows it may not be enough to merely inform consumers that VLNC contain less nicotine or that VLNC are not addictive. With the widely held misbelief that nicotine causes cancer, smokers could equate less nicotine with less physical harm. The FDA recommended that VLNC manufacturers use the statement "Nicotine is addictive. Less nicotine does NOT mean safer. All cigarettes can cause disease and death" in product labeling and advertising (U.S. Food and Drug Administration, 2021). Our study shows messages on VLNC safety and health consequences are effective and indispensable. Both cigarette smokers and other tobacco users could benefit from educational messages that address not only the addictiveness but also the health risks. Regulators could consider making physical harm statements a requirement rather than a recommendation.

Research is needed to identify arguments that would resonate well with different types of VLNC smokers. In this study, for example, we found the second-hand smoke argument and the cancer argument affected other tobacco users but not cigarette smokers. The relative risk argument left a more substantial mark on cigarette-only smokers than cigarette dual/poly smokers.

##### 4.3. Limitations

The study findings are limited by the sample size. As discussed above, some meaningful message effects were not detected due to the

lack of statistical power. This study also left out some critical sub-populations. The risk of smoking initiation with VLNC is mainly imminent for adolescents, ex-smokers, and other tobacco product users (e.g., e-cigarette users). The current study could not specifically address some of these high-risk populations as we have only recruited the sample from the adult population, and the sample was too small to allow meaningful comparison between ex-smokers and current smokers. Future research could examine messaging strategies suitable for youths and ex-smokers.

In addition, this study included a no-message control which may have created an imbalance in attention between the experimental and control conditions. However, given the length of the message, we believe that the observed effects on beliefs, attitudes, and intentions are primarily due to the content of the message rather than differences in attention or fatigue.

## 5. Conclusions

Education programs are needed to correct the misperception of nicotine carcinogenicity and address VLNC-specific misbeliefs. It is important to tailor messages based on audiences' tobacco use status. A message stressing the VLNC health risks in cancer and second-hand smoke would benefit cigarette-only smokers and other tobacco users the most. New message strategies need to be explored for cigarette dual/poly smokers.

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## CRedit authorship contribution statement

**Rui Shi:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Robert Feldman:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Jiaying Liu:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Pamela I. Clark:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

## References

- Apelberg, B.J., Feirman, S.P., Salazar, E., Corey, C.G., Ambrose, B.K., Paredes, A., Richman, E., Verzi, S.J., Vugrin, E.D., Brodsky, N.S., Rostron, B.L., 2018. Potential public health effects of reducing nicotine levels in cigarettes in the United States. *N. Engl. J. Med.* 378 (18), 1725–1733. <https://doi.org/10.1056/NEJMs1714617>.
- Benowitz, N.L., Donny, E.C., Hatsukami, D.K., 2017. Reduced nicotine content cigarettes, e-cigarettes and the cigarette end game. *Addiction* 112 (1), 6–7. <https://doi.org/10.1111/add.13534>.
- Berman, M.L., Glasser, A.M., 2019. Nicotine reduction in cigarettes: literature review and gap analysis. *Nicotine Tob. Res.* 21 (Suppl 1), S133–S144. <https://doi.org/10.1093/ntr/ntz162>.

- Byron, M.J., Jeong, M., Abrams, D.B., Brewer, N.T., 2018. Public misperception that very low nicotine cigarettes are less carcinogenic. *Tob. Control* 27 (6), 712–714. <https://doi.org/10.1136/tobaccocontrol-2017-054124>.
- Cornelius, M.E., Wang, T.W., Jamal, A., Loretan, C.G., Neff, L.J., 2020. Tobacco product use among adults—United States, 2019. *MMWR Morb. Mortal. Wkly Rep.* 69 (46), 1736–1742. <https://doi.org/10.15585/mmwr.mm6946a4>.
- Fishbein, M., Ajzen, I., 2011. *Predicting and Changing Behavior: The Reasoned Action Approach*. Taylor & Francis.
- U.S. Food and Drug Administration. (2021, December 23). *FDA Authorizes Marketing of Tobacco Products that Help Reduce Exposure to and Consumption of Nicotine for Smokers Who Use Them*. FDA; FDA. <https://www.fda.gov/news-events/press-announcements/fda-authorizes-marketing-tobacco-products-help-reduce-exposure-and-consumption-nicotine-smokers-who>.
- U.S. Food and Drug Administration. (2022, June 21). *FDA Announces Plans for Proposed Rule to Reduce Addictiveness of Cigarettes and Other Combusted Tobacco Products*. FDA; FDA. <https://www.fda.gov/news-events/press-announcements/fda-announces-plans-proposed-rule-reduce-addictiveness-cigarettes-and-other-combusted-tobacco>.
- Hamilton, W.L., Norton, diStefano, G., Ouellette, T.K., Rhodes, W.M., Kling, R., Connolly, G.N., 2004. Smokers' responses to advertisements for regular and light cigarettes and potential reduced-exposure tobacco products. *Nicotine Tob. Res.* 6 (Suppl 3), S353–S362.
- Kasza, K.A., Ambrose, B.K., Conway, K.P., Borek, N., Taylor, K., Goniewicz, M.L., Cummings, K.M., Sharma, E., Pearson, J.L., Green, V.R., Kaufman, A.R., Bansal-Travers, M., Travers, M.J., Kwan, J., Tworek, C., Cheng, Y.-C., Yang, L., Pharris-Ciurej, N., van Bemmel, D.M., Hyland, A.J., 2017. Tobacco-Product Use by Adults and Youths in the United States in 2013 and 2014. *N. Engl. J. Med.* 376 (4), 342–353. <https://doi.org/10.1056/NEJMs1607538>.
- McEachan, R., Taylor, N., Harrison, R., Lawton, R., Gardner, P., Conner, M., 2016. Meta-Analysis of the Reasoned Action Approach (RAA) to Understanding Health Behaviors. *Ann. Behav. Med.: Publ. Soc. Behav. Med.* 50 (4), 592–612. <https://doi.org/10.1007/s12160-016-9798-4>.
- McQueen, A., Tower, S., Sumner, W., 2011. Interviews With “Vapers”: Implications for Future Research With Electronic Cigarettes. *Nicotine Tob. Res.* 13 (9), 860–867. <https://doi.org/10.1093/ntr/ntr088>.
- Mercincavage, M., Smyth, J.M., Strasser, A.A., Branstetter, S.A., 2016. Reduced Nicotine Content Expectancies Affect Initial Responses to Smoking. *Tob. Regul. Sci.* 2 (4), 309–316. <https://doi.org/10.18001/TRS.2.4.3>.
- Miller, C.R., Smith, D.M., Goniewicz, M.L., 2020. Changes in Nicotine Product Use among Dual Users of Tobacco and Electronic Cigarettes: Findings from the Population Assessment of Tobacco and Health (PATH) Study, 2013–2015. *Subst. Use Misuse* 55 (6), 909–913. <https://doi.org/10.1080/10826084.2019.1710211>.
- Mooney, M.E., Leventhal, A.M., Hatsukami, D.K., 2006. Attitudes and Knowledge About Nicotine and Nicotine Replacement Therapy. *Nicotine Tob. Res.* 8 (3), 435–446. <https://doi.org/10.1080/14622006006070397>.
- O'Brien, E.K., Nguyen, A.B., Persoskie, A., Hoffman, A.C., 2017. U.S. adults' addiction and harm beliefs about nicotine and low nicotine cigarettes. *Prevent. Med.: Int. J. Dev. Pract. Theor.* 96, 94–100. <https://doi.org/10.1016/j.yjmed.2016.12.048>.
- Patel, M., Cuccia, A.F., Czaplicki, L., Donovan, E.M., Simard, B., Pitzer, L., Hair, E.C., Schillo, B.A., Vallone, D.M., 2019. Smokers' behavioral intentions in response to a low-nicotine cigarette policy. *Drug Alcohol Depend.* 205, 107645. <https://doi.org/10.1016/j.drugalcdep.2019.107645>.
- Patel, D., Davis, K.C., Cox, S., Bradfield, B., King, B.A., Shafer, P., Caraballo, R., Bunnell, R., 2016. Reasons for current E-cigarette use among U.S. adults. *Prev. Med.* 93, 14–20. <https://doi.org/10.1016/j.ypmed.2016.09.011>.
- Pokhrel, P., Herzog, T.A., Kawamoto, C.T., Fagan, P., 2021. Heat-not-burn Tobacco Products and the Increased Risk for Poly-tobacco Use. *Am. J. Health Behav.* 45 (1), 195–204. <https://doi.org/10.5993/AJHB.45.1.16>.
- Rutten, L.J.F., Blake, K.D., Agunwamba, A.A., Grana, R.A., Wilson, P.M., Ebbert, J.O., Okamoto, J., Leischow, S.J., 2015. Use of E-Cigarettes Among Current Smokers: Associations Among Reasons for Use, Quit Intentions, and Current Tobacco Use. *Nicotine Tob. Res.* 17 (10), 1228–1234. <https://doi.org/10.1093/ntr/ntv003>.
- Shi, R., Feldman, R., Liu, J., Clark, P.I., 2021. The Dilemma of Correcting Nicotine Misperceptions: Nicotine Replacement Therapy versus Electronic Cigarettes. *Health Commun.* 36 (14), 1856–1866. <https://doi.org/10.1080/10410236.2020.1800288>.
- Sung, H.-Y., Wang, Y., Yao, T., Lightwood, J., Max, W., 2018. Polytoabacco Use and Nicotine Dependence Symptoms Among US Adults, 2012–2014. *Nicotine Tob. Res.* 20 (suppl 1), S88–S98. <https://doi.org/10.1093/ntr/nty050>.
- Tan, A.S.L., Lee, C., Bigman, C.A., 2016. Comparison of beliefs about e-cigarettes' harms and benefits among never users and ever users of e-cigarettes. *Drug Alcohol Depend.* 158, 67–75. <https://doi.org/10.1016/j.drugalcdep.2015.11.003>.
- Villanti, A.C., Byron, M.J., Mercincavage, M., Pacey, L.R., 2019a. Misperceptions of Nicotine and Nicotine Reduction: The Importance of Public Education to Maximize the Benefits of a Nicotine Reduction Standard. *Nicotine Tob. Res.* 21 (Supplement 1), S88–S90. <https://doi.org/10.1093/ntr/ntz103>.
- Villanti, A. C., Naud, S., West, J. C., Pearson, J. L., Wackowski, O. A., Niaura, R. S., Hair, E., & Rath, J. M. (2019). Prevalence and correlates of nicotine and nicotine product perceptions in U.S. young adults, 2016. *Addict. Behav.*, 98, 106020. <https://doi.org/10.1016/j.addbeh.2019.06.009>.
- Wikmans, T., Ramström, L., 2010. Harm perception among Swedish daily smokers regarding nicotine, NRT-products and Swedish Snus. *Tob. Induc. Dis.* 8 (1), 9. <https://doi.org/10.1186/1617-9625-8-9>.