# Associations of educational and marketing messages with beliefs about nicotine and reduced nicotine cigarettes

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## Abstract

**Introduction:** Widespread misperceptions about nicotine may have unintended effects on public health. We examined associations between existing messages about nicotine or tobacco and beliefs about nicotine and reduced nicotine cigarettes (RNC).

**Methods:** 2962 U.S. 18–45-year-olds were randomized in a May 2022 web-based survey to view one of 26 text-based messages about tobacco or nicotine from three sources: ongoing research (*n* = 8), messages authorized by FDA for VLN cigarettes (*n* = 6), and FDA's "From Plant to Product to Puff" campaign (*n* = 12); six messages from FDA's campaign did not reference nicotine and were treated as the reference source. Analyses examined associations between messages, grouped by source and individually, with beliefs about nicotine and RNC addictiveness and harms.

**Results:** Relative to FDA messages that did not reference nicotine, all message sources were associated with greater odds of a correct belief about nicotine (Odds Ratios [ORs] = 1.40–1.87, *p*'s < 0.01); VLN messages were associated with greater correct beliefs about RNC addictiveness (*b* = 0.23, *p* < .05). No campaign produced greater correct beliefs about RNC harms. At the

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individual level, only five messages were associated with a correct belief about nicotine (ORs = 2.12–2.56, $p$-values < .01), and one with correct beliefs about RNC harms ($b = 1.09$, $p < .05$), vs. the reference message.

**Conclusions:** Few existing messages improved understanding of the risks of nicotine separately from the risks of combustible products. Communication research is needed to promote greater public understanding of nicotine while minimizing unintended effects on nicotine and tobacco use.

### Keywords

Nicotine education; Nicotine messaging; Reduced nicotine content; Message perceptions; Beliefs

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## 1. Introduction

A large body of research has shown that the public does not understand risks of nicotine, independently or related to specific tobacco products (O'Brien et al., 2017; Byron et al., 2018; Villanti et al., 2019a; O'Brien et al., 2023; Czoli et al., 2017). While nicotine is highly addictive and causes adverse cardiovascular and teratogenic effects, it does not play a major role in cigarettes' carcinogenicity (U.S. Department of Health and Human Services, 2014). Yet most individuals identify nicotine as the primary cause of cancer from smoking (O'Brien et al., 2017; Byron et al., 2018; Villanti et al., 2019a; O'Brien et al., 2023; Czoli et al., 2017). These misperceptions may hinder efforts to reduce tobacco-related morbidity and mortality, as scientists and public health officials may make recommendations about using tobacco products under the assumption that some are less harmful than others (Nutt et al., 2014), while the public believes all nicotine-containing products to be equally harmful.

Nicotine-related misperceptions may also impact perceptions about reduced nicotine cigarettes (RNCs). In 2018, the U.S. Food and Drug Administration (FDA) issued an Advanced Notice of Proposed Rulemaking to restrict the maximum nicotine content in combustible cigarettes to make them minimally or non-addictive, and in 2022 restated its intent to issue a proposed rule (U.S. Food and Drug Administration, 2022). Studies have shown that RNCs are less satisfying to those who smoke and reduce daily cigarette consumption (Mercincavage et al., 2016). As such, the projected public health effects of a reduced nicotine policy depend upon preventing smoking initiation/escalation and promoting cessation (Apelberg et al., 2018; Vugrin et al., 2015). In December 2021, FDA authorized two RNCs, VLN King and VLN Menthol King, as "modified risk tobacco products" (MRTPs) (U.S. Food and Drug Administration, 2021), permitting the use of reduced exposure claims such as "greatly reduces nicotine consumption" and "helps you smoke less" in their marketing. VLN cigarettes represent one-fifth of available MRTPs – and the first combustible products – to receive this designation. VLN cigarettes entered test markets in the Chicago, IL region in April 2022 and continue to expand nationally. RNCs with very low nicotine content may reduce nicotine exposure and addiction risk (Mercincavage et al., 2016; Donny et al., 2015) if used to reduce cigarette consumption and facilitate cessation. However, RNCs broadly do not reduce exposure to other harmful constituents. Due to the pervasive misperception that nicotine is the primary harmful constituent in cigarettes (O'Brien et al., 2017), a concern regarding RNCs is that individuals who hold inaccurate beliefs about their safety may substitute these products rather than reduce or quit smoking.

If this were to occur, the health effects of smoking RNCs could be similar to conventional cigarettes and, therefore, reduce their public health benefit.

The introduction of FDA-authorized RNCs to the marketplace and a forthcoming nicotine product standard present an important educational opportunity, as marketing and communication about nicotine and RNCs will likely drive their uptake and determine their impact on public health (Villanti et al., 2019a). Further, given that a wide array of tobacco products are now available to consumers that vary in their delivery of exposure to harmful constituents, FDA has signaled its interest in communicating that tobacco products exist on a continuum of risk (King and Toll, 2023). This may necessitate educating individuals about the risks of nicotine separately from combusted tobacco to ensure that restricting nicotine content in combustible cigarettes achieves its intended public health impacts.

Our prior research has shown that even a brief, single exposure to nicotine corrective messages can result in significant changes in beliefs about nicotine as well as nicotine-containing products not explicitly mentioned in the messages, including e-cigarettes and RNCs, while not affecting non-targeted beliefs (Villanti et al., 2019b). Subsequent findings from a three-month randomized controlled trial of nicotine corrective messages show that multiple exposures to these messages can reduce false beliefs about nicotine and other products like nicotine replacement therapy, e-cigarettes, and RNCs (Villanti et al., 2023), suggesting the potential for messages about nicotine to have a broader impact on beliefs about a range of nicotine and tobacco products. Finally, messages specific to RNCs, including those designed by researchers and the tobacco industry (Duong et al., 2022; Loud et al., 2022; Byron et al., 2019; Popova et al., 2019; Differding et al., 2022), have also been shown to have nuanced effects on beliefs.

Ahead of a potential nicotine reduction standard and amid the availability of VLN RNC MRTPs, it is relevant to know how a range of existing messages about nicotine, including those that currently exist to warn about nicotine, and those that are and are not RNC specific, may impact perceptions about nicotine and RNCs to inform future corrective and educational messages. This study builds upon prior nicotine and RNC communication research (Villanti et al., 2019b; Villanti et al., 2023; Duong et al., 2022; Loud et al., 2022; Byron et al., 2019; Popova et al., 2019; Differding et al., 2022) and examines associations between messages from various sources, including messages currently used in marketing and educational campaigns, with beliefs about nicotine and RNCs. Based on prior work demonstrating differences in message effects by smoking status (Duong et al., 2022; Differding et al., 2022), we also explore these associations controlling for smoking status. Finally, because perceived message effectiveness ratings are commonly used in the development, evaluation, and selection of messages for educational campaigns (Noar et al., 2018) (e.g., how discouraging of cigar use participants perceived messages in an anti-cigar campaign), we also explore associations between messages and beliefs controlling for message perceptions related to discouraging nicotine use.

## 2. Methods

### 2.1. Participants and design

Data were collected in May 2022 during Wave 2 of the Rutgers Institute for Nicotine & Tobacco Studies Omnibus study: a repeated, cross-sectional, web-based survey of 18–45 year-olds in the U.S. that is fielded quarterly (Delnevo and Ganz, 2023; Bover Manderski et al., 2024). Core items that appear in every study iteration include assessments of ever and current use of tobacco and nicotine products, as well as exposure to tobacco advertising, purchasing behaviors, and standard demographic information. Examples of rotating modules that are included periodically are items assessing cessation, product risk perceptions, and social norms.

Approximately 2500 to 3000 individuals are surveyed at each wave, focusing on maximizing responses from eligible individuals not participating in prior waves. We used the research company, CloudResearch, to recruit from a list of approved participants from Amazon Mechanical Turk (MTurk), an online crowdsourcing platform commonly used for survey and experimental research. CloudResearch managed recruitment, oversaw data collection, managed participant payments, and implemented data quality procedures such as checks for "straight-liners" and "bot-like" responses, failed simple attention checks, and limiting eligibility to those with high approval ratings from prior MTurk assignments. Tobacco users were not specifically targeted for recruitment, but consistent with other crowdsourcing studies (Kraemer et al., 2017), we anticipated and have observed in prior Omnibus iterations higher tobacco use prevalence compared to national estimates. After completing the Omnibus core survey, participants were randomized to view one of 26 text-based messages, 20 of which explicitly referenced nicotine or RNCs (see Table 1). Messages were displayed via Qualtrics in black text on a white background below the instructional text, "Please read the following message and then answer the questions that follow." Following message exposure, participants completed measures of message perceptions and nicotine and RNC beliefs. The Rutgers University Institutional Review Board deemed this survey as exempt (protocol no. Pro2022000130).

### 2.2. Messages

Of the 26 messages tested, we included eight from our prior (Villanti et al., 2019b; Villanti et al., 2023) and ongoing research (designed for the purpose of educating and correcting beliefs about nicotine) that demonstrated effectiveness in reducing false beliefs about nicotine, RNCs, and other products; all other messages were selected for their real-world relevance, as they are currently used in marketing and education campaigns (Table 1). The MRTP messages ($n = 6$) were authorized by FDA for use in VLN cigarette marketing (U.S. Food and Drug Administration, 2021) starting in 2022. Messages from FDA's 2020 "From Plant to Product to Puff" web-based education campaign that explicitly referenced nicotine (n = 6) or did not reference nicotine (n = 6) were selected to represent messages used by the FDA to discourage tobacco use (U.S. Food and Drug Administration, 2020). Individual messages were examined to determine whether specific messages were driving overall campaign effects, as well as to compare overall campaigns/marketing. Given that

the FDA's non-nicotine messages were not expected to impact nicotine beliefs, these were included as attention control messages for part of our analysis.

### 2.3. Measures

#### 2.3.1. Belief outcomes

**2.3.1.1. Nicotine and cancer.:** A single item (Villanti et al., 2019b) stating, "Nicotine is a cause of cancer," was used to address beliefs about nicotine's role in causing cancer, with response options of "true," "false," and "don't know;" false was scored as "correct" and true/don't know as "incorrect."

**2.3.1.2. RNC addictiveness and harms.:** RNC beliefs were assessed post-exposure using six items taken from previous work (Mercincavage et al., 2019) that provided statements about risks of "low nicotine" cigarettes relative to "regular" cigarettes (i.e., "less likely to cause cancer," "safer," "healthier," "have fewer chemicals," "less addictive," "make it easier to quit"), rated on a 5-point response scale (1 = "definitely not true," 5 = "definitely true"). Since research supports the accuracy of the "less addictive" and "easier to quit" items (Mercincavage et al., 2016; Donny et al., 2015), all other items were reverse-scored. The "less addictive" and "easier to quit" items were summed to create a composite scale assessing correct beliefs about RNC addictiveness ($a = 0.82$), while the remaining items were summed to create a composite scale assessing beliefs about RNC harms ($a = 0.89$). Higher scores indicated more correct beliefs.

#### 2.3.2. Other measures/covariates

**2.3.2.1. Smoking status.:** A current smoking variable was created in which those who endorsed smoking cigarettes "every day" or "some days" were coded as currently smoking.

**2.3.2.2. Message perceptions. Discouraging nicotine use.:** The FDA has previously used message perceptions measures, and perceived message effectiveness ratings in particular, in formative testing to assess the likely impact of messaging on campaign-targeted beliefs, attitudes, and smoking behaviors (Davis et al., 2013; Zhao et al., 2016). The FDA used a threshold of messages performing above the scale midpoint to select which messages are included in educational campaigns.

Message perceptions related to discouraging nicotine use were assessed using the mean of three items from an adapted version of a perceived message effectiveness scale ($a = 0.91$) (Baig et al., 2019): "This message discourages me from wanting to use nicotine," "This message makes me concerned about the health effects of using nicotine," and "This message makes nicotine seem unpleasant to me." Participants were asked to indicate their agreement with each item on a 5-point response scale (1 = "strongly disagree", 5 = "strongly agree").

**2.3.2.3. Demographic information.:** We assessed demographic variables of age, sex at birth, education, and race.

**2.3.3. Analytic plan—**Analyses were conducted using Stata 18.0. We first examined balance of participant characteristics across the 26 experimental message conditions. We

then used logistic and linear regression models to examine associations of exposure to individual messages (relative to a reference message) with correct beliefs about nicotine and RNC addictiveness and harms (Table 1). The message, "Nicotine is the addictive substance in tobacco products," was chosen as the reference message because of its similarity to the current warning message on most non-combusted nicotine products (i.e., "This product contains nicotine. Nicotine is an addictive chemical.") Given few associations between individual messages and correct beliefs, we then grouped messages according to their source (i.e., FDA campaign not referencing nicotine, FDA campaign referencing nicotine, ongoing research, and FDA-authorized MRTP messages) and explored associations between message source and beliefs using logistic and linear regression models, using FDA campaign messages not referencing nicotine as the reference group (Table 2). Covariates in adjusted models included current smoking status (Model A), message perceptions (Model B), and demographic variables of age, sex at birth, education, and race (Model C).

## 3. Results

### 3.1. Sample characteristics

The May 2022 Omnibus survey yielded 2962 participants from all 50 U.S. states, with approximately equal sex distribution (44.7% male), a race/ethnicity distribution comparable to national surveys (68.4% non-Hispanic white, 9.5% Hispanic, 10.5% non-Hispanic Black), and fair representation from priority populations such as sexual minorities (18%). Approximately half reported some college or less education (53.6%) compared with a bachelor's degree or more (46.4%). Nearly half were aged 25–34 (45.9%) or 35–45 (43.7%), with 10.4% aged 18–24. Nearly a quarter (24.8%) of the sample reported current cigarette use; 15.4% reported current e-cigarette use; and 2% reported using other forms of nicotine and tobacco (e.g., cigarillos, nicotine pouches). There were no significant demographic differences by experimental message condition ($p$-values = .07–0.87).

Table 1 provides the mean message perceptions score of each message among those exposed ($n$ = 100–124 participants per message), ranked by score (i.e., highest to lowest perceived nicotine harms; range = 2.71 to 4.34), as well as the mean score by message source. The Flesch-Kincaid reading level for individual messages ranged from grade 5.2 (ongoing research) to grade 15.3 (FDA campaign referencing nicotine), though three of four sources averaged a high school reading level.

### 3.2. Belief outcomes

**3.2.1. Nicotine and cancer**—Five individual messages were associated with greater odds of a correct belief about nicotine's role in causing cancer (odds ratios (*OR*s) = 2.12–2.56; all $p$'s < 0.01) vs. the reference message (Table 1). The reading grade levels of these messages ranged from 5.8 to 14.1. When grouped by message source, compared to FDA campaign messages that did not reference nicotine, messages from ongoing research (*OR* = 1.52), FDA-authorized MRTP messages (*OR* = 1.87), and FDA campaigns that referenced nicotine (*OR* = 1.40) were associated with greater odds of a correct belief about nicotine and cancer ($p$'s < 0.01) in both unadjusted and adjusted models (Table 2). These associations remained even after controlling for current smoking, which was not associated with the

nicotine and cancer belief, and message perceptions, which were negatively associated with a correct belief about nicotine and cancer ($OR$'s = 0.73–0.74, $p$'s < 0.01).

**3.2.2. RNC addictiveness**—None of the individual messages tested were significantly associated with correct beliefs about the addictiveness of RNCs compared with the reference message (Table 1). When grouped by source, FDA-authorized MRTP messages were associated with more correct beliefs about RNC addictiveness ($b$ = 0.23, $p$ < .05) compared to FDA campaign messages that did not reference nicotine. This association remained when controlling for smoking status (Table 2, Model A), but was no longer present after controlling for message perceptions. Message perceptions were negatively associated with correct beliefs about RNC addictiveness ($b$'s = −0.15–0.14, $p$'s < 0.01).

**3.2.3. RNC harms**—Only one individual message of the seven that directly addressed RNCs ("Low nicotine cigarettes are as harmful as regular cigarettes. But they may help people quit and prevent new users from becoming addicted to cigarettes.") was associated with more correct beliefs about RNC harms compared with the reference message ($b$ = 1.09, $p$ = .022); it had a reading grade level of 9.7. Similarly, none of message sources were associated with more correct beliefs about RNC harms. In adjusted models including current smoking status as a covariate, current smokers had fewer correct beliefs about RNC harms ($b$'s = −1.31 to −1.29, $p$'s < 0.01); this association remained even after controlling for message perceptions and demographic covariates (Table 2). Message perceptions were not associated with correct beliefs about RNC harms in any model.

## 4. Discussion

In this large online experimental study, we examined associations between 26 educational and marketing messages with beliefs about nicotine and cancer, RNC addictiveness, and RNC harms, with 100–124 participants viewing each message. When examining associations between individual messages and beliefs, we found that compared to a reference message about nicotine being the addictive substance in tobacco products, only five messages were associated with a correct belief about nicotine's role in cancer, one message with correct beliefs about RNC harms, and no messages associated with correct beliefs about RNC addictiveness. No messages produced correct beliefs about both nicotine and RNCs, suggesting fundamental differences in understanding the risks of nicotine and a combusted product with less nicotine after viewing a single message. The readability of study messages did not appear to impact message effects.

When examining associations across all messages, we found that relative to FDA campaign messages that did not reference nicotine, messages from all other sources were associated with greater odds of endorsing a correct belief about nicotine. The only message source associated with correct beliefs about RNC addictiveness was the FDA-authorized MRTP marketing messages, though this effect was attenuated when controlling for message perceptions (i.e., that the messages discourage nicotine use). Thus, similar to analyses of individual messages, none of the message sources effectively addressed both nicotine and RNC beliefs. Together, these findings may illustrate the difficulty of communicating in a single message about nicotine harms while improving understanding about RNCs as less

addictive, but still harmful combusted products. Findings emphasize the need for future messages that convey this nuance to improve misperceptions of the risks of RNCs, either through more targeted messages designed to address these multiple beliefs together, or using a combination of messages presented together.

This study also found that current smoking was associated with more correct beliefs about RNC addictiveness, although this association was attenuated when controlling for message perceptions. Adults who smoked also had fewer correct beliefs about RNC harms. This finding aligns with results from a randomized controlled trial of nicotine corrective messaging (Villanti et al., 2023) that included messages tested in this study, which observed more false beliefs about RNCs among those who received the nicotine messaging intervention and who reported past 30-day tobacco use, suggesting attenuation of the effects of the study's nicotine messaging intervention. Findings suggest that future messaging about nicotine and RNCs may need to target individuals who do and do not smoke separately or provide enhanced messaging to adults who smoke (Villanti et al., 2023). If the population benefit of a low nicotine product standard and/or the authorization of future RNC MRTPs rests largely upon adults using these products to ultimately quit smoking, better education is needed to convey the risks of continued combustible tobacco use, regardless of the nicotine content.

Finally, this study found associations between message perceptions and correct beliefs about nicotine and RNCs, such that messages that were more strongly perceived as discouraging nicotine use were associated with greater misperceptions about nicotine causing cancer and RNC addictiveness in adults (Sawyer and Brandon, 2023). These findings are consistent with other research showing that adults exposed to messages focused on discouraging nicotine use in current youth anti-vaping campaigns report greater nicotine misperceptions than those not exposed to the messages (Sawyer and Brandon, 2023). While this association could be due to message perception items being framed as discouraging nicotine use rather than discouraging combusted tobacco use, these results underscore the challenge in developing messages about tobacco products for use in campaigns that can improve knowledge of both nicotine and combusted tobacco risks. Further, while previous studies in tobacco control have identified effective prevention campaign messages as those scoring above the midpoint on similar scales (Davis et al., 2013; Zhao et al., 2016; Duke et al., 2014), most of the tested messages in this study had scores above the message perception scale midpoint, but did not increase correct beliefs about nicotine or RNCs. Findings suggest that different items may be needed to evaluate the perceived effectiveness of nicotine education messages in the context of a continuum of risk and the different goals of respective campaigns (i.e., youth vaping campaigns targeting prevention (Noar et al., 2020) vs. adult campaigns targeting improved knowledge and understanding about nicotine and RNC risks to promote cessation or harm reduction).

Findings must be interpreted in the context of some limitations, including use of a crowdsourced (rather than probability) sample to estimate message effects. However, this approach allowed us to collect data from a large, demographically and geographically diverse national sample, and prior research has shown that findings from early-stage message testing studies conducted in crowdsourced samples mirror those of more resource-

intensive, probability-based samples (Jeong et al., 2019). Additionally, we examined associations with beliefs following one exposure to a brief, single, text-based candidate message (some of which did not explicitly address nicotine or RNCs). Repeated exposure to multiple messages directly addressing their risks may better convey nuance and simulate the impact of messaging on nicotine and tobacco product beliefs (Villanti et al., 2023). Further, because images enhance attention to and understanding of messages (e.g., graphic warning labels on cigarettes have been robustly shown to be more effective than text-only warning statements (Noar et al., 2016)), it is possible that delivering messages to participants in a text-based format attenuated their impact; future work may wish to administer messages utilizing other modalities to maximize their effectiveness. Additionally, we were unable to control for, and did not have a priori hypotheses about, sources of variation among individual study messages (e.g., length, readability, emotionality) that may have affected their comprehension. The sample also largely comprised adults not currently smoking cigarettes (i.e., not 'consumers'); however, it is critical to understand misperceptions among this population as they may increase likelihood of initiating RNC use and undermine public health goals related to nicotine regulation. Finally, our cross-sectional study design prevented conducting formal mediation analyses of message perceptions on associations between messages and beliefs. Because nearly all messages tested above the message perceptions scale midpoint, there was no clinically meaningful cutoff to conduct moderation analyses, necessitating future studies prospectively designed to better understand these associations. Despite these caveats, our study contributes substantively to extant evidence on messaging to educate consumers about RNCs given the number of messages tested, the sample size per message tested, the inclusion of message perception measures, and collection of both nicotine and RNC belief measures.

## 5. Conclusions

Few existing messages about nicotine were associated with correct beliefs about nicotine and RNCs. Communication research is needed to promote greater public understanding of nicotine while minimizing unintended effects on nicotine and tobacco use. Of relevance to impending rulemaking on nicotine content in certain combusted tobacco products and FDA-authorized RNC MRTPs, results highlight the need for greater efforts to develop and test messages to educate consumers about nicotine and RNCs and reduce misperceptions to achieve public health benefits of these policies.

## Funding

## Data availability

Data will be made available on request.

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**Table 1**

Associations between educational and marketing messages with correct nicotine and reduced nicotine cigarette (RNC) beliefs in U.S. adults aged 18–45, individually and by message source ($n = 2962$).

| Message | N per message | Mean message perceptions score | Flesch-Kincaid grade level | Logistic regression predicting correct belief about nicotine and cancer OR (95% CI) | Linear regression predicting mean correct beliefs about RNC addictiveness b (95% CI) | Linear regression predicting mean correct beliefs about RNC harms b (95% CI) |
|---|---|---|---|---|---|---|
| FDA campaign messages not referencing nicotine | 686 | 3.99 | 9.3 | Ref. | Ref. | Ref. |
| There are >7000 chemicals in cigarette smoke. >70 of those chemicals are linked to cancer. | 121 | 4.34 | 7.3 | 1.14 (0.61, 2.13) | −0.02 (−0.52, 0.47) | −0.09 (−1.01, 0.83) |
| There are harmful chemicals in every stage of the process of making and smoking a cigarette. | 113 | 4.19 | 9.1 | 1.02 (0.54, 1.94) | −0.10 (−0.60, 0.41) | 0.16 (−0.78, 1.09) |
| All cigarettes – Even those advertised as "natural," "organic," or "additive-free" – Have chemicals that can cause serious harm to your health. | 112 | 4.14 | 14.0 | 0.68 (0.34, 1.35) | 0.00 (−0.50, 0.51) | 0.11 (−0.83, 1.05) |
| When it comes to tobacco, "all natural" doesn't mean "safe." some of the toxic chemicals in tobacco are present in the plant itself. | 117 | 3.85 | 6.3 | 1.08 (0.57, 2.04) | −0.03 (−0.52, 0.47) | 0.52 (−0.41, 1.45) |
| Some of the toxic chemicals in tobacco are present in the plant itself. | 113 | 3.70 | 7.6 | 0.76 (0.39, 1.50) | 0.16 (−0.34, 0.66) | 0.19 (−0.75, 1.12) |
| Not all of the harmful chemicals created during cigarette manufacturing are man-made. Some of the carcinogens occur naturally as tobacco is cured. | 110 | 3.68 | 11.7 | 1.11 (0.59, 2.11) | −0.23 (−0.74, 0.27) | 0.03 (−0.92, 0.97) |
| FDA campaign messages referencing nicotine | 678 | 4.02 | 12.6 | **1.40**[**] **(1.09, 1.80)** | 0.11 (−0.09, 0.31) | −0.09 (−0.47, 0.29) |
| Tobacco itself contains highly addictive nicotine, tobacco-specific nitrosamines, or TSNAs, which cause cancer of the lungs and esophagus, and other toxic chemicals. | 107 | 4.32 | 18.1 | 0.92 (0.48, 1.79) | −0.19 (−0.70, 0.32) | 0.13 (−0.82, 1.07) |
| Cigarette manufacturers also may add sugars to mask harshness. These natural and added sugars can lead to the formation of acetaldehyde – a cancer-causing chemical that can make nicotine even more addictive. | 113 | 4.29 | 13.2 | 0.91 (0.48, 1.76) | −0.12 (−0.62, 0.38) | 0.20 (−0.74, 1.14) |
| Cigarette manufacturers may add ammonia compounds to change how easily nicotine can be absorbed into the body. | 117 | 4.25 | 15.3 | 1.30 (0.70, 2.42) | −0.04 (−0.53, 0.46) | 0.44 (−0.49, 1.37) |
| Nicotine can change the way your brain works, causing you to crave more nicotine. | 109 | 4.05 | 5.8 | **2.56**[**] **(1.41, 4.66)** | 0.36 (−0.15, 0.87) | −0.05 (−1.00, 0.89) |
| Nicotine is the chemical that causes addiction and it's the main reason it's so hard to quit smoking once you start. | 115 | 3.91 | 9.4 | 1.40 (0.75, 2.59) | 0.33 (−0.17, 0.83) | −0.30 (1.23, 0.63) |
| Nicotine naturally exists in the tobacco plant, serving as its pesticide against insects and animals. | 117 | 3.32 | 13.8 | 1.30 (0.70, 2.42) | 0.09 (−0.41, 0.59) | −0.04 (−0.96, 0.89) |
| Ongoing research | 914 | 3.57 | 9.3 | **1.52**[**] **(1.20, 1.93)** | 0.11 (−0.08, 0.30) | 0.00 (−0.35, 0.36) |

| Message | N per message | Mean message perceptions score | Flesch-Kincaid grade level | Logistic regression predicting correct belief about nicotine and cancer OR (95% CI) | Linear regression predicting mean correct beliefs about RNC addictiveness b (95% CI) | Linear regression predicting mean correct beliefs about RNC harms b (95% CI) |
|---|---|---|---|---|---|---|
| Nicotine makes it harder for people to quit smoking. | 124 | 4.02 | 6.2 | 1.49 (0.81, 2.72) | 0.13 (−0.36, 0.63) | −0.01 (−0.93, 0.90) |
| Nicotine is the addictive substance in tobacco products. | 110 | 3.98 | 11.1 | Ref. | Ref. | Ref. |
| Nicotine makes it easier for people to start smoking regularly. | 121 | 3.98 | 9.5 | 1.48 (0.81, 2.71) | 0.36 (−0.14, 0.85) | −0.32 (−1.23, 0.60) |
| Low nicotine cigarettes are as harmful as regular cigarettes. But they may help people quit and prevent new users from becoming addicted to cigarettes. | 115 | 3.77 | 9.7 | 1.72 (0.94, 3.16) | 0.19 (−0.31, 0.69) | **1.09 *(0.16, 2.02)** |
| *E*-cigarettes may expose users to significantly lower amounts of toxic substances than regular cigarettes. But they can contain as much or more nicotine. | 123 | 3.66 | 10.9 | 1.06 (0.57, 1.99) | −0.20 (−0.70, 0.29) | 0.33 (−0.58, 1.25) |
| Chemicals in cigarette smoke, not nicotine, largely cause cancer, heart disease, and other health problems in people who smoke. | 103 | 3.35 | 11.0 | **2.12 **(1.15, 3.91)** | −0.31 (−0.82, 0.20) | 0.67 (−0.29, 1.63) |
| Nicotine can be used safely in quit smoking products like nicotine patches, gum, or lozenges, even long-term. | 118 | 2.96 | 11.1 | 1.53 (0.83, 2.81) | 0.18 (−0.32, 0.68) | −0.32 (−1.26, 0.61) |
| Nicotine does not cause cancer. | 100 | 2.71 | 5.2 | 1.55 (0.82, 2.90) | 0.23 (−0.29, 0.75) | −0.18 (−1.14, 0.78) |
| FDA-authorized MRTP messages (VLN) | 684 | 3.51 | 10.2 | **1.87 **(1.46, 2.39)** | **0.23 *(0.02, 0.43)** | −0.22 (−0.60, 0.16) |
| Nicotine is addictive. Less nicotine does NOT mean safer. All cigarettes can cause disease and death. | 106 | 3.94 | 5.6 | 1.11 (0.58, 2.11) | −0.27 (−0.78, 0.24) | 0.77 (−0.18, 1.72) |
| Very low nicotine cigarettes help you smoke less. | 114 | 3.59 | 6.7 | **2.38 **(1.31, 4.31)** | 0.47 (−0.03, 0.97) | 0.00 (−0.93, 0.94) |
| Very low nicotine cigarettes help reduce your nicotine consumption. | 113 | 3.54 | 12.8 | 1.37 (0.73, 2.54) | 0.06 (−0.44, 0.57) | −0.32 (−1.26, 0.61) |
| Very low nicotine cigarettes have 95% less nicotine than regular brands. | 122 | 3.39 | 11.2 | **2.21 **(1.23, 3.98)** | 0.21 (−0.28, 0.71) | −0.51 (−1.42, 0.41) |
| Very low nicotine cigarettes greatly reduce your nicotine consumption. | 111 | 3.36 | 14.1 | **2.48 **(1.37, 4.51)** | 0.41 (−0.09, 0.92) | −0.28 (−1.22, 0.66) |
| Very low nicotine cigarettes are less addictive than regular brands. | 118 | 3.30 | 10.7 | 1.47 (0.80, 2.70) | 0.22 (−0.27, 0.72) | 0.00 (−0.92, 0.93) |

Note:

*
indicates $p < .05$

**
$= p < .01$

For message source (category groupings), reference source is FDA messages not referencing nicotine; for individual messages, reference message is "Nicotine is the addictive substance in tobacco products."

Acronyms: MRTP = modified risk tobacco product, CI = confidence interval, OR = odds ratio.

**Table 2**

Odds ratios and beta coefficients (95% confidence intervals [CI]) for logistic and linear regression models exploring associations between message source, smoking status, and message perceptions.

| Belief item | Nicotine and cancer (selecting false) | RNC addictiveness | RNC harms |
|---|---|---|---|
| Unadjusted model | *OR* (95% CI) | *b* (95% CI) | *b* (95% CI) |
| FDA messages referencing nicotine | **1.40**\*\***(1.09, 1.80)** | 0.11 (−0.09, 0.31) | −0.09 (−0.47, 0.29) |
| Ongoing research | **1.52**\*\***(1.20, 1.93)** | 0.11 (−0.08, 0.30) | 0.00 (−0.35, 0.36) |
| FDA-authorized MRTP messages | **1.87**\*\***(1.46, 2.39)** | **0.23**\***(0.02, 0.43)** | −0.22 (−0.60, 0.16) |
| Adjusted model A (controlling for smoking status) | | | |
|   FDA messages referencing nicotine | **1.40**\*\***(1.08, 1.80)** | 0.10 (−0.10, 0.31) | −0.05 (−0.42, 0.33) |
|   Ongoing research | **1.52**\*\***(1.20, 1.93)** | 0.11 (−0.08, 0.30) | −0.01 (−0.36, 0.34) |
|   FDA-authorized MRTP messages | **1.87**\*\***(1.46, 2.39)** | **0.23**\***(0.03, 0.43)** | −0.25 (−0.62, 0.13) |
|   Current cigarette use | 1.12 (0.93, 1.35) | **0.22**\*\***(0.06, 0.38)** | **−1.29**\*\***(−1.59, −1.00)** |
| Adjusted model B (controlling for smoking status and perceived message effectiveness) | | | |
|   FDA messages referencing nicotine | **1.43**\*\***(1.11, 1.85)** | 0.11 (−0.10, 0.31) | −0.04 (−0.41, 0.34) |
|   Ongoing research | **1.34**\***(1.05, 1.70)** | 0.05 (−0.14, 0.24) | −0.01 (−0.36, 0.35) |
|   FDA-authorized MRTP messages | **1.62**\*\***(1.26, 2.08)** | 0.16 (−0.05, 0.36) | −0.24 (−0.62, 0.13) |
|   Current cigarette use | 0.89 (0.73, 1.09) | 0.11 (−0.57, 0.28) | **−1.28**\*\***(−1.59, −0.97)** |
|   Message perceptions | **0.73**\*\***(0.67, 0.79)** | **−0.15**\*\***(−0.22, −0.08)** | 0.00 (−0.13, 0.13) |
| Adjusted model C (controlling for smoking status and perceived message effectiveness and additional covariates) | | | |
|   FDA messages referencing nicotine | **1.46**\*\***(1.13, 1.80)** | 0.10 (−0.10, 0.30) | −0.04 (−0.41, 0.34) |
|   Ongoing research | **1.37**\***(1.07, 1.75)** | 0.05 (−0.14, 0.24) | 0.00 (−0.35, 0.36) |
|   FDA-authorized MRTP messages | **1.65**\*\***(1.28, 2.12)** | 0.16 (−0.05, 0.36) | −0.24 (−0.62, 0.14) |
|   Current cigarette use | 0.91 (0.74, 1.11) | 0.17 (0.00, 0.33) | **−1.31**\*\***(−1.62, −1.00)** |
| Message perceptions | **0.74**\*\***(0.68, 0.80)** | **−0.14**\*\***(−0.21, −0.07)** | 0.01 (−0.11, 0.14) |

Notes:

\*
indicates $p < .05$

\*\*
$= p < .01$

reference message source group is FDA messages not referencing nicotine; higher scores on belief items = correct/more correct; Model C controls for the following additional variables: age (0 = 35–45, 1 = 18–34), gender (0 = male, 1 = female), education (0 = College graduate or greater, 1 = Some college or less), and race (0 = non-White, 1 = White). Acronyms: RNC = reduced nicotine cigarette; MRTP = modified risk tobacco product, CI = confidence interval, OR = odds ratio.