



Supplement Article

Reducing Nicotine Without Misleading the Public: Descriptions of Cigarette Nicotine Level and Accuracy of Perceptions About Nicotine Content, Addictiveness, and Risk

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Abstract

Significance: The public incorrectly believes very low nicotine content (VLNC) cigarettes are less carcinogenic than current cigarettes, a belief associated with lower motivation to quit under a VLNC standard. We examined how different descriptions of the nicotine level in VLNC cigarettes affect the accuracy of the public's perceptions about nicotine content, addictiveness, and cancer risk.

Methods: Participants were a national convenience sample of 1353 US adults (22% smokers). In an online experiment, we randomized participants to a VLNC description using (1) concise language; (2) a percentage; (3) an interpretation; (4) a percentage and interpretation; (5) a percentage and a pictograph; or (6) a percentage, interpretation, and pictograph; or to a control description using (7) FDA's "minimally or nonaddictive" phrasing. We assessed accuracy of perceived nicotine content, addictiveness, and cancer risk compared to current cigarettes.

Results: Compared to control, the percentage description resulted in more accurate perceptions about nicotine content (76% vs. 49% accuracy) and addictiveness (44% vs. 34%), but less accurate perceptions about cancer risk (56% vs. 68%; all $ps < .05$). Adding interpretation or pictographs to the percentage description did not increase accuracy. The concise language description reduced accuracy of perceived nicotine content and addictiveness but increased accuracy of cancer risk (all $ps < .05$).

Conclusions: Stating that 95% of nicotine would be removed more accurately conveyed the nicotine content and addictiveness of VLNC cigarettes. However, descriptions that better conveyed nicotine content and addictiveness misled people about cancer risk.

Implications: Implementation of a VLNC standard should include plans for a communication campaign that conveys that VLNC cigarettes will be less addictive but equally toxic to smoke. Stating the percent reduction in nicotine is likely to more clearly communicate reduced addictiveness but may also exacerbate risk misperceptions. VLNC communication requires further study to ensure the public accurately understands a VLNC standard.

Introduction

Nicotine is a major driver of tobacco use and the chemical that makes it so frustratingly difficult for smokers to successfully quit.¹ In 2017, the US Food and Drug Administration (FDA) announced a shift in its approach to tobacco regulation, with a key focus on reducing nicotine in cigarettes to levels low enough that cigarettes would be minimally or non-addictive.^{2,3} If implemented, this standard would allow only very low nicotine content (VLNC) cigarettes to be sold in the United States. Clinical research has found that VLNC cigarettes lead to lower dependence, fewer cigarettes smoked per day, and increased quit attempts compared to standard nicotine level cigarettes.⁴⁻⁹ The FDA has not stated whether a nicotine reduction standard would be implemented in one large reduction or gradually phased in over a number of years. Models of population-level effects of a nicotine reduction product standard in the United States suggest that a large reduction of nicotine would lead to 5 million smokers quitting in the first year alone, and tens of millions of life-years saved over the next few decades.¹⁰ Toxicologically, VLNC cigarettes would retain all or nearly all of the same carcinogens and other toxins in current cigarettes and would therefore not be meaningfully safer to smoke.

However, 80% of the public believes nicotine is the carcinogenic substance in cigarettes,¹¹ and a national survey shows nearly half of smokers believe VLNC cigarettes are less carcinogenic to smoke than current cigarettes,¹² in line with findings from clinical trials.^{13,14} This misunderstanding is associated with a lower motivation to quit smoking under a VLNC standard.¹² Thus, it is critical to study how to announce a nicotine reduction standard to the public in a way that does not exacerbate misperceptions. The public needs to understand what the standard does (greatly reduces nicotine and addictiveness) and what it does not do (make cigarettes safe to smoke).

In the era of social media, in which facts and rumors can spread rapidly, framing plays an increasingly important role in how the public receives new health information. For example, recommendations for HPV vaccination and changes in breast cancer screening in the United States generated substantial confusion, misinformation, and backlash that effective message framing may have at least lessened.¹⁵⁻¹⁷ Preliminarily testing of messages to communicate a new nicotine standard is vital to preparing for a smooth implementation. Message testing is also important to help the FDA clearly and consistently communicate to the public, amid opposing communications from the tobacco industry, which has deliberately misled the public for decades.¹⁸ In formal responses to possible FDA nicotine reduction, the industry has written long lists of concerns.^{19,20}

An important question is how to explain to the public what a nicotine reduction standard would do in terms of the nicotine level in cigarettes. The scientific standard (potentially a maximal limit of 0.4 mg nicotine per gram of tobacco) would likely be hard for the public to interpret. Alternatives such as “nicotine-free” would not be entirely accurate and could be legally problematic because the FDA is not authorized to reduce the nicotine content in cigarettes to zero.²¹ In public announcements, the FDA has used phrases such as “lowering nicotine in cigarettes to non-addictive levels”³ and “lowering nicotine in combustible cigarettes to minimally or non-addictive levels.”²² In studies of the public’s understanding of VLNC cigarettes researchers have also used various descriptions. These include describing cigarettes that have “a very low nicotine level, compared to most cigarettes

available in the United States”¹⁴ or are “lower in nicotine... than regular cigarettes.”²³

Both for the potential rollout of an FDA nicotine reduction policy and for research studies that involve describing VLNC cigarettes, there is a need to examine how people interpret different phrasings and how the FDA can most effectively convey nicotine reduction information. The FDA can use these findings to inform wording used in press releases and in mass media communication. Drawing from risk communication techniques, we sought to learn how different ways of describing the nicotine level of VLNC cigarettes affects the accuracy of perceived nicotine content, perceived addictiveness, and perceived cancer risk of VLNC cigarettes compared to current cigarettes.

Methods

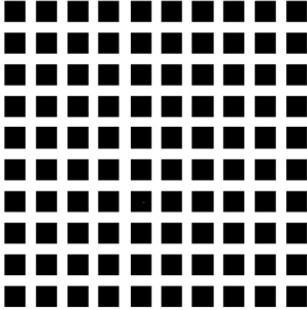
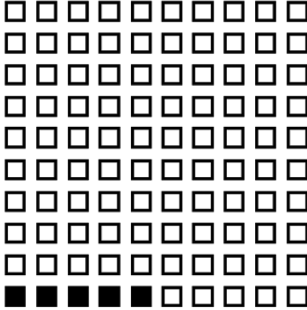
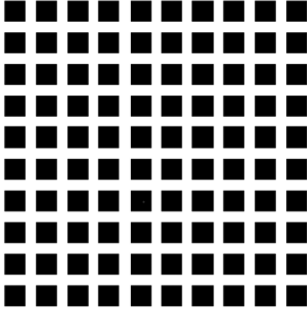
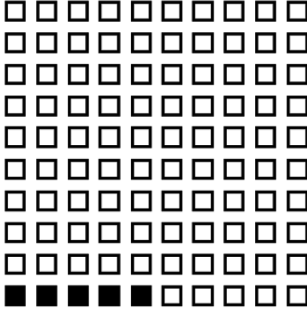
Participants

Participants were a national convenience sample of US adults (ages 18+) recruited in April 2018 through Amazon Mechanical Turk (MTurk), a platform often used for scientific research recruitment.²⁴ The inclusion criteria were being aged 18 or older and residing in the United States. Experiments using MTurk and probability-based samples generate the same general findings.²⁵ We have previously reported additional details on the recruitment and other methods for our study.^{26,27}

Procedures

Participants provided informed consent before taking the survey. In a between-subjects online experiment, we randomized participants to view 1 of 6 descriptions of a potential FDA product standard mandating lower nicotine levels in cigarettes or a control description (Table 1). We developed the descriptions by applying evidence-based risk communication principles.²⁸ The first description used *concise language*: “Imagine if tobacco companies were required to reduce the nicotine in cigarettes.” This follows the finding that communications are more effective if they are brief and devoid of extraneous information.²⁹ The second description provided numeric information as a *percentage*: “Imagine if tobacco companies were required to remove 95% of the nicotine from cigarettes.” Research shows that people have more accurate perceptions when given a number, rather than a qualitative word such as “common” or “low.”³⁰ The third description provided an *interpretation* of nicotine reduction: “Imagine if tobacco companies were required to make cigarettes nearly nicotine-free.” This interpretative language could make it easier for readers to gain the meaning of a message.^{31,32} The fourth description combined a *percentage and interpretation*: “Imagine if tobacco companies were required to remove 95% of the nicotine from cigarettes. This would make cigarettes nearly nicotine-free.” The fifth description combined the *percentage and pictographs*. Pictographs show the numerator and denominator to help a reader visualize a percentage.³³ The sixth description combined the *percentage, interpretation, and pictographs*. The *control* description used language from FDA’s wording in press releases to describe the reduction in nicotine:²² “Imagine if tobacco companies were required to lower the nicotine in cigarettes to a minimally or non-addictive level.” On the same webpage where participants saw their randomly assigned description of the potential new cigarette standard, participants answered questions about the description. Participants received \$2.20 for taking the survey. The institutional review board at the University of North Carolina approved the study.

Table 1. Descriptions of Very Low Nicotine Content Cigarettes

Condition	Wording
Control	“Imagine if tobacco companies were required to lower the nicotine in cigarettes to a minimally or non-addictive level.”
Concise language	“Imagine if tobacco companies were required to reduce the nicotine in cigarettes.”
Percentage	“Imagine if tobacco companies were required to remove 95% of the nicotine from cigarettes.”
Interpretation	“Imagine if tobacco companies were required to make cigarettes nearly nicotine-free.”
Percentage and interpretation	“Imagine if tobacco companies were required to remove 95% of the nicotine from cigarettes. This would make cigarettes nearly nicotine-free.”
Percentage and pictograph	“Imagine if tobacco companies were required to remove 95% of the nicotine from cigarettes.”
	<div><div><p>Nicotine in current cigarettes</p></div><div><p>Nicotine in changed cigarettes</p></div></div>
Percentage, interpretation, and pictograph	“Imagine if tobacco companies were required to remove 95% of the nicotine from cigarettes. This would make cigarettes nearly nicotine-free.”
	<div><div><p>Nicotine in current cigarettes</p></div><div><p>Nicotine in changed cigarettes</p></div></div>

Measures

The survey presented the three outcome measures in a random order for each participant. The *perceived nicotine content* item read, “Compared to current cigarettes, how much nicotine do you think the changed cigarettes would have?” The *perceived addictiveness* item read, “Compared to current cigarettes, how addictive do you think the changed cigarettes would be?” The *perceived cancer risk* item read, “Compared to smoking current cigarettes, smoking these changed cigarettes for 30 years would have what risk of lung cancer?” The perceived cancer risk item included recommended practices for perceived risk questions³⁴ and emphasized that the item was about risk related to continuing to actively smoke VLNC cigarettes. All items used the same five-point response scale: “Much, much less” (scored as 1), “Much less” (2), “Somewhat less” (3), “A little less” (4), and “The same” (5). In previous research using a broader scale, we found that few people responded that risks of VLNC cigarettes would be higher than current cigarettes.¹² We dichotomized

responses as accurate (1) or inaccurate (0). On the basis of current scientific understanding,³⁵ nicotine content ratings of 1 or 2, addictiveness ratings of 1 or 2, and perceived risk ratings of 4 or 5 were scored as being accurate.

The survey also assessed standard demographics and tobacco use. We defined current smoking as having smoked at least 100 cigarettes in one’s lifetime and now smoking some days or every day.³⁶ The survey also assessed standard demographics and tobacco use.

Analyses

The analytic sample included 1353 participants with complete data on our outcomes. Analyses were conducted using SAS 9.4 (Cary, NC) and a critical alpha of .05. We first conducted chi-square tests to check for demographic differences among the seven description conditions and found none.

We next put the description conditions in rank order by perceived nicotine content and then determined whether the difference

between adjacent descriptions was statistically significant using planned contrasts in a generalized estimating equation (GEE). We repeated the analysis for perceived addictiveness and perceived cancer risk. Next, to examine whether the descriptions were more effective for some groups than others, exploratory analyses added main effects for smoking status, gender, age group, and race and their interactions with description condition. These analyses used a dichotomous variable comparing the four description conditions that included a percentage to the remaining three description conditions. We did not find any interactions and so do not discuss them further. We calculated the Pearson correlation coefficients for the three outcome variables' associations with each other.

Results

Participant Characteristics

Overall, 22% of participants were current smokers (Table 2). Participants' mean age was 37 years (SD: 12), and 52% were male, 47% female, and 1% transgender. The sample was 82% white, 9% black, 5% Asian, and 4% other or multiracial; 9% were Hispanic. In addition, 36% did not have a college degree, and 49% reported a household income below \$50 000.

Perceived Nicotine Content

Around 49% of participants provided with the control description accurately understood that VLNC cigarettes would have much less

nicotine than current cigarettes (Figure 1). The *concise language* description elicited less accurate perceived nicotine content from participants (14% accurate) than the control description ($p < .001$). The *interpretation* description (58%) did not differ from control ($p = .10$). The *percentage and interpretation* description (74%) elicited more accuracy than the interpretation description ($p < .001$) and along with the remaining descriptions offered the highest accuracy: *percentage* (76%, $p = .60$ vs. percentage and interpretation); *percentage and pictograph* (81%, $p = .23$ vs. percentage); *percentage, interpretation, and pictograph* (87%, $p = .12$ vs. percentage and pictograph).

Perceived Addictiveness

About a third (34%) of participants provided with the control description accurately understood that VLNC cigarettes would be much less addictive than current cigarettes. Again, the *concise language* description elicited less accurate perceived addictiveness from participants (17% accurate) than the control description ($p < .001$). The *interpretation* description (36%) did not differ from control ($p = .67$). The *percentage and interpretation* description (48%) elicited more accuracy than the interpretation description ($p = .01$) and along with the remaining descriptions offered the highest accuracy: *percentage* (44%, $p = .36$ vs. percentage and interpretation); *percentage and pictograph* (52%, $p = .13$ vs. percentage); *percentage, interpretation, and pictograph* (48%, $p = .51$ vs. percentage and pictograph).

Perceived Cancer Risk

Around 68% of participants provided with the control description accurately understood that VLNC cigarettes would be about as carcinogenic as current cigarettes if smoked. In contrast with the prior two outcomes, the *concise language* description elicited more accurate perceived cancer risk from participants (77% accurate) than the control description ($p = .03$). The *interpretation* description (68%) did not differ from control ($p = .91$). In contrast to the previous two outcomes, the *percentage and interpretation* description (57%) elicited less accuracy than the interpretation description ($p = .03$) and along with the remaining descriptions offered the lowest accuracy: *percentage* (56%, $p = .83$ vs. percentage and interpretation); *percentage and pictograph* (48%, $p = .13$ vs. percentage); *percentage, interpretation, and pictograph* (55%, $p = .20$ vs. percentage and pictograph).

The three outcomes were all associated (all $p < .001$). Higher perceived nicotine content was strongly associated with higher perceived addictiveness ($r = .59$). Higher perceived cancer risk was modestly associated with higher perceived nicotine content ($r = .27$) and higher perceived addictiveness ($r = .34$).

Discussion

Using risk communication best practices for describing the nicotine level of VLNC cigarettes to the public yielded consistent findings. A substantial percentage of participants had misperceptions of nicotine content, addictiveness, and cancer risk. As descriptions elicited more accurate perceptions of the low nicotine content and low addictiveness of VLNC cigarettes, they elicited less accurate perceptions of the high cancer risk of these cigarettes. For communications or research studies that are only concerned with conveying that VLNC cigarettes have much less nicotine than current

Table 2. Participant Characteristics ($N = 1353$)

Characteristic	<i>n</i>	%
Current smoker	298	22.0%
Age		
18–29 years	361	26.7%
30–39 years	547	40.5%
40–54 years	295	21.8%
55+ years	149	11.0%
Mean (SD) years	37	12
Gender		
Male	704	52.1%
Female	639	47.3%
Transgender or other	9	0.7%
Gay, lesbian, or bisexual	141	10.4%
Hispanic	122	9.0%
Race		
White	1106	81.8%
Black or African American	127	9.4%
Asian	63	4.7%
Other/multiracial	47	3.5%
American Indian or Alaskan Native	8	0.6%
Native Hawaiian or Pacific Islander	1	0.1%
Education		
High school or less	170	12.6%
Some college	313	23.2%
College graduate or associate's degree	699	51.7%
Graduate degree	170	12.6%
Household income, annual		
\$0–\$24 999	234	17.3%
\$25 000–\$49 999	425	31.5%
\$50 000–\$74 999	322	23.8%
\$75 000+	370	27.4%
Low income ($\leq 150\%$ of Federal Poverty Level)	224	16.6%

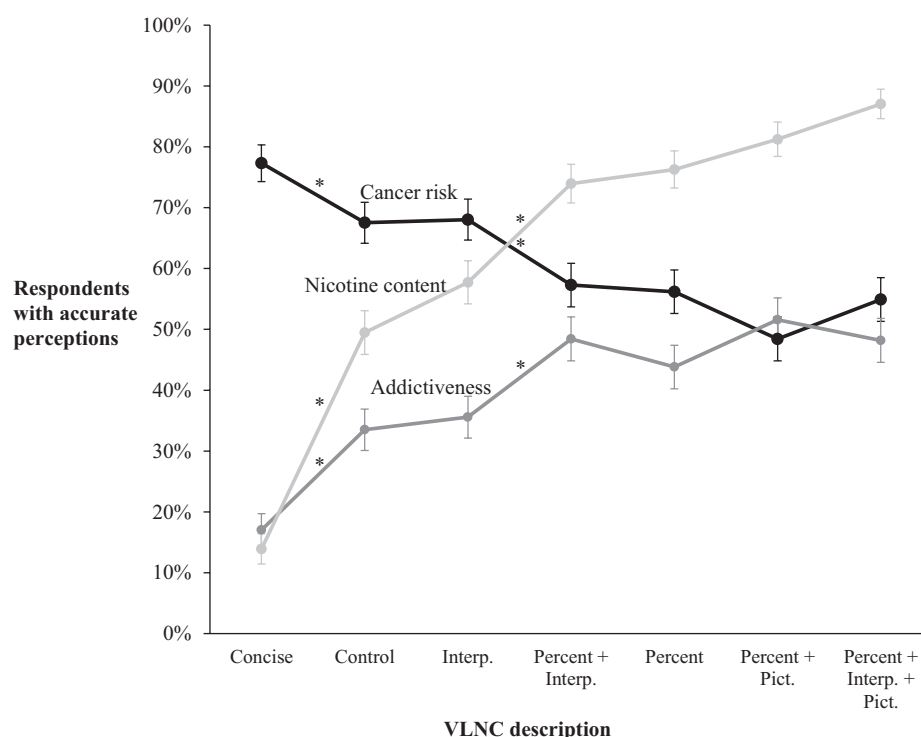


Figure 1. Impact of very low nicotine content descriptions. Error bars show standard errors. Abbreviations: percent = percentage, interp. = interpretation, pict. = pictograph. * $p < .05$ for adjacent points on the line.

cigarettes, our findings suggest that providing the percentage of nicotine removed is sufficient. For FDA mass media or other communications focused on accurately conveying the health benefits (less addiction) and risks (similar cancer risk) of VLNC cigarettes, the best approach is less clear. The sticking point is that messages that led to more accurate perceptions about the nicotine content and addictiveness of VLNC cigarettes also led to *less* accurate perceived cancer risk.

Our findings reinforce previous studies' findings that many people incorrectly believe nicotine is the main harmful chemical or carcinogen in cigarettes.^{11,37-39} For example, people perceive cigarettes such as Quest that are advertised as "low" nicotine to be less harmful than other cigarettes.^{39,40} Researchers have also shown that participants trying VLNC cigarettes¹⁴ or participants asked about "very low" nicotine cigarettes perceive them to be less harmful.²³ Our findings indicate that not only are VLNC cigarettes perceived as less harmful to smoke but also that this problem becomes exacerbated as people are provided more detailed information about the amount of nicotine reduction. This highlights the need for more research on how to communicate nicotine reduction clearly without causing potentially harmful misperceptions about risk. Communication about a VLNC standard could include a disclaimer that "The new cigarettes will not be safer to smoke than current cigarettes." However, disclaimers are often ineffective,⁴¹⁻⁴⁵ and additionally, the disclaimers would not necessarily be repeated in media coverage, social media discussions, or interpersonal communications. Another possible solution could be explaining a VLNC standard not by the nicotine content but by saying that cigarettes would be "changed so that they no longer relieved your cravings."⁴⁶ Popova and colleagues found that this language led to more accurate perceived risk than other scenarios in a study of what smokers said they would do in

response to a VLNC policy. We are currently developing and testing messages to reduce the misperception that VLNC cigarettes are less carcinogenic.

For press releases, mass media campaigns, and other communications, the FDA will have to make important decisions about what the public needs to know about a reduced nicotine standard. Is there a legal or ethical obligation that smokers be fully informed about the great reduction in the amount of nicotine and addictiveness? If so, more communication research is needed to learn how to do this while simultaneously conveying the high cancer risk of continuing to smoke VLNC cigarettes. In addition, it will be important to consider how other actors, such as the news media, the tobacco industry, and opponents on social media will frame nicotine reduction.¹⁹

As our study surveyed a convenience sample, a limitation is that the generalizability to the US adult population remains to be established. Our point estimates are likely to differ from those of probability samples, but our experimental findings are likely to be replicable across representative samples.²⁵ Second, a single survey item assessed risk beliefs, and because it was asked of both nonsmokers and smokers, it did not specifically ask about the participant's own cancer risk. Multi-item risk perception scales about own risk can yield stronger associations with behavior.³⁴ Third, the response scale offered responses that ranged from "much, much less" to "the same," and some participants could have wanted to respond that VLNC cigarettes would have more nicotine, be more addictive, or be more carcinogenic. However, in previous work, we found that few (~5%) people used this end of the response scale.¹² Fourth, if the FDA chooses a gradual nicotine reduction approach, the phrasings suggested here should be revised accordingly and re-tested.

Conclusion

Our study found that introducing VLNC cigarettes by describing their percentage reduction in nicotine (95%) led to accurate perceptions of nicotine content and addictiveness. However, we also found that as descriptions of VLNC cigarettes conveyed more accurate perceptions about the nicotine content and addictiveness of VLNC cigarettes, they elicited less accurate perceived cancer risk. Future research can examine how to educate the public about the continued risk of smoking cigarettes under a VLNC standard.

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Declaration of Interests

Kurt Ribisl has served as a paid expert consultant in litigation against tobacco companies. The other authors declare no conflicts of interest.

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