



Published in final edited form as:

*J Health Commun.* 2016 August ; 21(8): 855–867. doi:10.1080/10810730.2016.1177142.

## Examining Interpretations of Graphic Cigarette Warning Labels among US Youth and Adults

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### Abstract

Few studies have examined how diverse populations interpret warning labels. This study examined interpretations of 9 FDA-proposed graphic cigarette warning labels (image + text) among a convenience sample of youth (age 13–17) and adults (18+) across the US. Participants (N=1571) completed a cross-sectional survey. Participants were asked to select one of three plausible interpretations (1 preferred vs. 2 alternative) created by the research team about the particular consequence of smoking addressed in each warning label. Participants also rated each label for novelty, counterarguing, perceived effectiveness and harm. Smokers reported their thoughts of quitting, self-efficacy, and motivation to quit. Although at least 70% of the sample chose the preferred interpretation for 7 of 9 labels; only 13% of participants chose all 9 preferred interpretations. Odds of selecting the preferred interpretation was lower among African Americans, those with less education, and labels perceived as being more novel. Smokers reported greater counterarguing and less perceived effectiveness and harms than nonsmokers, but results were not consistent across all labels and interpretations. The alternative interpretations of cigarette warning labels were associated with lower perceived effectiveness and lower perceived harms of smoking, both of which are important for motivating quit attempts.

### Keywords

warning labels; tobacco; communication; packaging and labeling; knowledge

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Despite significant declines in tobacco use since the 1960's, 17.8% of U.S. adults still smoke, and the rates are higher among people with lower socioeconomic status (Centers for Disease Control and Prevention, 2013, 2014a). Since 1984, tobacco manufacturers have

been required to place text-only Surgeon General’s warning labels on all cigarette packages sold in the U.S to educate smokers about the health harms of smoking. However, national survey data indicate that smokers still underestimate their risk of cancers and continue to agree with myths like, “exercise undoes the harms of smoking” (Rutten, Augustson, Moser, Beckjord, & Hesse, 2008; Weinstein, Marcus, & Moser, 2005).

To be effective, warnings about smoking harms must be explicit, succinct, and credible (Fischhoff, Riley, Kovacs, & Small, 1998; Wogalter & Laughery, 1996). However, before individuals can act on a message, they must attend to and understand it (McGuire, 1980; Petty & Cacioppo, 1986; Wogalter, Conzola, & Smith-Jackson, 2002). Visual images can convey larger amounts of information in a single glance than text alone, and can benefit those with reading or language barriers. The use of visual images to supplement text messages in warning labels for a variety of consumer products has been shown to increase attention, but fewer studies have examined the impact on comprehension and recall (Magnan & Cameron, 2015; Strasser, Tang, Romer, Jepson, & Cappella, 2012; Wogalter & Laughery, 1996).

Our research was needed due to the lack of formative research reported in the literature on the evaluation of graphic warning labels for use in the US, and it was unknown how such labels would be interpreted by diverse populations of youth and adults in the US (Hammond, Reid, Driezen, & Boudreau, 2013). This is an important oversight because some graphic images could actually undermine understanding; for example, if they are less concordant with the text warning (Houts, Doak, Doak, & Loscalzo, 2006; Sussenbach, Niemeier, & Glock, 2013) or if the causal mechanisms between smoking and the illustrated harms are more distal (e.g., baldness due to chemotherapy treatment for a smoking-related cancer) (McCool, Webb, Cameron, & Hoek, 2012; Wakefield et al., 2013; Wogalter et al., 2002). If the graphic image doesn’t help decipher difficult or unfamiliar text (e.g., carbon monoxide), people with less education and/or language barriers still may not benefit from the graphic warning (Morris, Gilpin, Lenos, & Hobs, 2011; Wakefield et al., 2013). Such misunderstandings may limit the extent to which adding graphic warning labels to cigarette packs may reduce tobacco-related health disparities in the US. Additionally, it is unclear how misinterpreting warning labels may impact cognitive reactions and motivation to quit. For example, motivation to quit smoking is greater among smokers with greater understanding of the health harms of smoking and greater perceptions of personal vulnerability (Curry, Grothaus, & McBride, 1997; Hammond, Fong, McDonald, Brown, & Cameron, 2004; McCaul et al., 2006). However, it is unknown whether the effectiveness of health warnings requires nuanced understanding of the specific health risk being addressed versus a general understanding of smoking as harmful. This research can inform the design of future warning labels for US audiences (Bayer, Johns, & Colgrove, 2013).

This study examined the following research questions:

1. How do diverse audiences interpret graphic cigarette warning labels?
2. Does interpretation of the warning labels vary by audience characteristics (e.g., demographic factors, smoking status, and prior exposure to a risk or image)?

3. Do common outcomes of risk messages such as counterarguing, perceived effectiveness (acceptance of the risk message), and perceived harm of smoking vary by interpretation of the warning label? Among smokers, do thoughts of quitting and motivation to quit vary by interpretation of the warning label?

## Methods

### Graphic Warning Labels

The US Food and Drug Administration (FDA) proposed nine graphic warning labels to be printed on all cigarette packs in the U.S. starting in September 2012 (Supplement Table). Nine new health warning messages were specified in the Family Smoking Prevention and Tobacco Control Act, and preliminary research determined the proposed graphics for each text warning (Nonnemaker, Farrelly, Kamyab, Busey, & Mann, 2010). Our research was funded in April 2012 to evaluate these nine graphic warning labels (image + text), and we collected data from June 2012 to March 2013. Also in March 2013, the FDA announced it would not appeal the Supreme Court decision against the implementation of the proposed graphic warning labels (Bayer et al., 2013). The FDA is still mandated to design improved warning labels and continued research is needed to inform these efforts. Since the start of this study, related research evaluating the FDA-proposed labels using online panels has been published (Blanton, Snyder, Strauts, & Larson, 2014; Cameron, Pepper, & Brewer, 2015; Gibson et al., 2015; Hammond et al., 2013; Nonnemaker, Choiniere, Farrelly, Kamyab, & Davis, 2015). Although most studies involve some measures of perceived effectiveness, less attention has been paid to conceptual understanding of graphic warning labels, especially among diverse populations. Cameron et al. (2015) asked participants if the message was “easy to understand” and “confusing.” Nonnemaker et al. (2015) asked if the label is “informative” and whether participants believe specific health outcomes such as heart disease and stroke.

### Sample Characteristics

We recruited a convenience sample of youth and adults from across the US. To ensure participation from a socioeconomically and racially diverse sample, we used targeted recruitment strategies with established and new community partners. We recruited participants in three age strata (youth 13–17 years, young adults 18–24 years, adults 25 and older) from six population sub-groups with higher rates of smoking and/or smoking-related diseases (rural Americans, low-income Americans, African Americans, American Indians, U.S. military personnel, blue-collar workers) (Centers for Disease Control and Prevention, 2014b; DeSantis, Nasishadham, & Jemal, 2013; Ham et al., 2011; Meyer, Yoon, & Kaufmann, 2013; Vander Weg, Cunningham, Howren, & Cai, 2011). Recruitment venues included schools, youth services agencies, public health agencies, community centers, businesses, tribal organizations, military organizations, and trade unions.

### Study Design and Procedures

Cross-sectional surveys were administered on iPads in either a group or individual setting. Group settings primarily involved classroom-based recruitment, wherein iPads were first distributed to all eligible and consented participants in the classroom, and then instructions

were delivered at once to the whole group. Individual settings involved a single participant who received directions one-on-one from project staff. Research assistants were available to assist participants as needed with technology or literacy needs. The survey took approximately 30 minutes to complete. Participants viewed a photo representation of each of the nine FDA-proposed graphic label (image plus text as shown in the Supplement Table) on an unbranded cigarette pack in random order and responded to related survey questions. Participants received remuneration for their time including gift cards (adults) or drawstring backpacks and ear buds (youth). Prior to survey administration, written parental consent and child assent was obtained for minors, and written consent was obtained for adults. All study procedures and materials were approved by Washington University's Human Research Protections Office.

## Measures

**Socio-demographic characteristics and smoking status**—Standard items from national surveys were used to assess age, gender, race/ethnicity, and years of education completed (Centers for Disease Control and Prevention, 2010, 2011). The RUCA (Rural-Urban Commuting Areas) taxonomy was applied to recruitment locations; rurality was defined as a RUCA code of 4 or above (WWAMI Rural Health Research Center). To classify adult participants as “low income” responses to a standard household income question and responses were dichotomized (<\$25,000, \$25,000), whereas youth were classified as low-income if they reported receiving reduced price or free lunch at school (yes/no).

Standard smoking-related variables assessed participant's lifetime use of cigarettes (≥ 100 vs. <100), use of cigarettes in the past 30 days (number of days smoked a cigarette), and current use of cigarettes (every day, some days, not at all). Adults were classified as smokers if they currently smoked cigarettes every day or some days. Youth who reported smoking at least one day in the past 30 days were classified as smokers.

**Interpretations of labels**—Interpretations of warning labels are comprised of the viewers' amalgamation of the graphic image plus the written warning message. However, some of the graphic images were not specific to the written warning message. For example, the image of a woman crying was paired with text that read, “tobacco smoke causes fatal lung disease in nonsmokers.” The FDA did not indicate the “intended” meaning of the graphic warning labels beyond the warning text alone. To address this omission, a team of health communication and behavioral science faculty led individual and group discussions to reach consensus on the perceived “intended” meaning and plausible alternative meanings of each label. No formal Delphi methods or quantitative rankings were used to select the final response options. The team selected one preferred interpretation and two additional plausible interpretations for each graphic warning label. All interpretations were written to be effective in discouraging smoking; however, this study examined whether the preferred, more nuanced interpretations elicited different reactions to the labels. Participants were shown each label (graphic image plus written warning message) and asked, “What do you think is the main point that the label is trying to show?” with the three interpretations in random order as possible response options. All responses were written using plain language. Responses were dichotomized as preferred vs. alternative interpretations due to some small

cell sizes for some demographic variables. Although some alternative interpretations are inaccurate, we acknowledge that several of the alternate interpretations are not necessarily wrong or inappropriate responses. All label interpretations are shown in Table 2.

**Reactions to labels**—Two items assessed *novelty* of the graphic warning labels: “The information in this label is something I’ve heard before.” and “I’ve seen pictures like this before in messages about smoking.” Response options were “Agree”, “Disagree” and “Not sure.” A label was considered “not novel” if participants agreed with either item, otherwise it was considered “novel”. *Counterarguing* against each label was measured by the mean of two items: “How much did you find the warning label to be [exaggerated, dishonest]” (1=not at all to 7=completely) (Witte, 1996). Alpha coefficients ranged from 0.79 to 0.86 across the nine graphic labels. *Perceived effectiveness* was measured by reverse scoring and averaging three items evaluating each label as: informative, believable, and convincing (1=definitely yes, 2=probably yes, 3=probably not, and 4=definitely not; alpha coefficients ranged from 0.76 to 0.82). *Perceived harm* of smoking was assessed for all participants with the item: “Looking at the label makes me feel like smoking could hurt the health of my close friends or family members;” and for smokers only: “Looking at the label makes me feel like smoking could hurt my health” (1=not at all, 7=completely).

To assess *self-efficacy*, we asked smokers to indicate their agreement (1=strongly disagree, 7=strongly agree) with the statement: “I feel confident that I can quit smoking.” We assessed motivation for quitting with two measures. First, smokers were asked to what extent each label made them *think about quitting* smoking (probably/definitely yes vs. probably/definitely not). Around 60–70% of participants selected probably/definitely yes across labels and so we dichotomized the variable for analysis. Second, we defined *action steps* as the mean of 5 items about the likelihood of taking steps to quit smoking in the next 3 months by: buying nicotine replacement products, taking prescription cessation aids, calling 1–800-QUIT-NOW (tobacco quitline), enrolling in a quit smoking program if available and convenient, and talking to a medical professional about how to quit smoking (alpha = 0.90). Response options ranged from 1=not at all likely to 7=extremely likely, which we dichotomized for ease of analysis (≥5 likely vs. <5 not likely).

## Statistical Analysis

Descriptive analyses were conducted on sample characteristics and interpretation items (RQ1). For each graphic warning label, we conducted a multivariable logistic regression analysis to examine covariates of label interpretation (preferred, alternative) (RQ2). Models included age, race (African American, American Indian, other/mixed vs. white), gender (female vs. male), smoking status (non-smokers vs. smokers), income (<\$25,000 vs. ≥25,000), education (less than high school, high school or GED vs. some post-secondary education or more) and label novelty (yes vs. no/not sure). Non-significant covariates (i.e., rural vs. urban) were dropped from analyses.

We conducted multivariate regression analyses to examine whether reactions to each warning label were significantly related to label interpretation (RQ3). Models were adjusted for the same covariates as the previous analysis and included an interaction term between

smoking status and label interpretation. T-tests of the differences between least squares means for the two alternative interpretations compared to the preferred interpretation were conducted. For smokers only, we conducted multivariable logistic regression analyses predicting thinking about quitting smoking and action steps. Covariates for this subgroup analysis of smokers included label interpretation, counterarguing, perceived effectiveness, perceived harm, and self-efficacy for quitting controlling for age, sex, race, low income, education, and label novelty. Acknowledging the exploratory nature of our study and the increased probability of making Type I errors due to the number of hypothesis tests being conducted, we also report results controlling for the false discovery rate (FDR) (Benjamini & Hochberg, 1995). FDR reduces the probability of incorrectly rejecting null hypotheses by using a more conservative alpha for each test.

## Results

The total sample size was 1571. The mean age was 26.4 years old (range 13–81) and 46.5% were female. As planned, the sample was diverse: 37.2% were white, 36.7% were African American, 14.0% were American Indian, and 12.2% were another or mixed race. In addition, 40.6% were low income, 23.8% were from rural recruitment sites, 13.3% were blue collar workers, and 7.5% were U.S. military. Smokers comprised 53.8% of adults and 4.9% of youth. Of adult smokers, 72.5% smoked every day and 27.5% smoked some days. Among adults, 16.7% completed less than 12 years of schooling, 37.1% completed high school/GED, and 46.2% had at least some post-secondary education.

Table 1 reports significant covariates of the interpretation of each warning label. The most consistent pattern of associations across labels was between race and interpretation. Compared to whites, African Americans were less likely to select the preferred interpretation for most labels (significant odds ratios ranged from 0.39 to 0.61). Independent of race/ethnicity, those with lower educational attainment or low income were less likely to choose the preferred interpretation of the label (significant odds ratios ranged from 0.42 to 0.71). Compared to those who had heard or seen the messages in the labels before, those for whom the labels were more novel were less likely to choose the preferred interpretation (significant odds ratios ranged from 0.24 to 0.60).

Table 2 shows the frequency of responses to the interpretation items. The preferred interpretation was selected by fewer people for the labels depicting the man smoking with a tracheotomy (Supplement Table – Label 1) and the healthy vs. diseased lung (Label 8). For all other labels, at least 70% of participants interpreted the label as intended by the research team. Few participants (13.2%) selected all nine preferred interpretations. On average, participants chose one of the alternative plausible interpretations for 2.7 (SD=1.9) labels. The percentage of participants who considered the graphic warning labels to be novel was low, and ranged from 4.7% (healthy/diseased lung; Label 8) to 13.6% (woman crying; Label 3).

Table 2 also presents differences in reactions by interpretation of the label (main effects). Across all labels, people who selected one of the alternative interpretations reported greater counterarguing than people who selected the preferred interpretation. Effect sizes for

significant mean differences were small to medium (Cohen's  $d=0.2$  to  $0.6$ ). For eight of nine labels, choosing the preferred interpretation was associated with greater perceived effectiveness compared to at least one of the alternative interpretations (Table 2). Effect sizes for significant mean differences ranged from  $d=0.2$  to  $0.6$ . For seven of nine labels, the perceived harm of smoking affecting close others was greater for people who selected the preferred interpretation of the label. Cohen's  $d$  for significant mean differences ranged from  $d=0.2$  to  $0.4$ .

Table 3 reports the significant interactions of label interpretation by smoking status. Reactions differed for smokers and non-smokers for 28 of the 81 (35%) possible comparisons. With one exception (Label 2), counterarguing was higher for smokers than non-smokers. In contrast, perceived effectiveness and harmfulness to others were higher among non-smokers than smokers. The effect sizes of mean differences ranged from  $d=-0.71$  to  $0.38$ ; however, the moderate effect sizes may be due more to the small cell sizes than meaningfully large mean differences.

Table 4 shows the results of multivariable logistic regression models examining the associations between reactions to the warning labels and motivation to quit among smokers, specifically: thinking about quitting and likelihood of taking action to support quitting. Selecting the preferred interpretation of the graphic warning label was only positively associated with thinking about quitting for the label showing the man smoking with a tracheotomy (Label 1). Counterarguing was only associated with action steps. For seven of nine labels, this association was positive and statistically significant. As this was an unexpected result, we checked the model for collinearity and re-analyzed it in several ways to verify the consistency of the result. Odds ratios for significant associations were modest and ranged from 1.16 to 1.27. For all nine labels, greater perceived effectiveness of the label was significantly associated with greater odds that the label made the person think about quitting smoking. Odds ratios for significant associations ranged from 1.97 to 6.16. However, there was no association between perceived effectiveness and action steps. One of the perceived harm measures (self or other) was consistently associated with thinking about quitting across labels, but not with action steps. Odds ratios for significant associations were modest and ranged from 1.28 to 1.49. Self-efficacy for quitting was positively associated with thinking about quitting (four of nine labels) and action steps (all nine labels). Odds ratios for significant associations were modest and ranged from 1.17 to 1.37.

## Discussion

Adding graphic images to cigarette warning labels is meant to increase attention and comprehension of the intended meaning for diverse audiences (Wogalter et al., 2002). Depending on the criterion (ANSI, 1998; Organization of International Standards, 1988) used for defining a minimum acceptable level of comprehension in the population, five or eight of the nine FDA-proposed warning labels were interpreted as intended by the research team, and few participants selected all nine preferred interpretations. For seven of nine labels, African Americans and people with less education were less likely to choose the preferred interpretation of the warning labels. This difference in interpretation could limit the potential impact of these labels on reducing tobacco-related health disparities.

Our study examined whether the effectiveness of health warnings requires a nuanced understanding of the specific health risk being addressed versus a general understanding of smoking as harmful. Previous research has posited that graphic warning labels may be most clearly understood when illustrating well-known, less abstract mechanisms of the harms of smoking (Magnan & Cameron, 2015; Wogalter & Laughery, 1996). Further, photographic images may be more clearly understood than drawings (Cameron et al., 2015). The label of the man smoking with a tracheotomy (Label 1) was the most misinterpreted label in this study, suggesting that some of our participants may not have understood the causal mechanism between the man's addiction to smoking and his tracheotomy. The abstract message of the power of addiction that prompts people to keep smoking even after experiencing serious health problems may mean the graphic image is not a suitable match for the simple text warning that "Cigarettes are addictive." However, the label was not perceived to be less effective when participants believed that the dangerous chemicals in cigarette smoke burned a hole in the man's throat compared to the correct medical interpretation of the label. Either interpretation was associated with similar ratings of the perceived harm of smoking to others. It is unknown whether the perceived severity of the harm from cigarettes increased the perceived effectiveness of the label in this case. The second most frequently selected interpretation of the label with the healthy vs. diseased lung (Label 8) was a reasonable choice (smoking turns organs black), but may reveal a less abstract understanding of the harms of smoking. In this case, the label was perceived to be less effective and less harmful to others when participants chose this alternative plausible interpretation. Future qualitative data may elucidate the independent and interactive effects of the perceived severity of smoking harms and comprehension of the causal mechanisms linking smoking to the illustrated harms (e.g., need for a tracheotomy; development of a diseased lung) to improve knowledge and message effectiveness. Similarly, future studies should quantitatively assess the difference in effect between labels with text that is vs. is not consistent with the image. If regulatory policy changes in support of graphic warning labels are dependent on evidence that greater conceptual understanding is gained from specific medical examples of smoking harms than simpler text warnings that "smoking kills", more empirical research is needed to specifically explore individuals' nuanced understanding of warnings of specific smoking harms and tobacco constituents.

In some cases, we also found that when participants' selected interpretations of the warning labels applied to a subgroup, counterarguing was increased, perceived effectiveness and perceived harm were decreased, but the consistency of effects varied across labels. For example, interpreting warning labels as being specific to African Americans (Label 1), women (Label 3) or older people (Label 5) were associated with greater counterarguing and less perceived effectiveness and/or harm. Future research should examine any negative effects of warning labels that evoke perceptions about specific population subgroups and whether effects differ by the perceived relevance of the audience.

With one exception, we found that interpretation of the warning labels was not related to smoking-related cognitions (i.e., thinking about quitting and action steps). Future longitudinal research can examine mediating and moderating effects of correctly interpreting warning labels. Our findings showed that the preferred interpretation of the labels was related to greater perceived effectiveness and harms of smoking, which were in turn related



to more thoughts about quitting among smokers. This is the expected pattern of associations that support the use of graphic warning labels for informing the population and increasing motivation to quit. Others have found that fear mediates the effect of graphic warning labels on perceived effectiveness, and future research should examine whether comprehension moderates these associations (Byrne, Katz, Mathios, & Niederdeppe, 2015).

Our results also showed that alternative interpretations of the labels' meaning was associated with more counterarguing, which often involves attacks on the message or source credibility (Festinger & Maccoby, 1964). We acknowledge that the temporality of the association between label interpretation and counterarguing cannot be established with this cross-sectional data. Counterarguing is expected to reduce the persuasive effect of the risk message. However, in our study, counterarguing was not related to thoughts about quitting and for some labels was unexpectedly *positively* associated with action steps toward quitting. In other studies, researchers have argued that defenses do not necessarily thwart tobacco control efforts. For example, avoidance of graphic warning labels on cigarette packs (cover up, keep out of sight, use a case) has been positively associated with quit attempts (Borland et al., 2009), and unrelated to cessation behavior (Hammond et al., 2004). More research is needed to explore different types of defenses and whether their role is similar to other psychological barriers to behavior change (e.g., perceived stigma, embarrassment) that can be overcome by motivated individuals. Future research also could examine perceptions of the strength of counterarguments as a possible mediator of these positive associations between resistance to persuasion attempts and actions related to quitting smoking (Petty, Tormala, & Rucker, 2004).

### Strengths and Limitations

While previous studies have assessed awareness or agreement with smoking as a harm in general or with lists of specific advertised constituents or harms of smoking that are more (e.g. gangrene, impotence) or less (e.g., lung cancer, emphysema) novel (Hammond, Fong, McNeill, Borland, & Cummings, 2006; Mutti, Hammond, Reid, & Thrasher, 2013; Swayampakala et al., 2015), this study focused on the combined interpretation of the image plus text in graphic cigarette warning labels. Further, we compared differences across graphic cigarette warning labels in contrast to previous studies that compared groups of graphic vs. text only warning labels (Hammond, 2011; Hammond, 2012; Hammond et al., 2013). In this study, we provided three possible interpretations of the combined text and image, which may differ from the developers' message intent or plausible interpretations other researchers may have generated. Also, all interpretations reflected harms of smoking and some interpretations specified population subgroups, so future studies should more systematically examine the relative effects of different interpretations across labels. Future studies also should examine the effects of specific content or designs within graphic warning labels that may cause different interpretations and reactions, as well as mediators of the effect of warning labels (Byrne et al., 2015; Cameron & Williams, 2015), particularly perceived harms of smoking. Similar to previous studies of graphic warning labels, some of our measures relied on single items and skewed categorical responses, which may have limited our ability to operationalize constructs such as motivation to quit.

## Conclusions

Altering tobacco packaging to include graphic warning labels is intended to inform smokers of the harms of smoking by attracting and sustaining their attention. A minority (13.2%) of this sample selected all nine preferred interpretations of the labels, which is far lower than we anticipated. African Americans and people who viewed a label as more novel were less likely to choose the interpretation of the graphic warning label preferred by the research team. Alternative interpretations of the warning labels were associated with lower perceived effectiveness of the label and harms of smoking, which were associated with less thoughts of quitting. These data support the use of graphic warning labels on cigarette packaging, but the results also emphasize the importance of conducting intensive audience testing during the design phase to ensure that the messages are interpreted as intended. These conclusions are applicable to public service announcements and related media campaigns to educate the public about the harms of smoking.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

**Funding:** Research reported in this publication was co-funded by the Food and Drug Administration (FDA) and the National Cancer Institute of the National Institutes of Health (NIH) as a supplement to the National Cancer Institute's Centers of Excellence in Cancer Communication Research program (P50 CA95815-09S1; PI: Kreuter). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or the FDA. The first author was also supported by NCI grant R03 CA175571-01. Dr. Vetta L. Sanders Thompson was also supported by a NCI Program for the Elimination of Cancer Disparities grant (U54 CA153460). Dr. Erika A. Waters was supported by the Barnes Jewish Hospital Foundation.

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**Table 1**

Statistically significant demographic covariates of preferred vs. alternative interpretations of the graphic warning labels

Labels	Significant Covariates	Outcome Preferred vs. Alternative Label Interpretation
		Adj. OR (95% CI)
<b>Man smoking with tracheotomy</b> (Label 1)	African American vs. White	<b>0.48 (0.34–0.66), p&lt;0.001</b>
	Other/mixed vs. White	<b>0.49 (0.31–0.78), p=0.002</b>
	High school/GED vs. post-secondary/more	<b>0.49 (0.36–0.69), p&lt;0.001</b>
	< high school vs. post-secondary/more	<b>0.60 (0.43–0.84), p=0.003</b>
<b>Baby exposed to smoke</b> (Label 2)	African American vs. White	<b>0.39 (0.19–0.80), p=0.010</b>
	American Indian vs. White	<b>0.25 (0.12–0.53), p&lt;0.001</b>
	< high school vs. post-secondary/more	<b>0.42 (0.21–0.83), p=0.013</b>
<b>Woman crying</b> (Label 3)	African American vs. White	<b>0.41 (0.27–0.61), p&lt;0.001</b>
	American Indian vs. White	<b>0.52 (0.32–0.83), p=0.007</b>
	High school/GED vs. post-secondary/more	<b>0.54 (0.36–0.82), p=0.003</b>
	< high school vs. post-secondary/more	<b>0.44 (0.30–0.67), p&lt;0.001</b>
	Smoker vs not	0.71 (0.50–0.99), p=0.041
	Novel vs. not	<b>0.57 (0.38–0.85), p=0.007</b>
<b>Diseased lip</b> (Label 4)	African American vs. White	0.53 (0.30–0.95), p=0.034
	< high school vs. post-secondary/more	<b>0.45 (0.25–0.80), p=0.007</b>
	Novel vs. not	<b>0.24 (0.14–0.42), p&lt;0.001</b>
<b>Oxygen mask on man's face</b> (Label 5)	Age	<b>0.99 (0.98–1.00), p=0.010</b>
	Female vs. Male	<b>1.41 (1.06–1.87), p=0.017</b>
	Other/mixed vs. White	<b>2.19 (1.21–3.97), p=0.010</b>
	Novel vs. not	0.60 (0.38–0.94), p=0.027
<b>Baby in an Incubator</b> (Label 6)	Female vs. Male	1.45 (1.02–2.06), p=0.037
	African American vs. White	<b>0.56 (0.36–0.89), p=0.014</b>
	High school/GED vs. post-secondary/more	<b>0.45 (0.29–0.71), p&lt;0.001</b>
	< high school vs. post-secondary/more	<b>0.47 (0.29–0.75), p=0.002</b>
<b>Man with I quit t-shirt</b> (Label 7)	Female vs. Male	1.46 (1.02–2.09), p=0.038
	Novel vs. not	<b>0.50 (0.31–0.80), p=0.004</b>
<b>Healthy/Diseased lung</b> (Label 8)	Age	<b>1.01 (1.00–1.03), p=0.009</b>
	African American vs. White	<b>0.61 (0.43–0.87), p=0.006</b>
	American Indian vs. White	0.61 (0.40–0.93), p=0.022
	High school/GED vs. post-secondary/more	<b>0.60 (0.42–0.85), p=0.005</b>
	Low Income vs. not	0.71 (0.53–0.95), p=0.019
	Novel vs. not	0.55 (0.32–0.97), p=0.037

**Outcome Preferred vs. Alternative Label  
Interpretation**

Labels	Significant Covariates	Adj. OR (95% CI)
<b>Man with chest staples</b> (Label 9)	African American vs. White	<b>0.52 (0.35–0.77), p=0.001</b>
	Low Income vs. not	<b>0.66 (0.48–0.91), p=0.010</b>

Note. All models include age, sex, race, low income status, education, novelty of label, and smoking status.

Note: Raw p-values are shown above. After controlling for the false discovery rate, it was found that p-values >0.018 were >0.05 after adjustment. Thus, 8/35 rejected null hypotheses would not be rejected after adjustment. The values that remained statistically significant after the adjustment are bolded.

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Table 2

Differences in reactions to graphic warning labels by label interpretation (main effects)

Labels	What do you think is the main point the label is trying to show? Response options:	Response Frequencies		Outcomes Adj. Mean (SE), p-value and Cohen's d		
		N (%)	Counterarguing	Perceived effectiveness	Harmfulness of smoking to others	
	It is so hard to stop smoking that some people keep smoking through a hole in their throat *	819 (58.9%)	2.47 (0.12)	3.28 (0.04) <sup>a</sup>	5.25 (0.15) <sup>a</sup>	
<b>Man smoking with tracheotomy (Label 1)</b>	The chemicals in cigarette smoke are so dangerous that they can burn a hole in someone's throat	532 (38.3%)	2.68 (0.13), p=0.056 d=0.11	3.34 (0.05), p=0.187 d=0.07	5.48 (0.15), p=0.079 d=0.10	
	Cigarette smoking is more harmful to African American men than to other groups	40 (2.9%)	<b>3.28 (0.29), p=0.006 d=0.45</b>	<b>2.92 (0.11)<sup>a</sup>, p&lt;0.001 d=-0.55</b>	5.12 (0.35), p=0.712 d=-0.06	
	Being around smoke from cigarettes can be bad for children *	1282 (93.2%)	2.36 (0.11)	3.44 (0.04) <sup>a</sup>	5.61 (0.13)	
<b>Baby exposed to smoke (Label 2)</b>	Allowing children to smoke cigarettes is harmful to them	93 (6.8%)	<b>3.52 (0.21)<sup>a</sup>, p&lt;0.001 d=0.35</b>	<b>3.26 (0.07), p=0.009 d=-0.28</b>	<b>5.03 (0.25), p=0.014 d=-0.26</b>	
	Smoke from cigarettes is only harmful when you can see it	0 (0%)	NA	NA	NA	
	Cigarette smoke can kill loved ones who don't smoke *	1046 (77.1%)	2.47 (0.09) <sup>a</sup>	3.26 (0.03) <sup>a</sup>	5.19 (0.11)	
<b>Woman Crying (Label 3)</b>	Cigarette smoking can cause serious depression in some people	183 (13.5%)	<b>3.16 (0.16)<sup>a</sup>, p&lt;0.001 d=0.34</b>	<b>3.06 (0.06), p&lt;0.001 d=-0.27</b>	5.19 (0.11), p=0.890 d=-0.01	
	Cigarette smoking is more harmful to women	128 (9.4%)	<b>3.51 (0.19), p&lt;0.001 d=0.52</b>	3.21 (0.07), p=0.522 d=-0.06	<b>4.41 (0.22), p&lt;0.001 d=-0.34</b>	
	Smoking can cause serious mouth disease *	1268 (91.0%)	2.61 (0.11) <sup>a</sup>	3.42 (0.04) <sup>a</sup>	5.42 (0.13) <sup>a</sup>	
<b>Diseased lip (Label 4)</b>	Smoking can cause people's teeth to get cavities	62 (4.5%)	<b>3.47 (0.25), p&lt;0.001 d=0.45</b>	<b>3.11 (0.08), p&lt;0.001 d=-0.51</b>	5.11 (0.3), p=0.297 d=-0.14	
	Smoking can cause burns on people's lips	63 (4.5%)	3.15 (0.27), p=0.049 d=0.25	<b>3.10 (0.09), p&lt;0.001 d=-0.47</b>	5.1 (0.31), p=0.300 d=-0.13	
<b>Oxygen mask on man's face (Label 5)</b>	Cigarette smoking can cause sudden health problems *	1019 (72.6%)	2.76 (0.14) <sup>a</sup>	3.3 (0.04) <sup>a</sup>	5.45 (0.12) <sup>a</sup>	
	People who smoke cigarettes may need a mask to breathe	257 (18.3%)	2.76 (0.14), p=0.017 d=0.17	3.30 (0.05), p=0.970 d<-0.01	5.16 (0.17), p=0.057 d=-0.13	

Labels	What do you think is the main point the label is trying to show? Response options:	N (%)	Outcomes Adj. Mean (SE), p-value and Cohen's d		
			Counterarguing	Perceived effectiveness	Harmfulness of smoking to others
	Cigarette smoking is most harmful when people are older	128 (9.1%)	<b>3.17 (0.18), p&lt;0.001 d=0.38</b>	<b>3.01 (0.06)<sup>a</sup>, p&lt;0.001 d=-0.43</b>	<b>4.96 (0.21)<sup>a</sup>, p=0.016 d=0.23</b>
	Cigarette smoking while pregnant can cause health problems for babies *	1202 (85.1%)	2.45 (0.10) <sup>a</sup>	3.33 (0.04) <sup>a</sup>	5.31 (0.13) <sup>a</sup>
<b>Baby in an incubator (Label 6)</b>	It is important to keep babies protected from cigarette smoke	124 (8.8%)	2.78 (0.18), p=0.063 d=0.18	3.19 (0.06), p=0.028 d=-0.21	5.09 (0.24), p=0.310 d=-0.10
	Cigarette smoking while pregnant makes babies cry more	87 (6.2%)	<b>3.09 (0.22), p=0.003 d=0.33</b>	3.24 (0.08), p=0.249 d=-0.13	<b>4.63 (0.28), p=0.012 d=-0.28</b>
	People who quit smoking will have less chance of getting a disease *	1205 (86.2%)	2.42 (0.09)	3.20 (0.03) <sup>a</sup>	4.17 (0.13) <sup>a</sup>
<b>Man with I quit t-shirt (Label 7)</b>	Even tough men can quit smoking	150 (10.7%)	<b>3.03 (0.16), p&lt;0.001 d=0.33</b>	<b>2.94 (0.06), p&lt;0.001 d=-0.39</b>	3.80 (0.24), p=0.111 d=-0.14
	People who quit smoking will get a free t-shirt	43 (3.1%)	<b>3.32 (0.31), p=0.004 d=0.45</b>	2.99 (0.11), p=0.070 d=-0.28	3.26 (0.42), p=0.035 d=-0.33
	Smoking can cause death from lung disease *	940 (69.5%)	2.26 (0.12) <sup>a</sup>	3.36 (0.04)	5.89 (0.15) <sup>a</sup>
<b>Healthy/Diseased lung (Label 8)</b>	Smoking can cause the organs in people's bodies to turn black	311 (23.0%)	<b>2.93 (0.15)<sup>a</sup>, p&lt;0.001 d=0.34</b>	<b>3.24 (0.05)<sup>a</sup>, p=0.006 d=-0.18</b>	<b>5.31 (0.17), p&lt;0.001 d=-0.26</b>
	Smoking will not harm someone until their lungs look dirty	102 (7.5%)	<b>3.34 (0.22), p&lt;0.001 d=0.55</b>	3.35 (0.07), p=0.893 d=-0.01	<b>4.97 (0.26), p&lt;0.001 d=-0.41</b>
	People can die from smoking cigarettes *	1043 (77.7%)	2.50 (0.10)	3.26 (0.03) <sup>a</sup>	5.42 (0.11) <sup>a</sup>
<b>Man with chest staples (Label 9)</b>	People may need surgery if they smoke cigarettes	194 (14.5%)	<b>2.98 (0.17)<sup>a</sup>, p=0.003 d=0.23</b>	3.27 (0.06), p=0.902 d=-0.11	<b>4.99 (0.19), p=0.014 d=-0.19</b>
	People who have had surgery should not smoke cigarettes	105 (7.8%)	<b>3.67 (0.21), p&lt;0.001 d=0.60</b>	3.19 (0.07), p=0.290 d=-0.01	<b>4.66 (0.24), p=0.001 d=-0.33</b>

\* indicates "preferred" interpretation of label

<sup>a</sup> indicates a significant difference between non-smokers and smokers; see Table 3 for significant interactions

Note. Response order was varied in the survey to disguise the preferred response. All models include covariates: age, sex, race, low income, education, novelty of label, smoking status, and an interaction term of smoking status and label interpretation.

Note: Raw p-values are shown above. After controlling for the false discovery rate, it was found that p-values >0.016 were >0.05 after adjustment. Thus, 4/33 rejected null hypotheses would not be rejected after adjustment. The values that remained statistically significant after the adjustment are bolded.



**Table 3**  
Significant differences in reactions to warning labels by label interpretation and smoking status (interaction effects)

Labels	What do you think is the main point the label is trying to show? Response options:	Subgroup	Counterarguing			Perceived effectiveness			Harmfulness of smoking to others		
			Adjusted mean (SE)	p-value Cohen's d	Adjusted mean (SE)	p-value Cohen's d	Adjusted mean (SE)	p-value Cohen's d			
<i>Man smoking with tracheotomy</i>	It is so hard to stop smoking that some people keep smoking through a hole in their throat *	Smokers			3.22 (0.05)	p=0.021	4.89 (0.17)	p<.0001			
		Non-smokers			3.34 (0.05)	d=-0.17	5.60 (0.16)	d=-0.32			
	Cigarette smoking is more harmful to African American men than to other groups	Smokers			2.70 (0.15)	p=0.029					
		Non-smokers			3.15 (0.14)	d=-0.69					
<i>Baby exposed to smoke</i>	Being around smoke from cigarettes can be bad for children *	Smokers			3.38 (0.04)	p=0.003					
		Non-smokers			3.50 (0.04)	d=-0.17					
	Allowing children to smoke cigarettes is harmful to them	Smokers	3.34 (0.31)	p=0.001							
		Non-smokers	3.70 (0.26)	d=-0.20							
<i>Woman crying</i>	Cigarette smoke can kill loved ones who don't smoke *	Smokers	2.65 (0.12)	p=0.005	3.20 (0.04)	p=0.011					
		Non-smokers	2.29 (0.10)	d=0.18	3.32 (0.04)	d=-0.17					
	Cigarette smoking can cause serious depression in some people	Smokers	3.52 (0.24)	p=0.015							
		Non-smokers	2.79 (0.20)	d=0.38							
<i>Diseased lip</i>	Smoking can cause serious mouth disease *	Smokers	2.85 (0.13)	p<.001	3.36 (0.04)	p=0.002	5.19 (0.15)	p=0.001			
		Non-smokers	2.37 (0.12)	d=0.23	3.48 (0.04)	d=-0.18	5.65 (0.15)	d=-0.19			
<i>Oxygen mask on man's face</i>	Cigarette smoking can cause sudden health problems *	Smokers	2.56 (0.13)	p=0.045	3.25 (0.05)	p=0.020	5.26 (0.15)	p=0.011			
		Non-smokers	2.30 (0.11)	d=0.14	3.35 (0.04)	d=-0.16	5.64 (0.13)	d=-0.17			
	Cigarette smoking is most harmful when people are older	Smokers			2.89 (0.08)	p=0.026	4.21 (0.26)	p=0.011			
		Non-smokers			3.14 (0.09)	d=-0.16	5.71 (0.30)	d=-0.71			
<i>Baby in an incubator</i>	Cigarette smoking while pregnant can cause health problems for babies *	Smokers	2.62 (0.12)	p=0.006	3.27 (0.04)	p=0.004	5.16 (0.16)	p=0.034			
		Non-smokers	2.29 (0.11)	d=0.17	3.39 (0.04)	d=-0.18	5.47 (0.15)	d=-0.13			
<i>Man with I quit t-shirt</i>	People who quit smoking will have less chance of getting a disease *	Smokers			3.12 (0.04)	p<0.001	3.93 (0.16)	p=0.006			
		Non-smokers			3.28 (0.04)	d=-0.22	4.40 (0.15)	d=-0.17			
<i>Healthy/Diseased lung</i>	Smoking can cause death from lung disease	Smokers	2.40 (0.15)	p=0.030			5.66 (0.17)	p=0.002			

Labels	What do you think is the main point the label is trying to show? Response options:	Subgroup	Counterarguing			Perceived effectiveness			Harmfulness of smoking to others	
			Adjusted mean (SE)	p-value Cohen's d	Adjusted mean (SE)	p-value Cohen's d	Adjusted mean (SE)	p-value Cohen's d		
		Non-smokers	2.11 (0.13)	d=0.15			6.13 (0.16)		d=-0.22	
	Smoking can cause the organs in people's bodies to turn black	Smokers	3.16 (0.2)	p=0.039	3.11 (0.07)	p=0.001				
		Non-smokers	2.70 (0.18)	d=0.25	3.37 (0.06)	d=-0.41				
		Smokers			3.18 (0.04)	p=0.001	5.24 (0.14)	p=0.011		
	People can die from smoking cigarettes *	Non-smokers			3.34 (0.04)	d=-0.23	5.61 (0.13)	d=-0.17		
		Smokers	3.30 (0.23)	p=0.035						
	People may need surgery if they smoke cigarettes	Non-smokers	2.67 (0.21)	d=0.32						

*Man with chest staples*

\*,"preferred" interpretation

Note. All models include covariates: age, sex, race, low income, education, novelty of label, current smoking status and an interaction term of current smoking status and interpretation. Only significant differences shown.

**Table 4**

Association between reactions to graphic warning labels and motivation to quit among smokers

Labels	Reaction	Outcomes Adj. OR (95% CI)	
		Label made me think about quitting smoking (yes vs. no)	Action steps (likely vs. not likely)
Man smoking with tracheotomy (Label 1)	Preferred interpretation of label (yes vs. no)	<b>2.51 (1.29–4.91), p=0.007</b>	1.15 (0.62–2.12), p=0.654
	Counterarguing	1.01 (0.83–1.24), p=0.904	1.13 (0.97–1.31), p=0.118
	Perceived effectiveness	<b>2.63 (1.50–4.61), p&lt;0.001</b>	2.19 (1.05–4.59), p=0.372
	Perceived harm to self of smoking	1.36 (1.07–1.72), p=0.012	0.83 (0.6–1.16), p=0.277
	Perceived harm to others of smoking	1.14 (0.90–1.44), p=0.274	1.31 (0.95–1.82), p=0.103
	Self-efficacy for quitting smoking	1.11 (0.95–1.29), p=0.198	<b>1.32 (1.11–1.56), p=0.002</b>
Baby exposed to smoke (Label 2)	Preferred interpretation of label (yes vs. no)	0.39 (0.11–1.40), p=0.149	1.49 (0.44–5.01), p=0.520
	Counterarguing	1.16 (0.94–1.42), p=0.163	1.16 (1.01–1.34), p=0.039
	Perceived effectiveness	<b>4.47 (2.50–8.00), p&lt;0.001</b>	0.84 (0.45–1.57), p=0.581
	Perceived harm to self of smoking	1.08 (0.90–1.30), p=0.399	1.08 (0.88–1.33), p=0.451
	Perceived harm to others of smoking	<b>1.49 (1.22–1.82), p&lt;0.001</b>	1.42 (1.06–1.91), p=0.018
	Self-efficacy for quitting smoking	<b>1.23 (1.05–1.44), p=0.010</b>	<b>1.29 (1.08–1.52), p=0.004</b>
Woman crying (Label 3)	Preferred interpretation of label (yes vs. no)	0.76 (0.37–1.55), p=0.454	0.63 (0.31–1.26), p=0.192
	Counterarguing	1.15 (0.97–1.37), p=0.114	1.14 (0.98–1.32), p=0.085
	Perceived effectiveness	<b>6.16 (3.51–10.83), p&lt;.001</b>	1.35 (0.76–2.38), p=0.300
	Perceived harm to self of smoking	1.1 (0.90–1.35), p=0.361	1.04 (0.81–1.34), p=0.747
	Perceived harm to others of smoking	<b>1.39 (1.12–1.73), p=0.003</b>	1.08 (0.8–1.45), p=0.609
	Self-efficacy for quitting smoking	1.13 (0.97–1.31), p=0.107	<b>1.37 (1.15–1.63), p&lt;0.001</b>
Diseased lip (Label 4)	Preferred interpretation of label (yes vs. no)	0.52 (0.17–1.61), p=0.258	1.01 (0.35–2.93), p=0.981
	Counterarguing	1.07 (0.88–1.31), p=0.499	1.16 (1.01–1.34), p=0.034
	Perceived effectiveness	<b>3.08 (1.79–5.32), p&lt;.001</b>	1.17 (0.62–2.21), p=0.626
	Perceived harm to self of smoking	<b>1.47 (1.19–1.83), p=0.001</b>	0.92 (0.67–1.24), p=0.571
	Perceived harm to others of smoking	1.17 (0.96–1.42), p=0.115	1.25 (0.96–1.62), p=0.093
	Self-efficacy for quitting smoking	1.17 (1.00–1.38), p=0.052	<b>1.34 (1.13–1.60), p=0.001</b>
Oxygen mask on man's face (Label 5)	Preferred interpretation of label (yes vs. no)	0.75 (0.41–1.37), p=0.355	0.94 (0.49–1.80), p=0.841
	Counterarguing	1.02 (0.85–1.21), p=0.847	<b>1.27 (1.10–1.48), p=0.002</b>
	Perceived effectiveness	<b>2.67 (1.67–4.26), p&lt;0.001</b>	1.14 (0.65–2.01), p=0.651
	Perceived harm to self of smoking	1.28 (1.02–1.6), p=0.036	1.14 (0.82–1.57), p=0.439
	Perceived harm to others of smoking	1.24 (0.99–1.55), p=0.066	1.05 (0.76–1.44), p=0.785

Labels	Reaction	Outcomes Adj. OR (95% CI)	
		Label made me think about quitting smoking (yes vs. no)	Action steps (likely vs. not likely)
	Self-efficacy for quitting smoking	1.03 (0.89–1.19), p=0.736	<b>1.34 (1.13–1.59), p&lt;0.001</b>
<b>Baby in an incubator (Label 6)</b>	Preferred interpretation of label (yes vs. no)	0.80 (0.38–1.66), p=0.545	0.82 (0.40–1.68), p=0.589
	Counterarguing	1.05 (0.88–1.24), p=0.618	1.18 (1.01–1.37), p=0.032
	Perceived effectiveness	<b>1.97 (1.19–3.24), p=0.008</b>	1.20 (0.61–2.35), p=0.604
	Perceived harm to self of smoking	<b>1.47 (1.24–1.73), p&lt;0.001</b>	1.21 (0.97–1.52), p=0.092
	Perceived harm to others of smoking	1.11 (0.92–1.34), p=0.265	1.04 (0.79–1.38), p=0.776
	Self-efficacy for quitting smoking	1.17 (1.02–1.34), p=0.028	<b>1.32 (1.11–1.56), p=0.001</b>
<b>Man with I quit t-shirt (Label 7)</b>	Preferred interpretation of label (yes vs. no)	0.73 (0.36–1.49), p=0.392	1.30 (0.58–2.95), p=0.525
	Counterarguing	1.07 (0.91–1.26), p=0.426	<b>1.24 (1.07–1.44), p=0.005</b>
	Perceived effectiveness	<b>4.57 (3.02–6.92), p&lt;0.001</b>	1.31 (0.83–2.06), p=0.247
	Perceived harm to self of smoking	1.02 (0.84–1.23), p=0.861	1.23 (0.97–1.56), p=0.083
	Perceived harm to others of smoking	1.15 (0.94–1.40), p=0.181	0.99 (0.78–1.26), p=0.950
	Self-efficacy for quitting smoking	<b>1.20 (1.05–1.38), p=0.008</b>	<b>1.27 (1.07–1.50), p=0.006</b>
<b>Healthy/Diseased lung (Label 8)</b>	Preferred interpretation of label (yes vs. no)	1.19 (0.59–2.42), p=0.624	0.65 (0.34–1.22), p=0.177
	Counterarguing	1.04 (0.85–1.27), p=0.716	1.14 (0.98–1.32), p=0.083
	Perceived effectiveness	<b>2.64 (1.53–4.55), p&lt;0.001</b>	1.07 (0.62–1.86), p=0.813
	Perceived harm to self of smoking	1.08 (0.82–1.43), p=0.585	0.58 (0.32–1.04), p=0.066
	Perceived harm to others of smoking	<b>1.47 (1.13–1.92), p=0.004</b>	2.13 (1.16–3.91), p=0.015
	Self-efficacy for quitting smoking	0.97 (0.82–1.14), p=0.676	<b>1.35 (1.14–1.59), p&lt;0.001</b>
<b>Man with chest staples (Label 9)</b>	Preferred interpretation of label (yes vs. no)	0.73 (0.35–1.53), p=0.404	0.96 (0.47–1.96), p=0.915
	Counterarguing	0.89 (0.75–1.06), p=0.210	<b>1.23 (1.05–1.43), p=0.009</b>
	Perceived effectiveness	<b>2.37 (1.48–3.81), p&lt;0.001</b>	1.33 (0.74–2.39), p=0.334
	Perceived harm to self of smoking	1.24 (0.97–1.59), p=0.082	1.05 (0.71–1.54), p=0.825
	Perceived harm to others of smoking	1.20 (0.95–1.53), p=0.127	1.11 (0.77–1.60), p=0.574
	Self-efficacy for quitting smoking	<b>1.27 (1.10–1.47), p&lt;0.001</b>	<b>1.33 (1.12–1.58), p=0.001</b>

Note: All models included age, sex, race, low income, education and novelty of label.

Note: Raw p-values are shown above. After controlling for the false discovery rate, it was found that p-values >0.010 were >0.05 after adjustment. Thus, 7/38 rejected null hypotheses would not be rejected after adjustment. The values that remained statistically significant after the adjustment are bolded.