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REGULAR ARTICLE

Experimental Test of the Educational Impact of the Newly Proposed FDA Graphic Cigarette Warnings Among U.S. Adults

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Abstract

Background In August 2019, the U.S. Food and Drug Administration proposed a set of 13 new graphic warnings for cigarette packaging and advertisements.

Purpose We evaluated these warnings relative to text-only equivalents for their ability to educate the public regarding harms of smoking and influence outcomes associated with quitting.

Methods: In an experimental within-subjects design, U.S. adult nonsmokers, smokers, and dual smoker/electronic cigarette (e-cigarette) users ($N = 412$) recruited from an online internet platform evaluated the newly proposed graphic warnings and corresponding text-only warnings on understandability, perceived new knowledge, worry elicited about the content of the warning, discouragement from smoking, and encouragement to use e-cigarettes.

Results Graphic warnings were generally rated as providing better understanding, more new knowledge, eliciting more worry about harms of smoking, and providing more discouragement from smoking relative to text-only warnings.

Conclusions The newly proposed graphic warnings could influence important responses to warnings associated with motivation to reduce smoking.

Keywords Graphic warning labels · Cigarette packaging · E-cigarettes · Tobacco regulation

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Introduction

Despite reductions in prevalence, smoking continues to be a leading preventable cause of death worldwide [1, 2]. Thus, tobacco control efforts should continue to discourage smoking among nonsmokers and, among smokers, encourage quitting or completely switching to a potentially less harmful product (e.g., electronic cigarettes). One approach to tobacco regulation is communicating the harms of tobacco products via warnings on packaging and advertisements. Since 2003, the World Health Organization's Framework Convention on Tobacco Control encourages the use of large, graphic warnings on tobacco products [3]. Since then, at least 118 countries worldwide require some form of graphic warnings on their tobacco products [4]. In 2009, the U.S. Family Smoking Prevention and Tobacco Control Act (FSPTCA) gave the U.S. Food and Drug Administration (FDA) purview over tobacco regulatory policies and mandated that graphic warnings be included on all cigarette packaging and advertisements. However, litigation prevented warnings originally proposed by the FDA in 2011 from being implemented [5]. The ruling was based in part on criticism of a paucity of evidence that graphic warnings educated the public about the harms of smoking and that knowledge about harms of smoking would subsequently reduce smoking rates.

In August 2019, the FDA released a new set of 13 proposed warnings for comment and, in March 2020, released a rule on a final set of 11 of those warnings [6]. The FDA relied on empirical support of smoking consequences to generate factual and accurate statements about lesser-known negative health consequences of smoking and, then, used an empirically based, iterative process to test the statements, images, and their pairings. Pursuant to the First Amendment of the U.S. constitution, FDA believes that these warnings advance the U.S. Government's interest to inform the public and correct misperceptions about the risks of smoking, promote

greater public understanding of negative harms of smoking, and are not overly burdensome [7] (for more information on First Amendment considerations regarding cigarette warnings, see Section VIII of the proposed rule [7]; Yang [8]). The final rule is already undergoing litigation (e.g., [9]); thus, it is important to identify the potential impact of these warnings in educating the public about the harms of smoking and influencing outcomes associated with quitting across different tobacco use groups.

A growing body of evidence points to the ability of graphic warnings to enhance recall of message content [10, 11] and promote accurate cognitions and thinking about the harms of smoking [12–14]. Thus, graphic warnings can have a greater impact on smoking cognitions relative to text-only warnings conveying the same information. Furthermore, our prior work indicates that the warnings perceived as most informative about the harms of smoking subsequently influence outcomes associated with motivation to change [12]. In a test of a preliminary framework to explain the effects of enhancing new knowledge on subsequent motivational outcomes, we found that graphic warnings rated as eliciting greater perceptions of new knowledge predicted discouragement from smoking both directly and indirectly through greater worry about the harms of smoking. Thus, the new knowledge gained from these warnings could inform decisions about tobacco use and influence cigarette use. While graphic warnings may elicit multiple emotional responses, we focus on worry as it predicts health-protective behavior, including cigarette quit attempts [15], and is linked to greater motivation for behavior change [16].

The landscape of tobacco use is changing and it is important to determine how responses to cigarette warnings differ across tobacco use groups. Data from the 2018 U.S. National Health Interview Survey [17] estimate that 13.7% of U.S. adults are smokers (approximately 25% of whom are nondaily smokers) and 3.2% use electronic cigarettes (e-cigarettes). Global estimates indicate that smoking is on the decline, although there is substantial variability across regions [2]. Moreover, 18.8% of U.S. tobacco users in 2018 reported the use of two or more tobacco products, most commonly cigarettes and e-cigarettes, and e-cigarette use, in general, continues to gain in popularity [18–20]. E-cigarettes contain nicotine, a highly addictive substance, and use is associated with higher rates of smoking in longitudinal studies, especially, among youth and young adults [21, 22]. Given these changes, studies that focus exclusively on daily smokers may underestimate the influence of graphic warnings given that infrequent and nondaily smokers could be ideal targets for graphic warnings due in part to daily users' strong intent to smoke [23]. Designers of warnings may also need to consider how stronger cigarette warnings may affect perceptions and motivations to use e-cigarettes. The perspective of nonusers is also important as these warnings may serve as a prevention tool to discourage uptake.

The purpose of the current study was to evaluate the potential of the newly proposed graphic warnings to inform the public about the health harms of smoking and to influence outcomes associated with motivations to avoid smoking or switch to potentially less harmful products. To this end, we evaluated whether the graphic warnings elicited stronger responses (relative to equivalent text-only warnings) on understandability, perceived new knowledge, worry, discouragement from smoking, and encouragement to switch to e-cigarettes. We expected that graphic warnings would be rated as more understandable, providing more new knowledge, eliciting more worry, and inducing more discouragement to smoke relative to text-only warnings. We also evaluated whether responses to graphic warnings differed by tobacco user groups, including nonusers, smokers, and dual/e-cigarette users. We hypothesized that nonsmokers would have stronger reactions to graphic warnings compared to smokers and dual/e-cigarette users on worry and discouragement to smoke but did not expect differences by user group on understandability or perceived new knowledge in keeping with prior work showing that nonsmokers can have stronger cognitive and affective reactions to cigarette warnings than smokers but not reactions related to learning [12, 24]. This expected pattern is also supported by psychological reactance theory [25], which suggests that persuasive information can create a sense of threat to individual freedom, ultimately eliciting anger and negative cognitions. In other words, those who smoke may experience more defensive responses to the warnings [26]. However, reactance may not result in less attention to the warnings [27] and, thus, viewing graphic warnings should improve knowledge outcomes regardless of user status.

Method

Participants

In September 2019, individuals 18 and older and who resided in the USA were recruited through the online research platform Cloud Research (formally known as Turk Prime) [28] and received $2.50 for the completion of the survey. Individuals were first screened for smoking status to establish approximately equal numbers of nonsmokers and smokers. Although a convenience sample, findings from online experimental and observational studies conducted through Amazon Mechanical Turk (MTurk) demonstrate

generalizability [29]. Prior to analysis, we evaluated data for valid responses. Consistent with recommendations [30], we excluded respondents (n = 18) if they completed less than 30% of the survey questions, completed the survey very quickly (less than 5 min), and/or had invariability in responses. This resulted in a final sample of 412 adults.

Procedure

Participants first read an online consent form and provided informed consent by selecting "I agree" to participate. For each of the 13 proposed graphic warnings, we created an equivalent text-only version, which presented the warning statement in black text in Helvetica font on a white background, resulting in a total of 26 warnings. These colors were selected to match the black font and white backgrounds used in the 13 proposed warnings. As of this writing, the 13 proposed graphic warnings can be viewed at https://www.fda.gov/tobacco-products/labeling-and-warning-statements-tobacco-products/cigarette-health-warnings and the 11 FDA warnings for the final rule can be downloaded at https://www.fda.gov/media/136157/download. Participants evaluated each warning on understandability, perceived new knowledge, worry elicited, discouragement to smoke, and encouragement to switch to e-cigarettes. Warnings were presented to participants in a random order to account for order effects. The study protocol was deemed exempt by the Washington State University Internal Review Board.

Measures

Smoking behavior

Assessment of smoking behavior was formatted similar to our prior work testing evaluations of cigarette warnings [12, 24, 31] and was designed to capture variability in use (i.e., infrequent smokers). User status was identified with two items: "How often do you smoke now?" and "How often do you use e-cigarettes now?" Responses were never, I do not smoke (use e-cigarettes); less than once a month; at least once a month; and at least once a day. We categorized participants as *nonusers* if they reported never currently smoking/using e-cigarettes; as *smokers* if they reported smoking less than once a month or more but reported never currently using e-cigarettes; and as dual/e-cigarette users if they indicated smoking less than once a month or more and/or used e-cigarettes less than once a month or more. We used a broad definition of smoker to capture variability in use and to better reflect the characteristics of the U.S. adult smoking population (i.e., approximately 25% nondaily users) [17]. We also grouped dual users with e-cigarette users based on evidence that most e-cigarette users also smoke [32, 33] and that only a small proportion of individuals (4.1%) indicated e-cigarette use exclusively in this sample.

Warning evaluations

All measures were single items evaluated using a seven-point scale (*not at all* = 1; *very much/extremely* = 7). All measures show sensitivity in prior work [12, 24] with the exception of encouragement to use e-cigarettes, which has not been used in prior research. *Understandability* was assessed with "How much does this label give you better understanding of the consequences of smoking?" *Perceived new knowledge* was assessed with "How much did you learn something new from this label that you did not know before?" *Worry* was assessed with "How much does this label make you feel worried?" *Discouragement to smoke* was assessed with "How much does this warning discourage you from wanting to smoke cigarettes?" *Encouragement to use e-cigarettes* was assessed with "How much does this label encourage you to use e-cigarettes?"

Analysis

For each of the 13 warnings, we conducted paired-samples t-tests comparing the graphic warning to the text-only warnings for understandability, perceived new knowledge, worry, discouragement to smoke, and encouragement to use e-cigarettes combining across all user groups. To test for user group differences in responses to the graphic warnings, we calculated mean ratings of each dependent measure across all 13 graphic warnings and used an analysis of variance (ANOVA). Post hoc comparisons applying the Games–Howell post hoc procedure for nonparametric data were used to determine significant differences between user groups. We controlled for multiple comparisons using an alpha of $p \leq .001$. We described effect sizes of graphic to text-only warnings and effect sizes between user groups using Cohen's d.

Results

Participant Characteristics and Smoking Status

On average, the sample was 41.19 years of age (standard deviation = 12.64; range 19–74). The sample consisted of female (50.2%), male (49.3%), and nonbinary (0.5%) individuals. The vast majority (86.7%) had attended

vocational/tech school or at least some college. The sample consisted of individuals who identified as White/Caucasian (74.3%), Black/African American (7.8%), Hispanic/Latinx (7.5%), Asian American (6.3%), bi or mixed race (2.2%), American Indian/Alaskan Native (1.2%), Native Hawaiian/Pacific Islander (0.2%), and other or not identified (0.2%).

In terms of smoking status, individuals identified as nonusers and who also indicated smoking 100 cigarettes in their lifetime were considered former smokers (35.5% of nonusers). We compared never users to former smokers on 13 outcomes: age, ethnicity, gender, and the five evaluative outcomes averaged separately for graphic warnings and text-only warnings. Former smokers were older than never users ($t[150] = 5.36$, $p < .001$) and had a higher proportion of White/Caucasian ($\chi^2[1, n = 152] = 6.53$; $p = .01$). However, they did not significantly differ by gender ($p = .69$) or averaged evaluations for graphic or text-only warnings (all ps = .20–.98). Among individuals identified as never users, White/Caucasian versus other differed on only one evaluation score, averaged perceived new knowledge for text warnings ($t[150] = 2.27$, $p = .03$, $d = .38$, ps for all other evaluation scores = .07–.98). Given the few differences between never users and former smokers in this sample, we combined former smokers and never users under the category of "nonuser" rather than removing them from the analysis.

The final distribution was 40.3% nonusers, 22.3% smokers, and 36.9% dual/e-cigarette users (two participants did not respond to both questions to be categorized). Table 1 presents descriptive characteristics by the user group. User groups differed by age ($F[2,406] = 4.93$, $p = .008$) and proportion of White/Caucasian ($\chi^2[2, n = 410] = 14.04$; $p = .001$). Dual/e-cigarette users were younger than smokers ($p = .02$) and nonusers ($p = .02$) and smokers had a higher proportion of White/Caucasian compared to nonusers and dual/e-cigarette users (ps < .05). Controlling for age and proportion of White/Caucasian did not change the interpretation of the user group analyses; thus, we report the raw scores.

Overall Comparisons to Text-Only Warnings

For descriptive purposes, we created short titles for each warning (see Table 2 for warning text and descriptive title). We compared the overall mean for the 13 graphic warnings to the overall mean for the 13 text-only warnings on the five outcomes of interest. Graphic warnings overall were rated as more understandable ($d = .31$), increasing new knowledge ($d = .25$), eliciting more worry ($d = .22$), and eliciting more discouragement to smoke ($d = .23$). Warning type did not vary for encouragement to use e-cigarettes ($d = .02$). Table 3 presents the graphic versus text-only ratings for each outcome for all 13 warnings.

Understandability

The proposed graphic warnings were generally rated highly on understandability (ranging from 4.95 to 5.41). All 13 of the proposed graphic warnings provided significantly better understanding relative to the text-only version. The strongest effect was found for *Neck Growth* ($d = .41$) and the weakest effect for *Man on Bed* ($d = .15$).

Perceived New Knowledge

Overall, the proposed graphic warnings were rated as providing a modest to moderate amount of new information (ranging from 2.82 to 5.03). Eight of the graphic warnings were rated as providing significantly more new knowledge than the text-only equivalent (Table 3). Of the significant comparisons, the strongest effect was found for *Boy with Oxygen Mask* ($d = .29$) and the weakest effect for *Baby on Scale* ($d = .11$). Although not universally statistically significant, a consistent pattern was that all warnings were rated higher on perceived new knowledge than their text-only equivalents.

Worry

The proposed graphic warnings elicited a moderate amount of worry (ranging from 3.65 to 5.02). The only

Table 1. Characteristics by user group

	Nonuser ($n = 152$)	Smoker ($n = 92$)	Dual/e-cigarette user ($n = 166$)
Age (mean, *SD*)	42.72 (13.70)	42.97 (12.63)	38.86 (11.24)
Gender (% female)	55.3	50.0	46.4
Ethnicity (% White/Caucasian)	66.4	88.0	74.1
Vocational/tech school or at least some college (% yes)	91.4	83.7	84.9

Two individuals did not respond to both questions used to identify user status and could not be categorized into a user group.
SD standard deviation.

Table 2. Graphic warning description and shortened titles

Label statement	Graphic image/shortened title	FDA shortened title for final 11 warnings
Tobacco smoke can harm your children[a]	Boy with oxygen mask	Asthma
Smoking during pregnancy stunts fetal growth[a]	Baby on scale	Fetal growth
Smoking causes age-related macular degeneration, which can lead to blindness	Needle in eye	–
Smoking causes bladder cancer, which can lead to bloody urine[a]	Urine sample	Bladder cancer
Smoking reduces blood flow to the limbs, which can require amputation[a]	Amputated toes	Peripheral vascular disease
Smoking causes cataracts, which can lead to blindness[a]	Cataract	Cataracts
Smoking causes COPD, a lung disease that can be fatal	Hands holding lungs	–
Smoking causes COPD, a lung disease that can be fatal[a]	Man with oxygen tank	COPD
Smoking can cause heart disease and strokes by clogging arteries[a]	Chest scar	Heart disease
Smoking causes head and neck cancer[a]	Neck growth	Neck growth
Smoking causes Type 2 diabetes, which raises blood sugar[a]	Insulin test	Diabetes
Tobacco smoke causes fatal lung disease in nonsmokers[a]	Hands holding lungs-2	Lung disease
Smoking reduces blood flow, which can cause erectile dysfunction[a]	Man on bed	Erectile dysfunction

Warnings can be viewed on the Food and Drug Administration (FDA) website: https://www.fda.gov/tobacco-products/labeling-and-warning-statements-tobacco-products/cigarette-health-warnings and a downloadable PDF with the final warnings is available at https://www.fda.gov/media/136157/download.

[a]Warnings selected in the FDA's final rule.

graphic warning that was not rated as 4 or higher was *Man on Bed* (M = 3.65). Twelve of the graphic warnings were rated as eliciting significantly more worry than their text-only equivalent (Table 3). The exception was the image of an insulin test (p = .052, d = .07). Of the significant comparisons, the strongest effect was found for *Boy with Oxygen Mask* (d = .36) and the weakest effect for *Man on Bed* (d = .11).

Discouragement to Smoke

The graphic warnings were generally rated as being highly discouraging of smoking (ranging from 4.36 to 5.62). Three graphic warnings were rated below 5: *Man on Bed* (M = 4.36), *Baby on Scale* (M = 4.87), and *Insulin Test* (M = 4.99). Twelve of the proposed graphic warnings were rated as eliciting significantly more discouragement than the text-only equivalent (Table 3). The exception was the image of a man sitting on a bed (p = .012; d = .07). Of the significant comparisons, the strongest effect was found for *Hands Holding Lungs* (d = .33) and the weakest effect for *Baby on Scale* (d = .13).

Encouragement to Use E-Cigarettes

Overall, the proposed graphic warnings were rated as being generally low for encouraging e-cigarette use with little noticeable mean differences across each warning. All means ranged from 1.92 to 2.11. Furthermore, none of the proposed graphic warnings significantly enhanced encouragement to use relative to the text-only versions (ds = .00–.06).

User Group Differences on Evaluations of Graphic Warnings

A pattern emerged such that smokers (relative to nonusers and dual/e-cigarette users) gave the lowest ratings on better understanding, perceived new knowledge, worry, and discouragement to smoke. Differences in perceived new knowledge and worry as a function of user status did not reach the criterion of statistical significance of $p \leq .001$, with p-values for ANOVAs ranging up to p = .03. Smokers rated the graphic warnings as significantly less understandable relative to nonusers (d = .53) and dual/e-cigarette users (d = .49). Nonusers rated the graphic warnings as eliciting significantly more discouragement to smoke relative to smokers (d = 1.01) and dual/e-cigarette users (d = .68). Finally, dual/e-cigarette users rated graphic warnings as eliciting more encouragement to use e-cigarettes relative to nonusers (d = .89) and smokers (d = .99). Figure 1 shows the mean user group differences averaged across graphic and text-only warnings.

We also conducted an exploratory analysis of user group differences on each primary outcome measure for

Table 3. Means (standard deviations) and effect sizes for mean comparisons for warning evaluations

Label	Better personal understanding			Perceived new knowledge			Worry			Discouragement			Encouragement to use e-cigarettes		
	G	*T*	*d*	*G*	*T*	*d*	*G*	*T*	*d*	*G*	*T*	*d*	*G*	*T*	*d*
Boy with oxygen mask	**5.17 (1.93)**	**4.44 (1.95)**	.37	**2.82 (2.08)**	**2.27 (1.75)**	.29	**4.92 (2.14)**	**4.16 (2.12)**	.36	**5.42 (2.02)**	**4.79 (2.16)**	.30	2.05 (1.78)	2.00 (1.72)	.03
Baby on scale	**5.10 (1.82)**	**4.77 (1.86)**	.18	3.11 (2.10)	2.88 (2.00)	.11	**4.34 (2.23)**	**3.98 (2.22)**	.16	**4.87 (2.24)**	**4.57 (2.29)**	.13	1.96 (1.76)	1.98 (1.74)	.01
Needle in eye	**5.22 (1.60)**	**4.89 (1.64)**	.20	**5.03 (1.85)**	**4.69 (1.84)**	.18	**4.76 (1.93)**	**4.31 (1.92)**	.23	**5.24 (1.91)**	**4.80 (1.99)**	.23	2.06 (1.76)	2.00 (1.71)	.03
Urine sample	**5.11 (1.65)**	**4.83 (1.71)**	.17	**4.95 (1.83)**	**4.68 (1.91)**	.14	**4.58 (2.00)**	**4.22 (1.97)**	.18	**5.15 (1.96)**	**4.86 (2.00)**	.15	2.05 (1.76)	1.98 (1.66)	.04
Amputated toes	**5.41 (1.74)**	**4.78 (1.77)**	.36	**4.76 (1.98)**	**4.35 (1.98)**	.21	**4.99 (2.06)**	**4.38 (2.04)**	.30	**5.60 (1.89)**	**4.96 (2.08)**	.32	2.11 (1.87)	2.01 (1.71)	.06
Cataract	**5.17 (1.64)**	**4.81 (1.72)**	.21	**4.85 (1.81)**	**4.50 (1.94)**	.19	**4.46 (1.94)**	**4.13 (1.97)**	.17	**5.01 (1.95)**	**4.69 (1.99)**	.16	2.03 (1.73)	2.03 (1.68)	.00
Hands holding lungs	**5.39 (1.74)**	**4.80 (1.82)**	.33	**3.15 (2.12)**	**2.82 (2.01)**	.16	**5.02 (1.97)**	**4.40 (1.99)**	.31	**5.62 (1.75)**	**5.02 (1.94)**	.33	2.03 (1.80)	2.04 (1.73)	.00
Man with oxygen tank	**5.18 (1.76)**	**4.86 (1.81)**	.18	**3.08 (2.04)**	**2.83 (1.99)**	.12	**4.84 (1.88)**	**4.49 (1.96)**	.18	**5.44 (1.81)**	**5.00 (1.97)**	.23	2.04 (1.76)	1.99 (1.70)	.03
Chest scar	**5.25 (1.72)**	**4.88 (1.76)**	.21	3.32 (2.08)	3.11 (1.96)	.10	**4.95 (1.93)**	**4.51 (1.99)**	.22	**5.55 (1.79)**	**5.04 (1.96)**	.27	2.04 (1.77)	2.01 (1.68)	.02
Neck growth	**5.41 (1.63)**	**4.71 (1.75)**	.41	**4.51 (2.04)**	**4.11 (1.99)**	.20	**4.85 (2.02)**	**4.26 (2.09)**	.29	**5.43 (1.88)**	**4.80 (2.05)**	.32	2.09 (1.84)	2.03 (1.72)	.03
Insulin test	**4.95 (1.69)**	**4.67 (1.74)**	.16	4.66 (1.94)	4.49 (1.90)	.09	4.30 (1.99)	4.16 (2.02)	.07	**4.99 (1.93)**	**4.62 (2.11)**	.18	2.01 (1.70)	2.00 (1.65)	.01
Hands holding lungs-2	**5.25 (1.82)**	**4.65 (1.84)**	.33	3.34 (2.15)	3.14 (2.08)	.09	**5.00 (1.97)**	**4.42 (2.04)**	.29	**5.40 (2.00)**	**4.81 (2.13)**	.29	2.07 (1.79)	2.01 (1.71)	.03
Man on bed	**5.04 (1.65)**	**4.78 (1.74)**	.15	4.56 (2.02)	4.45 (2.10)	.05	**3.65 (2.12)**	**3.41 (2.09)**	.11	4.36 (2.13)	4.20 (2.27)	.07	1.92 (1.65)	1.92 (1.63)	.00
Overall	**5.21 (1.42)**	**4.76 (1.46)**	.31	**4.00 (1.44)**	**3.65 (1.35)**	.25	**4.65 (1.71)**	**4.27 (1.73)**	.22	**5.24 (1.65)**	**4.84 (1.77)**	.23	2.02 (1.62)	2.00 (1.53)	.01

"*G*" refers to graphic warnings and "*T*" to text-only warnings. *d* is Cohen's *d* effect size for mean comparisons between graphic and text-only warnings: $d = .2$ is a small effect, $d = .5$ is a medium effect, and $d = .8$ is a large effect. Significant differences ($p \leq .001$) between graphic and text-only warnings are bolded.

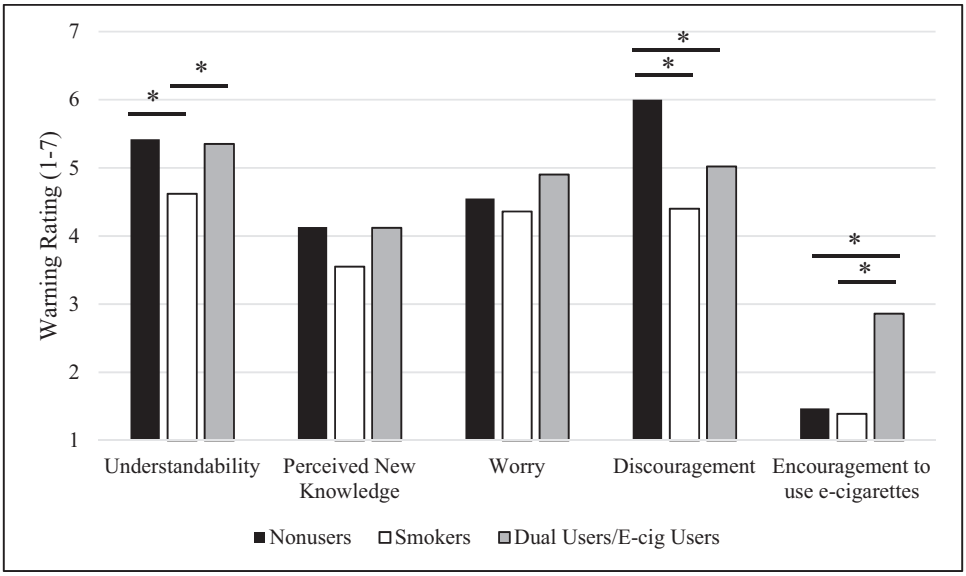

Fig. 1. Mean graphic warning ratings by user group. Asterisks denote significant group mean differences at $p \leq .001$.

each of the 13 graphic warnings. Largely consistent with the averaged outcomes, smokers reported significantly less understanding than nonusers for five warnings: *Oxygen Tank*, *Neck Growth*, *Insulin Test*, *Hands Holding Lungs–2*, and *Man on Bed*. See Supplementary Table 1 for detailed statistics on this outcome. No other user group differences were observed for understandability on any of the other warnings. Also, consistent with the averaged ratings, nonusers reported more discouragement from smoking than smokers and dual/e-cigarette users in response to all 13 graphic warnings. Dual/e-cigarette users reported more encouragement to switch to e-cigarettes than nonsmokers and smokers in response to all 13 graphic warnings. Finally, no differences were observed for perceived new knowledge or worry by user group across all 13 graphic warnings.

Discussion

The findings provide strong support that the 13 proposed graphic warnings effectively enhance understandability, perceptions of new knowledge about the harms of smoking, as well as worry about harms of smoking, and discouragement from smoking relative to their text-only equivalents. Thus, these findings support the implementation of these warnings in the USA. However, consideration should be given to the user group differences in response to the graphic warnings. Effects were stronger for nonusers compared to both smokers and dual/e-cigarette users on understandability and discouragement to smoke. This is in line with psychological reactance theory [25] and prior work suggesting that graphic warnings are more likely to elicit reactance than text-only warnings [34] and that smokers are more likely to report positive cognitions of smoking after viewing graphic warnings than nonsmokers [35]. However, this suggestive pattern of reactance was not found for worry or perceived new knowledge. Additionally, reactance does not necessarily translate to less attention to the message [27], meaning that people may still learn from viewing the warnings even if they have negative reactions to doing so. Furthermore, dual/e-cigarette users were more encouraged to use e-cigarettes in response to the warnings compared to both nonusers and smokers. Importantly, no user group differences occurred for perceived new knowledge indicating that people learn from these warnings regardless of their tobacco use. The FSPTCA requires these warnings to be displayed on all cigarette packaging, advertising, and promotional materials; thus, nonsmokers are also likely to be exposed to and informed by them.

These findings extend prior work across multiple countries on cigarette graphic warnings indicating that they are understandable, enhance knowledge, and elicit key motivational dynamics associated with quitting [12, 13, 24, 34, 36–38]. Of note, collapsing across all warnings, the strongest effects were for enhancing understandability and perceived new knowledge indicating that these graphic warnings can effectively educate regarding the health harms of smoking. Previously, Cameron et al. [24] compared the FDA's 36 originally proposed graphic warnings to their text-only equivalents on fear-related outcomes (e.g., worry) and discouragement to smoke among young adults. For the final nine warnings selected by the FDA for implementation in 2012, Cameron et al. [24] found similar but slightly stronger effects of graphic to text-only comparisons than were found in the current study (Cohen's *d*s: worry: .24 vs. .22; discouragement: .38 vs. .23). Note that Cameron et al. found one warning

elicited *less* worry and discouragement than the text-only version. Without this warning, the overall effect size for worry was $d = .30$ and discouragement $d = .43$. Thus, the newly proposed warnings may be less effective than the originally selected warnings; however, there are notable differences between the two sets of warnings. The older warnings included some vivid images of diseased body parts, suffering people, and children—images that have been found to be impactful in prior work [24, 36, 39, 40]. The new warnings include images that demonstrated efficacy in inducing worry and discouragement to smoke in prior work [39]. Specifically, all images are of diseased body parts (e.g., neck growth), bodily fluids (e.g., urine test), suffering or dying people, and children. Yet, the images are done in a stylistic way (i.e., not a photographic image), which may reduce effectiveness [24]. Thus, the newly proposed warnings appear toned down in comparison to the warnings previously proposed. Nevertheless, this new set of warnings has the intended effects on educating the public about the harms of smoking, and even these smaller effects could have important impacts on smoking motivations upon repeated exposure.

Considering the top five graphic-to-text-only effects across ratings of understandability, perceived new knowledge, worry, and discouragement to smoke, three warnings consistently had the greatest impact relative to text-only ratings: *Boy in Oxygen Mask, Amputated Toes,* and *Neck Growth.* The weakest effect was found for *Man on Bed* across most ratings. However, this warning had high ratings for both the graphic and text-only versions on perceived new knowledge in particular. A warning about erectile dysfunction may be novel and, while there may not be an initial difference between graphic and text-only versions, we expect that this difference will emerge over time (i.e., as novelty wears off) [41]. Importantly, the new text content alone (without the graphic components) could show some benefit over the current Surgeon General's text-only warnings used in the USA since 1984, at least in the short term. The outcomes of the current study suggest that the inclusion of the graphic warnings could elicit important responses of new knowledge, worry about the harms of smoking, and discouragement from smoking over any potential effects of the text warnings alone. The findings, thus, provide important evidence that the new graphic warnings, which present factual and accurate information about lesser-known health harms of smoking, enhance understanding of these harms. This evidence may be used in a First Amendment analysis to support their implementation [7, 8].

These findings also add new information regarding how dual/e-cigarette users respond to graphic cigarette warnings. Given the popularity of e-cigarettes and growing concerns of associated health consequences [42, 43], it is important to understand how stronger cigarette warnings may influence the motivation to use e-cigarettes. These findings indicate that the effects of graphic warnings extend to nonusers, as well as smokers and dual/e-cigarette users on enhancing knowledge of the health harms of smoking. Nonusers and dual/e-cigarette users generally found the graphic warnings more understandable and discouraging compared to smokers, and dual/e-cigarette users perceived them as eliciting more encouragement to use e-cigarettes relative to smokers and nonusers. From one perspective, this could mean that graphic cigarette warnings will not encourage smokers to reduce the harms of smoking by switching to a relatively safer product. However, this could also mean that nonusers will not be encouraged to start using e-cigarettes based on information presented in these warnings. Notably, encouragement to use e-cigarettes was quite low in response to both graphic and text-only warnings even among dual/e-cigarette users. Thus, cigarette warnings could discourage other forms of tobacco use. As one example, Brewer et al. [41] found that e-cigarette warnings made smokers less interested in smoking cigarettes. Whether stronger cigarette warnings will encourage (or discourage) other forms of tobacco use remains a critical empirical question.

Several limitations should be considered. This was a cross-sectional study and outcomes included immediate responses to a single exposure to each warning; thus, we cannot determine the extent to which effects vary by repeated exposure or last over time. For example, recent work suggests that the content of cigarette warnings eliciting stronger emotional responses is more likely to be recalled over time [10]. Additionally, warnings were not presented on cigarette packages or advertisements as they are intended to be used. Warning evaluations were assessed using single-item scales, which could result in low construct validity and reliability. However, these had the benefit of reducing participant burden and have been used in similar studies evaluating tobacco warnings [12, 24, 31, 44]. Although we captured a wide age range and had an equal representation of gender, this sample was majority White/Caucasian and, because it was recruited from MTurk, limits the generalizability of the findings to other racial, ethnic, economic, education, and less computer-literate backgrounds [45]. However, recent work suggests that findings from experimental and observational studies are similar for online convenience and probability samples [29, 46], somewhat reducing these concerns. In terms of tobacco use, we oversampled smokers; thus, this sample had a disproportionately large number of smokers and dual users relative to the general U.S. adult population. Our measure of tobacco use also incorporated less frequent users. More and less frequent tobacco users could vary in important ways (e.g., addiction); however, this measure also enhances

generalizability to less frequent smokers who are becoming more prominent among U.S. smokers [47, 48]. Nonetheless, these data provide initial evidence that the proposed cigarette graphic warnings could have an important impact on educating the public about the harms of smoking.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards The authors declare that they have no conflict of interest related to this work. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Authors' Contributions R.E.M. and L.D.C. contributed to the study conceptualisation and design. R.E.M. managed the project and led the manuscript preparation. R.E.M., W.K.H., and B.S.F. conducted analyses. R.E.M., W.K.H., B.S.F., and L.D.C. all contributed to writing of the manuscript.

Ethical Approval The study protocol was deemed exempt by the Washington State University Internal Review Board.

Informed Consent Informed consent was obtained online before individuals were enrolled in this study.

References

1. World Health Oranization. *WHO Report on the Global Tobacco Epidemic, 2017: Monitoring Tobacco Use and Prevention Policies*. Geneva, Switzerland: World Health Organization; 2017.
2. World Health Organization. *WHO Global Report on Trends in Prevalence of Tobacco Use 2000–2025*. 3rd ed. Geneva, Switzerland: World Health Organization; 2019.
3. World Health Organization. *WHO Framework Convention on Tobacco Control*. Geneva, Switzerland: World Health Organization; 2003.
4. Canadian Cancer Society, *Cigarette Package Health Warnings: International Status Report*. 6th ed; Canadian Cancer Society; 2018.
5. R. J. Reynolds Tobacco Co. v. Food and Drug Administration, No. 11–5332. United States Court of Appeals for the District of Columbia; 2012.
6. U.S. Food and Drug Administration. Tobacco products: Required warnings for cigarette packages and advertisements. *Final rule. Fed Regist*. 2020;85:15638–15710.
7. U.S. Food and Drug Administration. Tobacco products; required warnings for cigarette packages and advertisements. Proposed rule. *Fed Regist*. 2019;84:42754–42798.
8. Yang YT. New graphic tobacco warnings and the first amendment. *JAMA Oncol*. 2020;6:473–474.
9. Larson E. Philip Morris sues FDA over plans for graphic warning labels. 2020 Available at https://www.bloomberg.com/news/articles/2020-05-06/philip-morris-sues-fda-over-plans-for-graphic-warning-labels. Accessibility verified June 24, 2020.
10. Peters E, Shoots-Reinhard B, Evans AT, et al. Pictorial warning labels and memory for cigarette health-risk information over time. *Ann Behav Med*. 2019;53:358–371.
11. Wang AL, Shi Z, Fairchild VP, Aronowitz CA, Langleben DD. Emotional salience of the image component facilitates recall of the text of cigarette warning labels. *Eur J Public Health*. 2019;29:153–158.
12. Magnan RE, Cameron LD. Do young adults perceive that cigarette graphic warnings provide new knowledge about the harms of smoking? *Ann Behav Med*. 2015;49:594–604.
13. Noar SM, Francis DB, Bridges C, Sontag JM, Ribisl KM, Brewer NT. The impact of strengthening cigarette pack warnings: Systematic review of longitudinal observational studies. *Soc Sci Med*. 2016;164:118–129.
14. Noar SM, Francis DB, Bridges C, Sontag JM, Brewer NT, Ribisl KM. Effects of strengthening cigarette pack warnings on attention and message processing: A systematic review. *Journal Mass Commun Q*. 2017;94:416–442.
15. Borland R, Yong HH, Balmford J, et al. Motivational factors predict quit attempts but not maintenance of smoking cessation: Findings from the International Tobacco Control Four country project. *Nicotine Tob Res*. 2010;12(suppl):S4–S11.
16. Magnan RE, Köblitz AR, Zielke DJ, McCaul KD. The effects of warning smokers on perceived risk, worry, and motivation to quit. *Ann Behav Med*. 2009;37:46–57.
17. Creamer MR, Wang RW, Babb S, et al. Tobacco product use and cessation indicators among adults—United States, 2018. *Morb Mortal Wkly Rep*. 2019;68:1013–1019.
18. King BA, Patel R, Nguyen KH, Dube SR. Trends in awareness and use of electronic cigarettes among US adults, 2010-2013. *Nicotine Tob Res*. 2015;17:219–227.
19. Cullen KA, Ambrose BK, Gentzke AS, Apelberg BJ, Jamal A, King BA. Notes from the field: Use of electronic cigarettes and any tobacco product among middle and high school students—United States, 2011–2018. *Morb Mortal Wkly Rep*. 2018;67:1276–1277.
20. Quickstats. Percentage of adults aged 18–24 years who currently smoke cigarettes or who currently use electronic cigarettes, by year—National Health Interview Survey, United States, 2014–2018. *Morb Mortal Wkly Rep*. 2019;68:870.
21. Barrington-Trimis JL, Urman R, Berhane K, et al. E-Cigarettes and future cigarette use. *Pediatrics*. 2016;138(1):e20160379.
22. Primack BA, Shensa A, Sidani JE, et al. Initiation of traditional cigarette smoking after electronic cigarette use among tobacco-naïve US young adults. *Am J Med*. 2018;131:443.e1–443.e9.
23. Blanton H, Snyder LB, Strauts E, Larson JG. Effect of graphic cigarette warnings on smoking intentions in young adults. *PLoS One*. 2014;9:e96315.
24. Cameron LD, Pepper JK, Brewer NT. Responses of young adults to graphic warning labels for cigarette packages. *Tob Control*. 2015;24:e14–e22.
25. Brehm JW. *A Theory of Psychological Reactance*. New York, NY: Academic Press; 1966.
26. Clayton RB, Keene JR, Leshner G, Lang A, Bailey RL. Smoking status matters: A direct comparison of smokers' and nonsmokers' psychophysiological and self-report responses to secondhand smoke anti-tobacco PSAs. *Health Commun*. 2020;35:925–934.
27. Cho YJ, Thrasher JF, Swayampakala K, et al. Does reactance against cigarette warning labels matter? Warning label responses and downstream smoking cessation amongst adult

smokers in Australia, Canada, Mexico and the United States. *PLoS One.* 2016;11:e0159245.
28. Litman L, Robinson J, Abberbock T. TurkPrime.com: A versatile crowdsourcing data acquisition platform for the behavioral sciences. *Behav Res Methods.* 2017;49:433–442.
29. Jeong M, Zhang D, Morgan JC, et al. Similarities and differences in tobacco control research findings from convenience and probability samples. *Ann Behav Med.* 2019;53:476–485.
30. Curran PG. Methods for the detection of carelessly invalid responses in survey data. *J Exp Soc Psychol.* 2016;66:4–19.
31. Magnan RE, Cameron LD. A cross-sectional investigation of positive and negative smoker stereotypes and evaluations of cigarette warnings. *Health Psychol.* 2017;36:486–492.
32. Strong DR, Pearson J, Ehlke S, et al. Indicators of dependence for different types of tobacco product users: Descriptive findings from Wave 1 (2013-2014) of the Population Assessment of Tobacco and Health (PATH) study. *Drug Alcohol Depend.* 2017;178:257–266.
33. Rodu B, Plurphanswat N. E-cigarette use among US adults : Population Assessment of Tobacco and Health (PATH) Study. *Nicotine Tob Res.* 2018;20:940–948.
34. Noar SM, Hall MG, Francis DB, Ribisl KM, Pepper JK, Brewer NT. Pictorial cigarette pack warnings: A meta-analysis of experimental studies. *Tob Control.* 2016;25:341–354.
35. Süssenbach P, Niemeier S, Glock S. Effects of and attention to graphic warning labels on cigarette packages. *Psychol Health.* 2013;28:1192–1206.
36. Hammond D, Thrasher J, Reid JL, Driezen P, Boudreau C, Santillán EA. Perceived effectiveness of pictorial health warnings among Mexican youth and adults: A population-level intervention with potential to reduce tobacco-related inequities. *Cancer Causes Control.* 2012;23(suppl 1):57–67.
37. Jung M. Implications of graphic cigarette warning labels on smoking behavior: An international perspective. *J Cancer Prev.* 2016;21:21–25.
38. Borland R, Yong HH, Wilson N, et al. How reactions to cigarette packet health warnings influence quitting: Findings from the ITC Four-Country survey. *Addiction.* 2009;104:669–675.
39. Cameron LD, Williams B. Which images and features in graphic cigarette warnings predict their perceived effectiveness? Findings from an online survey of residents in the UK. *Ann Behav Med.* 2015;49:639–649.
40. Sutton JA, Yang S, Cappella JN. Perceived effectiveness of objective features of pictorial warning messages. *Tob Control.* 2019;28:e24–e30.
41. Brewer NT, Jeong M, Hall MG, et al. Impact of e-cigarette health warnings on motivation to vape and smoke. *Tob Control.* 2019;28:e64–e70.
42. CDC. Outbreak of lung injury associated with e-cigarette use, or vaping. 2019. Available at https://www.cdc.gov/tobacco/basic_information/e-cigarettes/severe-lung-disease.html. Accessibility verified September 27, 2019.
43. Bhatta DN, Glantz SA. Association of e-cigarette use with respiratory disease among adults: A longitudinal analysis. *Am J Prev Med.* 2020;58:182–190.
44. Baig SA, Byron MJ, Boynton MH, Brewer NT, Ribisl KM. Communicating about cigarette smoke constituents: An experimental comparison of two messaging strategies. *J Behav Med.* 2017;40:352–359.
45. Paolacci G, Chandler J. Inside the turk: Understanding mechanical turk as a participant pool. *Curr Dir Psychol Sci.* 2014;23:184–188.
46. Kraemer JD, Strasser AA, Lindblom EN, Niaura RS, Mays D. Crowdsourced data collection for public health: A comparison with nationally representative, population tobacco use data. *Prev Med.* 2017;102:93–99.
47. Jamal A, Gentzke A, Hu SS, et al. Tobacco use among middle and high school students—United States, 2011–2016. *Morb Mortal Wkly Rep.* 2017;66:597–603.
48. Schauer GL, Malarcher AM, Mowery P. National trends in frequency and amount of nondaily smoking, and relation to quit attempts, 2000-2012. *Nicotine Tob Res.* 2016;18:1539–1544.