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Assessing the Consequences of Implementing Graphic Warning Labels on Cigarette Packs for Tobacco-Related Health Disparities

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Abstract

Introduction: Population-level communication interventions, such as graphic warning labels (GWLs) on cigarette packs, have the potential to reduce or exacerbate tobacco-related health disparities depending on their effectiveness among disadvantaged sub-populations. This study evaluated the likely impact of nine GWLs proposed by the US Food and Drug Administration on (1) African American and (2) Hispanic smokers, who disproportionately bear the burden of tobacco-related illness, and (3) low education smokers, who have higher smoking rates.
Methods: Data were collected online from current smokers randomly assigned to see GWLs (treatment) or the current text-only warning labels (control). Participants were stratified by age (18–25; 26+) in each of four groups: general population ($n = 1246$), African Americans ($n = 1200$), Hispanics ($n = 1200$), and low education ($n = 1790$). We tested the effectiveness of GWLs compared to text-only warning labels using eight outcomes that are predictive of quitting intentions or behaviors including negative emotion, intentions to hold back from smoking, intentions to engage in avoidance behaviors, and intentions to quit.
Results: Across all outcomes, GWLs were significantly more effective than text-only warning labels more often than expected by chance. Results suggested that African Americans, Hispanics and smokers with low education did not differ from the general population of smokers in their reactions to any of the nine individual GWLs.
Conclusions: The nine GWLs were similarly effective for disadvantaged sub-populations and the general population of smokers. Implementation of GWLs is therefore unlikely to reduce or exacerbate existing tobacco-related health disparities, but will most likely uniformly increase intentions and behaviors predictive of smoking cessation.

Introduction

Negative health outcomes are not evenly distributed across smokers. Underserved and marginalized groups in the United States, including African Americans, Hispanics, and individuals with less than a high school education, are disproportionately burdened with tobacco-related illnesses. Even though African Americans and Hispanics have a lower smoking prevalence than whites, they are more likely to die from smoking-related diseases.[1,2] Higher rates of smoking among individuals with lower education levels also leads to more tobacco-related disease than among more highly educated smokers.[3]

One cessation intervention that reaches all smokers is cigarette pack warnings. US law requires that nine graphic warning labels (GWLs) be printed in rotation on 50% of both the front and back of all cigarette packs (see online Supplementary Material),[4] replacing the current text-only warning labels (TWLs) on the side of the pack. At least 77 countries have already imposed similar pictorial warnings and at least 60 countries require warnings to cover at least 50% of the package.[5,6] In general population samples, GWLs have been found to be more effective than TWLs.[6–10] GWLs in Canada significantly decreased smoking rates by 3–4 percentage points over 9 years relative to the United States.[8] GWLs have also increased knowledge about tobacco harms, discouraged nonsmokers from experimenting, prevented former smokers from relapsing, and increased smokers' intentions and attempts to quit, even discouraging them from having a cigarette when they were about to.[6,9] More specifically, the GWLs proposed by the US Food and Drug Administration (FDA) have produced strong negative emotional responses and perceptions of effectiveness among general population samples of US smokers.[7,10]

However, not enough is known about the effects of GWLs on tobacco-related health disparities.[6,11,12] A recent meta-analysis found that cigarette price increases most consistently reduce the gap between high and low socioeconomic groups, while marketing controls (including health warning labels) either reduce the gap or impact all groups equally.[13] Another meta-analysis found health warning labels worked equivalently across education groups.[12] More recently, Thrasher and colleagues[14] found that Brazilian smokers with low educational attainment said they perceived GWLs as more effective and GWLs made them forgo a cigarette more than educated smokers (a difference not found among Mexican smokers responding to TWLs). Pictorial information may be easier for low education smokers to understand than TWLs. Further, antismoking television ads high in emotion and narrative form are more effective at increasing the likelihood of quitting and calling a quitline among smokers with lower educational attainment and socioeconomic status than among those of higher attainment and status,[15–17] and so emotionally evocative GWLs might also be especially effective for these groups.

Other studies suggest that GWLs are as effective among disadvantaged groups as among the general population[18–21] and thus have a neutral effect on disparities. Cantrell and colleagues[18] found no significant interaction between race/ethnicity or education and treatment condition (GWLs or TWLs) on salience, perceived impact, credibility, or quit intentions. In similar studies, Hammond and colleagues[19] found no significant condition-by-education interaction on overall perceived effectiveness of the warnings and Thrasher and colleagues[20] found no significant condition-by-race interactions on credibility, believability, or personal relevance of the warnings. Race and education also did not moderate the demand for cigarette packs carrying GWLs or TWLs, as estimated by smokers' willingness-to-pay.[21] Finally, if disadvantaged groups do not identify with characters in a GWL (eg, because of racial differences), or if understanding is impaired,[22] GWLs may be less effective among disadvantaged groups than the general population, thereby exacerbating disparities; although to date there is no empirical evidence of such effects.

The primary objective of this study was to evaluate the potential impact of the nine GWLs proposed by the FDA on three of the sub-populations that disproportionately bear the burden of tobacco-related disease in the United States: African Americans, Hispanics, and smokers with low educational attainment. We built on findings from previous studies that have tested the effectiveness of the FDA-proposed GWLs,[7,10,18,20] by assessing the potential impact of each individual warning label as well as the set of GWLs. We compared responses from those exposed to GWLs and those exposed to TWLs on quit intentions, and on eight other measures shown to be positively associated with quitting intentions or behaviors: (1) "negative emotional responses," which may play a role in message acceptance and are positively linked to thinking about the health risks of smoking, quit intentions, and quit behaviors[6,23]; (2) "perceived effectiveness of the warning" (PE), as PE ratings of smoking cessation public service announcements have been shown to predict quit intentions and subsequent changes in smoking behavior[24–26]; (3) "beliefs about the harms of smoking," as having concerns about the effect of smoking on health has been shown to predict quit attempts[27]; (4) "intentions to talk about the warning," as smokers who talk about GWLs are more likely to quit smoking or make cessation attempts[28]; "intentions to talk about quitting" (with either (5) "a medical professional" or (6) "a close other") as that is also predictive of increased quit intentions and behaviors[29,30]; (7) "intentions to avoid warnings"; and (8) "intentions to hold back from smoking a cigarette as a result of warnings," as avoiding warning labels and forgoing smoking a cigarette also increases the likelihood of quitting activities as well as decreasing adolescent intentions to smoke.[31,32] We also measured reactance to see if the labels induced resistance to persuasion.[33]

In assessing the likely impact of the GWLs on tobacco-related disparities, we were interested in whether the magnitude of difference in responses to the GWLs versus TWLs was larger, smaller, or the same, in each of the sub-populations as in the general population of smokers. Guided by the following research questions, we examined the effectiveness of the FDA-proposed GWLs:

1. Are GWLs (in aggregate) more effective than TWLs?
2. Are particular individual GWLs more effective than TWLs?
3. Is the magnitude of the difference between seeing GWLs (in aggregate) and TWLs larger, smaller, or the same, for disadvantaged groups relative to the general population?
4. Is the magnitude of the difference between seeing individual GWLs and TWLs larger, smaller, or the same, for disadvantaged groups relative to the general population?

Methods

Sample

Data were collected through an online survey hosted by the University of Pennsylvania in the fall of 2012. Respondents were recruited through Survey Sampling International's opt-in US panel and their partner organizations. Participants were randomized into this study depending on their responses to eligibility questions. Respondents had smoked more than 100 cigarettes in their lifetime and currently smoked cigarettes. Young adult smokers (18–25) were sampled and analyzed separately from older adults because young adults have a higher rate of cigarette smoking relative to older adults.[3] Therefore smokers were stratified by age (18–25 vs. ≥26) into our targeted groups: general population ($n_{18–25}$ = 602; n_{26+} = 644), African Americans ($n_{18–25}$ = 600; n_{26+} = 600), Hispanics ($n_{18–25}$ = 600; n_{26+} = 600), and low education smokers ($n_{18–25}$ = 962; n_{26+} = 828).

Since respondents opt-in to the Survey Sampling International panel, the general population group was constructed to approximate a nationally representative sample of smokers by matching it to Behavioral Risk Factor Surveillance System 2010 estimates of smokers' racial/ethnic, education and gender distributions. The low education sample was recruited independently of the general population

sample, but was comprised of subsets of the other samples weighted to match Behavioral Risk Factor Surveillance System distributions of race and gender. Analyses combining sub-populations adjusted for over-sampling by including age, gender, race/ethnicity, and educational attainment.

Experimental Design and Stimuli

Respondents answered questions concerning their smoking behavior and then were randomly assigned to one of 10 conditions: 90% to the nine treatment conditions and 10% to the control condition. Respondents in each of the nine treatment conditions saw one of the nine GWLs (eg, Condition 1 = *L1-Harm Child*; see Figure 1) and

were asked to evaluate it using a number of measures. They then viewed two additional GWLs randomly assigned from the other conditions and evaluated each of those GWLs on a smaller number of measures (a slightly different set of measures was used after the second GWL and after the third GWL). Respondents in the control condition were randomly assigned to evaluate one of the four current TWLs. Respondents viewed each warning label for at least 4 seconds.

Measures
Message Evaluations
Three sets of message evaluations were collected after each exposure using a 5-point agreement scale (1 = *strongly disagree* to 5 = *strongly*
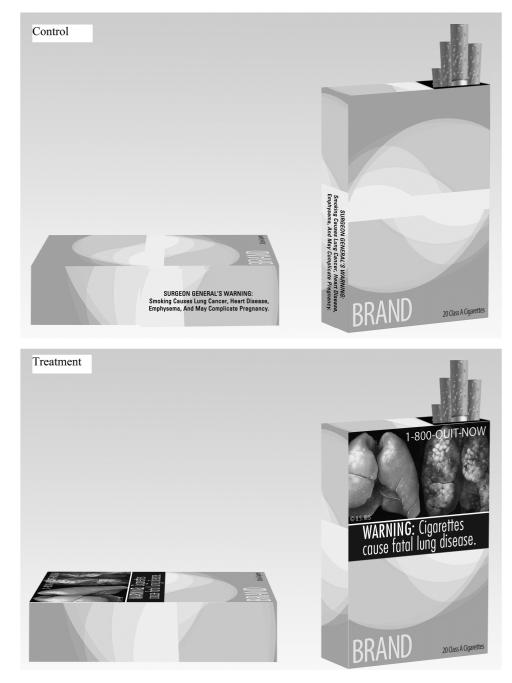

Figure 1. Stimulus for control and treatment conditions.

agree). Negative emotional responses were measured by averaging six emotions felt while looking at the warning (worry, guilt, disgust, sadness, regret, and anger at themselves for being smokers; Cronbach's α = .91; adapted from Nonnemaker and colleagues[10]). PE was measured by the degree to which: the warning was "relevant to my everyday life," "important to me," "convincing," "believable," "accurate," "makes me think about what it would be like if the situation shown in the warning happened to me," "put thoughts in my mind about quitting," and "put thoughts in my mind about wanting to continue smoking." The last two items were subtracted to create a difference score and then averaged with the remaining items (Cronbach's α = .87; adapted from Bigsby and colleagues and Zhao and colleagues[24,34]). Cognitive reactance was measured by the degree to which: the warning "is dishonest," "is exaggerated," "tries to manipulate me," and "makes me feel angry at the warning label and its sponsors" (Cronbach's α =.80).

Quit Intentions

After the first and third exposures, smokers rated their intentions to engage in three quitting-related behaviors in the next 30 days: "reduce the number of cigarettes I smoke in a day," "call a quitline," and "try to quit smoking" on a 4-point willingness scale (1 = *definitely will not* and 4 = *definitely will*; adapted from Bigsby and colleagues and Nonnemaker and colleagues[24,35]). These items were averaged into a quit intention scale (Cronbach's α =.79).

Other Measures Associated With Quit Intentions

Several other measures were collected only after the first exposure. Beliefs about the harms of smoking were measured with 11 items using the 5-point agreement scale. Respondents were also asked about three intentions to talk to someone in the next 30 days using the 4-point willingness scale: likelihood of talking "to someone (such as a friend, family member, partner) about the warning on the pack of cigarettes that I just saw," "to someone (such as a friend, family member, partner) about my quitting smoking," and "to a medical professional about my quitting smoking" (adapted from Bigsby and colleagues[24]). Finally, respondents rated how much they agreed that seeing the warning labels would make them engage in avoidance behaviors and forgo cigarettes using 5-point agreement scales. Intentions to engage in avoidance behaviors included: covering up the label, keeping the pack out of sight, and transferring the cigarettes to a different container (Cronbach's α = .90; adapted from Borland and colleagues[31]). Intention to forgo cigarettes was measured with whether they would "hold back from smoking a cigarette when they were about to smoke one" if the warning label was on their pack of cigarettes (adapted from Borland and colleagues[31]).

Potential Covariates

Covariates included respondents' age, gender, race/ethnicity, educational attainment, and annual household income. Participants' contemplation of quitting was measured on a 0–10 scale (adapted from Biener and Abrams[36]). Six questions from the Fagerstrom Test for Nicotine Dependence[37] measured respondents' nicotine dependence. Two questions adapted from the brief questionnaire of smoking urges measured cigarette cravings.[38] Participants also reported whether they currently smoke every day or some days, how many cigarettes they smoke on a typical day, and how many times they had tried to quit smoking in the past year.

Analytic Approach

Preliminary analyses indicated that smokers' quitting contemplation was the only potential covariate that varied by condition (treatment or control), and so all analyses adjusted for it (and not for the other covariates). Outcome measures were also checked for variability across conditions—reactance and beliefs did not vary, and were not analyzed. Using individual linear regression analyses, the remaining eight outcome measures were predicted from GWLs (aggregated) relative to the TWLs (RQ1) for the entire sample of smokers (by age group) and for each sub-population. Then, individual linear regression analyses predicted each of the four outcome measures most responsive to condition for RQ1 from the set of nine dummy-coded individual GWL conditions relative to the TWLs (RQ2). We then added interaction terms to the regression models for RQ1 and RQ2 crossing group (each sub-population vs. general population) and condition (treatment vs. control) to assess whether the difference between GWLs (aggregated; RQ3) or individual GWLs (RQ4) and the TWLs in each sub-population was larger, smaller, or the same, as the age-matched general population group. Finally, we substituted those interactions for interactions crossing age group and condition (within populations) and found very minimal differences by age group, so analyses are not reported here. We used omnibus significance testing for the individual GWL analyses (RQ2; RQ4) to facilitate control over Type I error (due to the numerous tests in these analyses). Significant differences ($P < .05$) for individual labels were only noted if the overall treatment effect or the interaction effect for the set of GWLs was significant at $P < .10$. These analyses used only responses to the first warning label, which are independent of later label evaluations. Analyses were conducted using Stata, version 13 (StataCorp, 2013, College Station, TX).

Results

Table 1 presents the demographic and smoking characteristics of the eight sub-populations and all smokers (18–25 and 26+ year olds). All of the sub-populations in this study smoked more cigarettes per day than expected based on National Survey on Drug Use and Health (2011) estimates. Intercorrelations among the eight analyzed outcomes for all smokers ranged from 0.19 to 0.69 with the strongest correlations between negative emotions and PE (0.67), talking about the warning and talking to someone about quitting (0.67), talking to someone about quitting and quit intentions (0.69), and talking to a medical professional about quitting and quit intentions (0.67; see Supplementary Material).

Effectiveness of Aggregated GWLs Compared to TWLs (RQ1)

In aggregate, GWLs were consistently rated as more effective than the current TWLs (Table 2). For the young adult smokers combined, the GWLs were significantly more effective on six of the eight outcomes (adjusted means: negative emotions $M_{GWL} = 3.45$, $M_{control} = 3.09$; intentions to talk about the warning $M_{GWL} = 2.54$, $M_{control} = 2.29$, to engage in avoidance behaviors $M_{GWL} = 3.10$, $M_{control} = 2.46$, to hold back from smoking $M_{GWL} = 3.10$, $M_{control} = 2.81$, to talk to someone about quitting $M_{GWL} = 2.64$, $M_{control} = 2.49$, and to talk to a medical professional about quitting $M_{GWL} = 2.20$, $M_{control} = 2.05$). For the older smokers combined, GWLs were more effective on four of the eight outcomes (negative emotions $M_{GWL} = 3.48$, $M_{control} = 3.19$; intentions to talk about the warning $M_{GWL} = 2.41$, $M_{control} = 2.11$, to

Table 1. Demographic and Smoking Characteristics of Each of the Eight Sub-Populations and All Current Smokers

Demographics and smoking characteristics	18–25 year olds					26+ year olds				
	Gen Pop, n = 602	AA, n = 600	Hisp, n = 600	Low Edu, n = 962	All, n = 2203[a]	Gen Pop, n = 644	AA, n = 600	Hisp, n = 600	Low Edu, n = 828	All, n = 2285[a]
Age	21.9	22.0	21.8	21.6	21.8	46.1	45.0	40.1	46.6	44.7
Gender (female)	46%	55%	55%	44%	50%	51%	61%	54%	50%	54%
Race (white)	73%	0%	74%	75%	57%	70%	0%	83%	74%	59%
(Black)	14%	87%[b]	6%	15%	29%	23%	97%[b]	5%	22%	35%
(Other)	12%	14%	20%	11%	14%	7%	3%	12%	4%	6%
Ethnicity (Hispanic)	17%	8%	100%	20%	34%	16%	4%	100%	15%	32%
Education (low)	57%	51%	43%	100%	59%	41%	34%	31%	100%	48%
Annual household income (in $1000s)	43	36	44	3.5	40	47	41	51	34	44
Smoke daily	72%	74%	65%	79%	72%	84%	85%	85%	85%	85%
Contemplation ladder (0–10)	6.1	6.2	5.9	5.5	5.9	6.0	6.1	5.9	5.5	5.9
Fagerstrom Test for Nicotine Dependence (0–10)	4.7	4.6	4.2	4.9	4.6	4.9	4.7	4.7	5.0	4.8
Cigarette cravings (1–5)	3.6	3.6	3.5	3.7	3.6	3.7	3.6	3.7	3.7	3.7
Cigarettes per day	12	13	10	14	12	17	16	14	18	16
Quit attempts in the past year	5	5	5	4	5	4	3	4	3	3

Note. AA = African American; Gen Pop = general population; Hisp = Hispanic; Low Edu = low education smokers. The defining demographic characteristic for each sub-population is underlined.

[a] Sample size for all current smokers (All) is less than the sum of the four sub-populations (general population, African American, Hispanic, and low education smokers) because the low education smoker sub-population contains proportionally weighted sub-sets of the African American and Hispanic sub-populations.

[b] Participants who chose more than one race to describe themselves were categorized as "Other" race. If any of the races they chose were black, they could be included in the African American sub-population (explaining why it is not 100% black).

Table 2. Aggregated Graphic Warning Labels' Effectiveness Relative to Current Text-only Warnings (Betas)

Outcome	18–25 year olds					26+ year olds				
	Gen Pop, n = 602	AA, n = 600	Hisp, n = 600	Low Edu, n = 962	All, n = 2203[a]	Gen Pop, n = 644	AA, n = 600	Hisp, n = 600	Low Edu, n = 828	All, n = 2285[a]
Negative emotions	0.05	0.11**	0.10*	0.15**	0.10**	0.07	0.13**	0.08	0.08*	0.09**
Perceived effectiveness	0.02	0.01	0.01	0.02	0.01	0.00	0.05	0.04	−0.04	0.01
Int: talk about the warning	0.07	0.07	0.09*	0.06*	0.08**	0.10**	0.11**	0.11**	0.07	0.09**
Int: engage in avoidance behaviors	0.14**	0.11**	0.23**	0.20**	0.17**	0.14**	0.17**	0.12**	0.16**	0.14**
Int: hold back from smoking	0.05	0.03	0.11**	0.08*	0.07**	0.07	0.15**	0.05	0.11**	0.09**
Int: talk to someone about quitting	0.02	0.03	0.09*	0.05	0.05*	−0.01	0.04	−0.01	−0.02	0.01
Int: talk to a medical professional about quitting	0.03	0.02	0.04	0.09**	0.05*	−0.01	0.07	−0.01	0.05	0.02
Int: quit	−0.02	0.02	0.03	0.07**	0.03	0.02	0.04	0.00	−0.03	0.01

Note. AA = African American; Gen Pop = general population; Hisp = Hispanic; Int = intentions; Low Edu = low education smokers. There are no significant differences between the effectiveness of the aggregated graphic warning labels relative to the text-only warnings for the six sub-populations of interest ([AA; 18–25, 26+], [Hisp; 18–25, 26+], and [Low Edu; 18–25, 26+]) and the effectiveness of the aggregated graphic warning labels relative to the text-only warnings for the age-matched general population. All analyses adjust for quitting contemplation, which was not randomly distributed across conditions. Given the oversampling, analyses for all current smokers (All) also adjust for race, education, sex, and age. Betas ≥ |0.10| are bolded to facilitate interpretation of similarly sized effects, since there were a range of sample sizes.

[a] Sample size for all current smokers (All) is less than the sum of the four sub-populations (general population, African American, Hispanic, and low education smokers) because the low education smokers sub-population contains proportionally weighted sub-sets of the African American and Hispanic sub-populations.

*P < .05; **P < .01.

engage in avoidance behaviors M_{GWL} = 2.89, $M_{control}$ = 2.36, and to hold back from smoking M_{GWL} = 2.99, $M_{control}$ = 2.66).

Considering each of the eight targeted sub-populations separately, from a total of 64 tests (eight outcomes for each of eight sub-populations), aggregated GWLs were significantly more effective than TWLs in 25 cases (39%)—an amount greater than expected by chance (betas range from 0.06–0.23). Most of these significant differences (22 of 25) occurred with four outcomes measuring responses most proximal to the warning (negative emotions and intentions to talk about the warning, engage in avoidance behaviors, and hold back from smoking).

For all groups except 18–25 year old smokers with low educational attainment, there were no significant differences in quit intentions after one GWL exposure relative to control. However, a single exposure may be insufficient to produce change in quit intentions, so we also assessed whether multiple exposures to GWLs led to stronger quit intentions. We employed multilevel mixed-effects linear regressions, using maximum-likelihood estimation with respondents as random effects, to compare quit intentions after one and after three GWL exposures within each target sub-population. In every sub-population, exposure to three GWLs was associated with stronger quit intentions (P < .001). Note that TWLs could not be included in this analysis because the control groups only evaluated one label.

Effectiveness of Nine Individual GWLs Compared to TWLs (RQ2)

Table 3 presents results for each of the nine individual GWLs for each population examined, on the four outcomes that showed the most effects at the aggregate level. Quit intentions are also presented, since it is the most proximal outcome to quitting behavior, although there were no positive significant effects. In analyses using all smokers, individual GWLs were significantly more effective than the TWLs in 62 of 72 tests (four outcomes by nine labels and two age groups). For older smokers, eight of the GWLs were more effective on the four outcomes (all except *L4-Quit*). For the young adult smokers, four GWLs (*L1-Harm Child*, *L5-Lung*, *L6-Cancer*, *L7-Stroke*) were more effective on the same outcomes.

Answering RQ2, we considered GWLs that had betas greater than 0.10 on all four of these outcomes to be particularly effective relative to control (Table 3). One label, *L6-Cancer*, was particularly effective for both age groups of combined smokers, as well as for young adult Hispanics, young adult low education smokers, and older African Americans. Additionally, *L5-Lung* was particularly effective for all four of the older smoker sub-populations and the young adult low education smokers. Only one label, *L4-Quit*, had betas less than 0.10 on all four of these outcomes for both age groups of combined smokers, and thus was deemed no more effective than the TWLs.

Individual Sub-populations Compared to the General Population (RQ3; RQ4)

Disadvantaged groups did not differ from the age-matched general populations of smokers in their reactions to GWLs (aggregated) relative to control (RQ3). From a total of 48 tests (six sub-population vs. general population comparisons for each of eight outcomes), no significant differences were observed, indicating that the magnitude of the difference in GWL and TWL ratings was not significantly different between groups. There was also no evidence that the sub-populations differed from the general population of smokers in the effect of three exposures relative to one exposure on quit intentions.

Among the individual labels, again there was no evidence that the disadvantaged groups differed from the general population of smokers in their reactions to each of the nine individual GWLs relative to control (RQ4). From a total of 48 tests (six sub-population vs. general population comparisons for each of eight outcomes), no significant differences were observed at the set of GWLs level (P < .10), and so no follow-up individual GWL interaction tests were conducted.

Discussion

Although the FDA has removed these nine GWLs from consideration due to ongoing tobacco industry litigation, these findings still inform our understanding of the potential impact of GWLs on tobacco-related health disparities. There was no evidence that GWLs were less effective for disadvantaged groups than for the general population and GWLs are thus unlikely to increase disparities. Instead, results consistently suggested that the effect for GWLs relative to the current TWLs in the three sub-populations was comparable to the effect in the general population (RQ3; RQ4). Thus, the GWLs are unlikely to directly impact disparities although their wide distribution would make them easily accessible to disadvantaged smokers.

GWLs were consistently more effective than the current TWLs across the general population and the sub-populations on four outcomes: negative emotions, intentions to talk about the warning, intentions to engage in avoidance behaviors, and intentions to hold back from smoking (RQ1). However, we were surprised that GWLs did not increase PE or quit intentions relative to the current labels after one exposure, although quit intentions did increase from one to three GWL exposures. These results are somewhat inconsistent with previous work on these GWLs. One explanation is that PE-like constructs in previous work included measures of PE for others,[7,18] while we only assess PE for oneself. Smokers may be less willing to endorse PE of GWLs for themselves than they are for other people. Additionally, Nonnemaker and colleagues' PE-like construct (cognitive impact)[10] includes GWL salience, which one would also expect to boost reported PE over TWLs. As for quit intentions, Cantrell and colleagues[18] found they were greater for GWLs among whites, African Americans, Hispanics, and smokers with some college education. On the other hand, Nonnemaker and colleagues[35] found that no GWLs showed effects on quit intentions. So, our lack of quit intention findings partially aligns with these results.

Since there were no differences between the responses of disadvantaged groups and the general population to the nine GWLs, we draw our conclusions about the effectiveness of individual labels from findings for all smokers combined (RQ2). Two labels were consistently strong across measured outcomes: *L5-Lung* and *L6-Cancer*. They produced the most negative emotion relative to control of all the GWLs. Both of these labels convey the health effects of smoking through images of diseased body parts. On the other hand, *L4-Quit* was no more effective than the current TWLs. By design, it was a positively-framed warning, and so it is unsurprising that it produced less negative emotion and intentions to engage in avoidance behaviors than the other GWLs. Given that negative emotion and intentions to engage in avoidance behaviors have been associated with quitting-related intentions and behaviors, we believe future GWLs that evoke those responses will be most effective for smokers.

Table 3. Individual Graphic Warning Labels' Effectiveness Relative to Current Text-only Warnings, by Group (Betas)

		18–25 year olds					26+ year olds				
	Outcome	Gen Pop, n = 602	AA, n = 600	Hisp, n = 600	Low Edu, n = 962	All, n = 2203[a]	Gen Pop, n = 644	AA, n = 600	Hisp, n = 600	Low Edu, n = 828	All, n = 2285[a]
L1 Harm Child	Negative emotions	0.04	0.11*	0.08	0.18**	0.10**	0.08	0.12*	0.11*	0.08	0.09**
	Int: talk about the warning	0.10	0.07	0.09	0.06	0.09**	0.10	0.09	0.12*	0.10*	0.10**
	Int: engage in avoidance behaviors	0.15**	0.11*	0.17**	0.19**	0.15**	0.12*	0.14*	0.11*	0.16**	0.13**
	Int: hold back from smoking	0.07	0.03	0.07	0.08	0.07*	0.09	0.15*	0.03	0.11*	0.09**
	Int: quit	−0.05	−0.03	0.03	0.09	0.01	0.05	0.06	0.05	−0.03	0.03
L2 Pregnancy	Negative emotions	0.01	0.04	0.07	0.15**	0.07**	0.05	0.08	0.09	0.06	0.08**
	Int: to talk about the warning	0.03	0.02	0.11*	0.05	0.06*	0.08	0.07	0.05	0.05	0.07**
	Int: engage in avoidance behaviors	0.11*	0.08	0.15**	0.17**	0.13*	0.18**	0.07	0.13*	0.11*	0.12**
	Int: hold back from smoking	−0.02	−0.01	0.04	0.07	0.03	0.06	0.06	0.04	0.09	0.07*
	Int: quit	−0.08	0.00	0.06	0.04	0.01	−0.01	0.04	0.01	−0.02	0.01
L3 Nonsmoker	Negative emotions	0.03	0.09	0.09	0.10*	0.08**	0.04	0.10*	0.03	0.10*	0.07**
	Int: talk about the warning	0.05	0.07	0.04	0.01	0.04	0.09	0.08	0.05	0.01	0.06*
	Int: engage in avoidance behaviors	0.11*	0.07	0.17**	0.09*	0.12**	0.14**	0.15**	0.06	0.13*	0.12**
	Int: hold back from smoking	0.01	0.01	0.06	0.01	0.03	0.01	0.08	0.04	0.10*	0.06*
	Int: quit	0.00	0.01	0.00	0.06	0.02	0.02	0.00	−0.05	−0.06	−0.01
L4 Quit	Negative emotions	−0.04	0.05	0.00	0.05	0.02	0.01	0.04	−0.08	−0.01	−0.01
	Int: to talk about the warning	0.09	0.04	0.06	0.07	0.08**	0.07	0.05	0.12*	0.04	0.07*
	Int: engage in avoidance behaviors	0.04	−0.04	0.13*	0.08*	0.06*	0.01	0.03	0.01	0.02	0.02
	Int: hold back from smoking	0.02	−0.07	0.08	0.04	0.03	0.00	0.10	0.01	0.04	0.03
	Int: quit	0.00	0.02	0.00	0.03	0.03	0.00	0.05	0.01	−0.03	0.01
L5 Lung	Negative emotions	0.12*	0.19**	0.13**	0.22**	0.17**	0.20**	0.16**	0.18**	0.15**	0.18**
	Int: talk about the warning	0.10	0.06	0.05	0.11**	0.08**	0.16	0.12*	0.13**	0.13*	0.12**
	Int: engage in avoidance behaviors	0.15**	0.13*	0.23**	0.23**	0.19**	0.27**	0.25**	0.20**	0.21**	0.23**
	Int: hold back from smoking	0.08	0.10	0.12*	0.14**	0.11**	0.14**	0.16**	0.10	0.17**	0.14**
	Int: quit	0.00	0.03	0.02	0.11	0.04	0.06	0.02	0.00	−0.03	0.02
L6 Cancer	Negative emotions	0.18**	0.15**	0.19**	0.21**	0.19**	0.04	0.17**	0.13**	0.09	0.11**
	Int: to talk about the warning	0.08	0.10	0.20**	0.15**	0.14**	0.06	0.18**	0.19**	0.04	0.11**
	Int: engage in avoidance behaviors	0.24**	0.15**	0.29**	0.33**	0.26**	0.13**	0.28**	0.25**	0.23**	0.21**
	Int: hold back from smoking	0.12*	0.06	0.14**	0.11*	0.12**	0.07	0.21**	0.09	0.06	0.10**
	Int: quit	0.02	0.02	0.10	0.09	0.06	0.00	0.08	−0.04	−0.10**	−0.01
L7 Stroke	Negative emotions	0.12*	0.11*	0.07	0.16**	0.12*	0.02	0.10	0.07	0.11*	0.07**
	Int: talk about the warning	0.10	0.09	0.08	0.07	0.09**	0.11	0.06	0.07	0.11*	0.08**
	Int: engage in avoidance behaviors	0.20**	0.12*	0.22**	0.25**	0.20**	0.08	0.19**	0.10*	0.20**	0.14**
	Int: hold back from smoking	0.06	0.05	0.13*	0.11*	0.09**	0.11*	0.12*	0.06	0.14**	0.10**
	Int: quit	0.02	0.04	0.05	0.07	0.05	0.04	0.00	0.01	0.00	0.02
L8 Kill	Negative emotions	0.01	0.09	0.14**	0.14**	0.10**	0.09*	0.16**	0.06	0.11*	0.10**
	Int: to talk about the warning	0.03	0.08	0.06	0.01	0.05	0.09	0.11*	0.08	0.07	0.08**
	Int: engage in avoidance behaviors	0.20**	0.17**	0.31**	0.16**	0.22**	0.12*	0.15**	0.13*	0.21**	0.15**
	Int: hold back from smoking	0.01	0.09	0.14**	0.05	0.08**	0.09	0.21**	0.00	0.12**	0.10**
	Int: quit	−0.03	0.05	0.01	0.04	0.02	0.05	0.06	−0.01	−0.03	0.01

Table 3. Continued

	Outcome	18–25 year olds					26+ year olds				
		Gen Pop, $n = 602$	AA, $n = 600$	Hisp, $n = 600$	Low Edu, $n = 962$	All, $n = 2203$[a]	Gen Pop, $n = 644$	AA, $n = 600$	Hisp, $n = 600$	Low Edu, $n = 828$	All, $n = 2285$[a]
L9 Addiction	Negative emotions	0.03	0.09	0.02	**0.12****	**0.07****	0.00	**0.15****	0.05	0.06	**0.06***
	Int: talk about the warning	0.04	0.04	0.05	0.01	0.04	0.09	**0.13***	**0.14****	0.09	**0.10****
	Int: engage in avoidance behaviors	0.11	0.07	**0.18****	**0.22****	**0.14****	**0.13****	**0.17****	0.09	**0.15****	**0.12****
	Int: hold back from smoking	**0.11***	0.00	**0.12***	0.05	**0.08****	0.05	**0.16****	0.10	**0.11***	**0.10****
	Int: quit	−0.03	0.04	−0.02	0.04	0.01	−0.01	0.06	0.05	0.02	0.03

Note. AA = African American; Gen Pop = general population; GWL = graphic warning label; Hisp = Hispanic; Int = intentions; Low Edu = low education smokers. There are no significant differences between the effectiveness of the individual graphic warning labels relative to the text-only warnings for the six sub-populations of interest ([AA; 18–25, 26+], [Hisp; 18–25, 26+], and [Low Edu; 18–25, 26+]) and the effectiveness of the individual graphic warning labels relative to the text-only warnings for the age-matched general population on all eight outcomes. Only the four most effective outcomes from the combined GWLs analysis are shown here, plus intentions to quit. All analyses adjust for quitting contemplation, which was not randomly distributed across conditions. Given the oversampling, analyses for all current smokers (All) also adjust for race, education, sex, and age. Betas ≥ |0.10| are bolded to facilitate interpretation of similarly sized effects, since there were a range of sample sizes.

[a]Sample size for all current smokers is less than the sum of the four sub-populations (general population, African American, Hispanic, and low education smokers) because the low education smokers sub-population contains proportionally weighted sub-sets of the African American and Hispanic sub-populations.

*P < .05; **P < .01. Significant differences (*P* < .05) for individual labels were only noted if the overall treatment effect for the set of GWLs was significant at *P* < .10.

One strength of this study design was the inclusion of a control group for each sub-population so that GWL effectiveness was assessed within populations and only the magnitude of that effect was compared to the general population. If sub-populations have different reporting biases, then comparing the effects of GWLs across groups, without knowing how that differs from control, would not provide a fair comparison of the effect for GWLs. However, one limitation is that the control group only saw one warning. Three exposures in the control group would have allowed follow-up tests of exposure frequency by label type (GWLs vs. TWL), which would have strengthened the analysis predicting quit intentions from multiple exposures.

Two additional strengths of this design include having a large enough sample to assess the effectiveness of individual GWLs relative to the current TWLs for disadvantaged groups, not just the effectiveness of the set of GWLs. Previous experimental studies of the response of disadvantaged groups to GWLs have either been within-participant designs[7,19] or not large enough to look at the effects of individual labels.[18] Another strength was the comparison of disadvantaged groups to the general population, rather than to the contrasting demographic groups (ie, whites and high education smokers). Although at first glance this comparison may seem unusual, it was appropriate because our main interest was in determining whether responses to the GWLs among disadvantaged groups would differ relative to the general population.

Two additional limitations include limited generalizability due to an opt-in internet sample. Although groups were weighted back to the Behavioral Risk Factor Surveillance System demographic distribution of smokers within each sub-population, there still may be some bias in responding. For example, our participants smoked more heavily than average smokers, so results may be more representative of heavier smokers' reactions to the GWLs. Another weakness is that our findings rely on self-reports of intentions to talk about the warning, engage in avoidance behaviors, and hold back from smoking. Although there is good evidence that intentions are predictive of behaviors,[39] they are not behavioral measures, which would be stronger evidence of treatment effectiveness.

This study provides evidence that the effectiveness of the proposed GWLs relative to the current TWLs does not differ among smokers with different racial/ethnic or education backgrounds and the general population. As in previous research,[12,13] our data suggest that GWLs are unlikely to reduce health disparities among three populations who are at greater risk for tobacco-related diseases in the United States: smokers with low educational attainment, African Americans, and Hispanics. Positive findings for emotionally evocative anti-smoking television ads among lower SES smokers[15–17] suggest that developing GWLs that are even more emotionally evocative may reduce disparities among smokers of low educational attainment. Even if new GWLs were just similarly effective at producing outcomes associated with quitting behaviors and intentions, given that mandatory GWLs would be seen by all smokers, disadvantaged groups would at least have equal access to an effective intervention.[22] Implementing GWLs similar to the ones tested here is likely to increase motivation to quit among these groups, so cessation treatment organizations will need to be prepared to provide support for quit attempts among these disadvantaged groups.

Supplementary Material

Supplementary Material can be found online at http://www.ntr.oxfordjournals.org

Declaration of Interests

None declared.

References

1. Haiman CA, Stram DO, Wilkens LR, et al. Ethnic and racial differences in the smoking-related risk of lung cancer. *N Engl J Med*. 2006;354(4):333–342. doi:10.1056/NEJMoa033250.
2. US Department of Health and Human Services. Tobacco use among US racial/ethnic minority groups—African Americans, American Indians and Alaska Natives, Asian Americans and Pacific Islanders, and Hispanics: a report of the Surgeon General. 1998. www.cdc.gov/tobacco/data_statistics/sgr/1998/complete_report/index.htm. Accessed August 15, 2014.
3. US Department of Health and Human Services. The health consequences of smoking—50 years of progress: a report of the Surgeon General. 2014. www.cdc.gov/tobacco/data_statistics/sgr/2012/. Accessed April 8, 2014.
4. H.R. 1256—111th Congress. Family Smoking Prevention and Tobacco Control Act. 2009. www.govtrack.us/congress/bills/111/hr1256. Accessed August, 15, 2014.
5. Canadian Cancer Society. Cigarette Package Health Warnings: International Status Report. 2014. www.tobaccolabels.ca/wp/wp-content/uploads/2014/10/Cigarette-Package-Health-Warnings-International-Status-Report-English-CCS-Sept-2014.pdf. Accessed December 24, 2014.
6. Hammond D. Health warning messages on tobacco products: a review. *Tob Control*. 2011;20(5):327–337. doi:10.1136/tc.2010.037630.
7. Hammond D, Reid JL, Driezen P, Boudreau C. Pictorial health warnings on cigarette packs in the United States: an experimental evaluation of the proposed FDA warnings. *Nicotine Tob Res*. 2013;15(1):93–102. doi:10.1093/ntr/nts094.
8. Huang J, Chaloupka FJ, Fong GT. Cigarette graphic warning labels and smoking prevalence in Canada: a critical examination and reformulation of the FDA regulatory impact analysis. *Tob Control*. 2014;23(suppl 1):i7–i12. doi:10.1136/tobaccocontrol-2013–051170.
9. Institute for Global Tobacco Control. State of evidence review: health warning labels on tobacco products. 2013. www.globaltobaccocontrol.org/node/13935. Accessed August 15, 2014.
10. Nonnemaker JM, Choiniere CJ, Farrelly MC, Kamyab K, Davis KC. Reactions to graphic health warnings in the United States. *Health Educ Res*. 2015;30(1):46–56. doi:10.1093/her/cyu036.
11. Fagan P, King G, Lawrence D, et al. Eliminating tobacco-related health disparities: directions for future research. *Am J Public Health*. 2004;94(2):211–217.
12. Thomas S, Fayter D, Misso K, et al. Population tobacco control interventions and their effects on social inequalities in smoking: systematic review. *Tob Control*. 2008;17(4):230–237. doi:10.1136/tc.2007.023911.
13. Brown T, Platt S, Amos A. Equity impact of population-level interventions and policies to reduce smoking in adults: a systematic review. *Drug Alcohol Depend*. 2014;138(1):7–16. doi:10.1016/j.drugalcdep.2014.03.001.
14. Thrasher JF, Villalobos V, Szklo A, et al. Assessing the impact of cigarette package health warning labels: a cross-country comparison in Brazil, Uruguay and Mexico. *Salud Publica Mex*. 2010;52(suppl 2):S206–S215.
15. Durkin SJ, Biener L, Wakefield MA. Effects of different types of antismoking ads on reducing disparities in smoking cessation among socioeconomic subgroups. *Am J Public Health*. 2009;99(12):2217–2223. doi:10.2105/AJPH.2009.161638.

16. Durkin SJ, Wakefield MA, Spittal MJ. Which types of televised anti-tobacco campaigns prompt more quitline calls from disadvantaged groups? *Health Educ Res*. 2011;26(6):998–1009. doi:10.1093/her/cyr048.

17. Farrelly MC, Duke JC, Davis KC, et al. Promotion of smoking cessation with emotional and/or graphic antismoking advertising. *Am J Prev Med*. 2012;43(5):475–482. doi:10.1016/j.amepre.2012.07.023.

18. Cantrell J, Vallone DM, Thrasher JF, et al. Impact of tobacco-related health warning labels across socioeconomic, race and ethnic groups: results from a randomized web-based experiment. *PLoS One*. 2013;8(1):e52206. doi:10.1371/journal.pone.0052206.

19. 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. doi:10.1007/s10552-012-9902-4.

20. Thrasher JF, Carpenter MJ, Andrews JO, et al. Cigarette warning label policy alternatives and smoking-related health disparities. *Am J Prev Med*. 2012;43(6):590–600. doi:10.1016/j.amepre.2012.08.025.

21. Thrasher JF, Rousu MC, Hammond D, Navarro A, Corrigan JR. Estimating the impact of pictorial health warnings and "plain" cigarette packaging: evidence from experimental auctions among adult smokers in the United States. *Health Policy*. 2011;102(1):41–48. doi:10.1016/j.healthpol.2011.06.003.

22. Viswanath K. Public communications and its role in reducing and eliminating health disparities. In: Thomson GE, Mitchell F, Williams M, eds. *Examining the Health Disparities Research Plan of the National Institutes of Health: Unfinished Business*. Washington, DC: Institute of Medicine; 2006:215–253.

23. Hammond D, Fong GT, McDonald PW, Brown KS, Cameron R. Graphic Canadian cigarette warning labels and adverse outcomes: evidence from Canadian smokers. *Am J Public Health*. 2004;94(8):1442–1445. doi:10.2105/AJPH.94.8.1442.

24. Bigsby E, Cappella JN, Seitz HH. Efficiently and effectively evaluating public service announcements: additional evidence for the utility of perceived effectiveness. *Commun Monogr*. 2013;80(1):1–23. doi:10.1080/03637751.2012.739706.

25. Brennan E, Durkin SJ, Wakefield MA, Kashima Y. Assessing the effectiveness of antismoking television advertisements: do audience ratings of perceived effectiveness predict changes in quitting intentions and smoking behaviours? *Tob Control*. 2014;23(5):412–418. doi:10.1136/tobaccocontrol-2012–050949.

26. Davis KC, Nonnemaker J, Duke J, Farrelly MC. Perceived effectiveness of cessation advertisements: the importance of audience reactions and practical implications for media campaign planning. *Health Commun*. 2013;28(5):461–472. doi:10.1080/10410236.2012.696535.

27. Vangeli E, Stapleton J, Smit ES, Borland R, West R. Predictors of attempts to stop smoking and their success in adult general population samples: a systematic review. *Addiction*. 2011;106(12):2110–2121. doi:10.1111/j.1360-0443.2011.03565.x.

28. Hammond D, Fong GT, McDonald PW, Cameron R, Brown KS. Impact of the graphic Canadian warning labels on adult smoking behaviour. *Tob Control*. 2003;12(4):391–395. doi:10.1136/tc.12.4.391.

29. Stead LF, Buitrago D, Preciado N, Sanchez G, Hartmann-Boyce J, Lancaster T. Physician advice for smoking cessation. *Cochrane Database Syst Rev*. 2013;5:CD000165. doi:10.1002/14651858.CD000165.pub4.

30. van den Putte B, Yzer M, Southwell BG, de Bruijn GJ, Willemsen MC. Interpersonal communication as an indirect pathway for the effect of antismoking media content on smoking cessation. *J Health Commun*. 2011;16(5):470–485. doi:10.1080/10810730.2010.546487.

31. 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(4):669–675. doi:10.1111/j.1360-0443.2009.02508.x.

32. White V, Webster B, Wakefield M. Do graphic health warning labels have an impact on adolescents' smoking-related beliefs and behaviours? *Addiction*. 2008;103(9):1562–1571. doi:10.1111/j.1360-0443.2008.02294.x.

33. Dillard JP, Shen L. On the nature of reactance and its role in persuasive health communication. *Commun Monogr*. 2005;72(2):144–168. doi:10.1080/03637750500111815.

34. Zhao X, Strasser A, Cappella JN, Lerman C, Fishbein M. A measure of perceived argument strength: reliability and validity. *Commun Methods Meas*. 2011;5(1):48–75. doi:10.1080/19312458.2010.547822.

35. Nonnemaker JM, Farrelly MC, Kamyab K, Busey A, Mann N. *Experimental Study of Graphic Cigarette Warning Labels: Final Results Report*. Prepared for the Center for Tobacco Products, Food and Drug Administration. Research Triangle Park, NC: RTI International; 2010.

36. Biener L, Abrams DB. The Contemplation Ladder: validation of a measure of readiness to consider smoking cessation. *Health Psychol*. 1991;10(5):360–365.

37. Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO. The Fagerström Test for Nicotine Dependence: a revision of the Fagerström Tolerance Questionnaire. *Br J Addict*. 1991;86(9):1119–1127.

38. Cox LS, Tiffany ST, Christen AG. Evaluation of the brief questionnaire of smoking urges (QSU-brief) in laboratory and clinical settings. *Nicotine Tob Res*. 2001;3(1):7–16. doi:10.1080/14622200020032051.

39. Webb TL, Sheeran P. Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychol Bull*. 2006;132(2):249–268. doi:10.1037/0033-2909.132.2.249.