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Pictorial Cigarette Pack Warnings Increase Some Risk Appraisals But Not Risk Beliefs: A Meta-Analysis

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Pictorial warnings on cigarette packs motivate smokers to quit, and yet the warnings' theoretical mechanisms are not clearly understood. To clarify the role that risk appraisals play in pictorial warnings' impacts, we conducted a meta-analysis of the experimental literature. We meta-analyzed 57 studies, conducted in 13 countries, with a cumulative N of 42,854. Pictorial warnings elicited greater cognitive elaboration (e.g., thinking about the risks of smoking; $d = 1.27$; $p < .001$) than text-only warnings. Pictorial warnings also elicited more fear and other negative affect ($d = .60$; $p < .001$). In contrast, pictorial warnings had no impact on perceived likelihood of harm ($d = .03$; $p = .064$), perceived severity ($d = .16$; $p = .244$), or experiential risk ($d = .06$; $p = .449$). Thus, while pictorial warnings increase affective and some cognitive risk appraisals, they do not increase beliefs about disease risk. We discuss the role of negative affect in warning effectiveness and the implications for image selection and warning implementation.

Keywords: Pictorial, Text, Warning, Risk Perception, Affect, Elaboration, Smoking

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Tobacco use is the leading cause of preventable death and disease in the world, causing nearly six million deaths each year (World Health Organization, 2013). While tobacco product packaging is a key part of marketing efforts to make tobacco use appealing (Moodie & Hastings, 2010; Wakefield, Morley, Horan, & Cummings, 2002), regulators can use that same packaging to communicate the health risks of tobacco products to consumers (Centers for Disease Control and Prevention, 2009). The World Health Organization Framework Convention on Tobacco Control has called

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for the implementation of large warnings on tobacco products, which may include pictures (World Health Organization, 2003). The implementation of pictorial (or graphic) warning policies have now been adopted in more than 100 countries and jurisdictions that are home to nearly 60% of the world's population (Canadian Cancer Society, 2016). A pack-a-day smoker potentially sees warnings an estimated 7,300 times per year (20 views/day x 365 days/year).

As pictorial cigarette pack warnings have proliferated globally, so has research on their impact. Recent work has suggested that pictorial warnings can change not only intentions to quit smoking (Noar et al., 2016b), but also smoking behaviors. For instance, in a large, randomized, controlled trial in which smokers' packs were labeled with pictorial or text-only warnings for 4 weeks ($N = 2{,}149$), smokers with pictorial warnings were more likely to report a quit attempt and sustained quitting by the end of the trial (Brewer et al., 2016). Moreover, syntheses of 32 observational studies conducted in 20 countries demonstrated that strengthening warnings—typically changing from text to pictorial—were associated with increased quit attempts and reductions in smoking prevalence (Noar et al., 2016a).

While the above work suggests that pictorial warnings are effective in motivating quitting behaviors, the theoretical mechanisms by which these warnings have impact require greater understanding. Because warnings' function is to communicate risk, they could change a variety of risk appraisals (Sheeran, Harris, & Epton, 2014), which we divide conceptually into two groups: risk beliefs and warning reactions. Risk perceptions or beliefs are central to many health behavior theories (Sutton, 1987; Weinstein, 1993), including the health belief model (Rosenstock, 1974), protection motivation theory (Rogers, 1975), and the extended parallel process model (Witte, 1992). These theories imply that to be effective, risk communications should increase smokers' beliefs about the likelihood of acquiring a disease (perceived likelihood) or their beliefs about the severity of disease (perceived severity). These risk beliefs tend to be cognitive in nature, particularly perceived likelihood, which refers to one's beliefs about the probability that one will acquire a disease. Pictorial warnings that include text that states that "smoking causes lung cancer," with an accompanying image of diseased lungs, may affect beliefs about perceived likelihood, perceived severity, or both.

More recently, theorizing has broadened the conceptualization of risk beliefs to be multi-faceted and to include constructs beyond the cognitively oriented risk beliefs described above (Ferrer, Klein, Persoskie, Avishai-Yitshak, & Sheeran, 2016; Kiviniemi et al., 2018). One example is the tripartite model of risk perception (Ferrer et al., 2016). While this model still acknowledges a role for cognitively oriented, deliberative risk beliefs, such as a perceived likelihood of harm (e.g., I am likely to develop lung cancer in the future), it also suggests that risk communications may work through experiential or affective beliefs. Experiential risk beliefs are not concerned with probabilistic judgements of risk, but rather feelings of vulnerability that are more akin to "gut-level reactions" about disease risk (e.g., "it is easy for me to imagine developing lung cancer"). Affective risk beliefs are concerned with emotional responses (e.g., fear) about the possibility of developing a disease (e.g., "I am fearful about developing lung cancer"). While tripartite risk beliefs are all focused on the possibility of acquiring a disease, the nature of the particular beliefs range from cognitive to experiential to affective. The lung cancer warning mentioned above could operate through either of these additional belief mechanisms, causing smokers to be concerned about (experiential risk) or scared of (affective risk) developing lung cancer.

While the above theoretical perspectives focus largely on beliefs about disease risk, other risk appraisals center on smokers' immediate responses to warnings, or what we refer to as warning reactions (Noar et al., 2016b). Since pictorial warnings often show graphic, gruesome, or upsetting images, negative emotions elicited by the warnings could be a key mechanism by which these warnings exert effects. The "risk-as-feelings" hypothesis suggests that emotional reactions better explain in-the-moment decision-making than cognitive assessments or beliefs (Loewenstein, Weber, Hsee, & Welch, 2001). Moreover, a longstanding body of literature has demonstrated the influence of emotion in health communication (Dillard & Nabi, 2006; Peters, Lipkus, & Diefenbach, 2006), especially fear as a theoretical (Leventhal, 1971) and empirical (Tannenbaum et al., 2015) motivator of behavior change. This perspective is focused not on beliefs about risk, but on warning-elicited emotions, such as fear, anxiety, sadness, and disgust (Brennan, Maloney, Ophir, & Cappella, 2017; Hall et al., 2018; Skurka et al., 2018). By eliciting discrete, negative emotions, pictorial warnings could directly activate action tendencies that result in behavior change (Nabi, 1999).

Another warning reaction is cognitive elaboration, or thinking about the risks of smoking. The elaboration likelihood model (Petty & Cacioppo, 1986) posits that cognitive elaboration is a key mechanism of persuasion, with central processing being more likely when receivers are both motivated and have the ability to process the message. Since pictorial warnings display risks that should be personally relevant to smokers, and on packages continually used by smokers, this results in repetition of the message and high message exposure (Noar et al., 2017). While smokers may be aware of some risks of smoking, such as lung cancer (Steptoe et al., 1995; Weinstein, Slovic, Waters, & Gibson, 2004), they may minimize or put those concerns out of their minds, and they are likely to be unaware of many other diseases caused by smoking (Weinstein et al., 2004). Pictorial warnings could be effective by acting as a constant reminder of the health threat posed by smoking (Brewer et al., 2018), increasing the salience of risks in the smoker's mind.

Above, we have identified individual cognitive and affective risk appraisal mechanisms that may account for warning effects, but it is also entirely plausible that multiple mechanisms may work in combination to produce warning effects. For instance, the extended parallel process model posits that risk communications first elicit risk beliefs (perceived likelihood and severity), which then lead to fear arousal (Witte, 1992), suggesting that risk appraisal is a cognitive and then affective process. From this perspective, warnings would only elicit negative affect among smokers who first perceive a health threat, supporting a process of risk beliefs driving negative affect. In contrast, other perspectives, such as the affect heuristic (Peters, Evans, Hemmerich, & Berman, 2016), suggest that emotional reactions are elicited first and that those emotions serve to influence information processes (Peters et al., 2006; Slovic, Finucane, Peters, & MacGregor, 2004). From this perspective, warnings elicit negative affect that may impact beliefs about smoking (Shi, Wang, Emery, Sheerin, & Romer, 2016) or beliefs about smoking's risks (Skurka et al., 2018). To date, empirical tests of such sequential processes in pictorial warnings have yielded differential results, with strong support for a primary role of negative affect and little or no support for a direct role of risk beliefs (Brewer et al., 2018; Hall et al., 2018; Skurka et al., 2018).

Our prior meta-analysis of experimental studies provided some hints of possible risk-related mechanisms of pictorial warnings (Noar et al., 2016b). We found that pictorial warnings elicited more negative affective reactions and cognitive elaboration than text-only warnings. We also found no impact of pictorial warnings on a perceived likelihood of harm. There were only a modest number of studies in those analyses, however, and we were unable to examine different types of negative affect or types of risk perceptions, due to a lack of available studies. Many relevant experiments testing the impact of pictorial warnings on risk-related outcomes have been published since we conducted our original meta-analysis. Therefore, to further advance our understanding of what role risk appraisals may play in the impact of pictorial warnings, we conducted a meta-analysis of the experimental literature on cigarette pack warnings.

Method

Search strategy

We used a comprehensive search strategy to locate studies relevant to this meta-analysis. We updated searches that were first conducted in April 2013 as part of our first meta-analysis of the impact of pictorial cigarette pack warnings in controlled experiments (Noar et al., 2016b) and again in April 2016 for a subsequent review of measures used in these experiments (Francis et al., 2017). For the current meta-analysis, in April 2018, we undertook a new search using the same parameters of the earlier searches. We searched PsycINFO, PubMed, Embase, Web of Science, Communication & Mass Media Complete, Business Source Complete, and CINAHL computerized databases. We used the following Boolean terms: (cigarette* OR tobacco) AND (warning* OR label* OR pictorial OR graphic OR messag* OR text*). We also examined the reference lists of the final set of articles included in our review. We included all reports that came up in our searches from 2016 forward—peer-reviewed journal articles, books chapters, and gray literature (e.g., dissertations, publicly available reports)—for which the full text was available.

To be included, a study had to use an experimental protocol that tested warnings intended for cigarette packs. Studies had to report data on both a pictorial warning condition and a text-only condition. Experimental designs could be between subjects (individuals were randomized to different warning label manipulation conditions; e.g., text versus pictorial) or within subjects (individuals viewed multiple warning label manipulations). We excluded studies of non-cigarette tobacco products, public service announcements or multi-component interventions, and warnings embedded in cigarette advertising. We excluded observational studies that asked individuals to report on warnings that they had seen on their own prior to the study. Articles reporting the studies had to be available in English.

To be included, a study also had to measure one or more forms of risk appraisals as a dependent variable, and these could be risk-related warning reactions or risk perceptions. We defined warning reactions as cognitive or emotional appraisals of risk in response to warnings. Specifically, we mean cognitive elaboration and negative affect (including fear, disgust, sadness, and guilt; see Table 1). We excluded measures primarily assessing unintended reactance to warnings (e.g., anger, irritation, annoyance). Risk perceptions are concerned with participants' beliefs about the risk of smoking-related disease: that is, the perceived likelihood of harm (also referred to as deliberative risk), perceived severity of harm, experiential risk, and affective risk (Table 1).

For the updated search, we initially identified over 4,000 total references. Removing duplicates reduced the number to 2,721 references (Figure 1). Two reviewers independently examined all study titles for relevance, reducing the number to 197, and then reviewed abstracts, further reducing the number to 41. During this process, we excluded articles only if both reviewers independently determined the article to not be relevant. Then, the two reviewers independently examined the full text of the 41 articles and tracked reasons for study exclusion. If the two reviewers made different determinations about an article, they consulted with the first author to resolve the discrepancy and make a final determination. This process identified 11 new articles, reporting on 17 independent samples. Combining these studies with studies that met the inclusion criteria from our previous reviews yielded 38 articles. Several articles reported the results of multiple studies or reported results separately for different subgroups, and we analyzed effect sizes for each independent sample. Thus, the meta-analysis synthesized the effects of 57 independent samples (see Supporting Information for the list of studies).

Coding study characteristics

Two independent reviewers coded articles on several features, including participant characteristics, such as gender, age, race/ethnicity, and country of origin, as well as study characteristics, such as within-/between-subjects designs and the use of theory. The reviewers also coded warning characteristics: the warning type (pictorial, text), nature of pictorial labels, whether the pictorial text and control text matched, number of different labels viewed, number of times viewing each label, number of exposure sessions, exposure medium (warning only, warning on two-dimensional pack, warning on three-dimensional pack), and label order (random, non-random).

Table 1 Risk Appraisal Outcomes Examined in the Meta-Analysis

Risk Appraisal Category and Construct	Definition	Example Item
Warning reactions		
Cognitive elaboration	Thinking about topics related to the warning's content, such as the harms of smoking or quitting	"When you notice your cigarette pack, how often do you think about the message that the warning conveys?" (Brewer et al., 2016)
Negative affect	Negative emotional reactions to the warning, such as fear or disgust	"While looking at the warning on this pack of cigarettes, I felt ... disgusted; fearful; guilty; regretful; sad ... " (Brennan et al., 2017)
Risk beliefs		
Perceived likelihood of harm (deliberative risk)	Beliefs that smoking cigarettes is likely to lead to smoking-related disease	"If I continue to smoke, I think my chances of getting a life-threatening illness because of smoking are ... " (Evans et al., 2017)
Perceived severity of harm	Beliefs that the health harms of smoking-related disease are serious	"Compared to other forms of cancer, the consequences of lung cancer are ... " (Nagelhout et al., 2016)
Experiential risk	Heuristic-based judgments about vulnerability to smoking-related disease	"How easy or hard is it to imagine having lung cancer?" (Pepper et al., 2013)
Affective risk	Affective responses to the possibility of developing smoking-related disease	Not assessed in this set of studies

Table 2 Participant and Study Characteristics of the Independent Samples in the Meta-Analysis

Variable	k	%
Age group		
Young adults and adults	29	50
Young adults only	14	25
Adolescents and young adults	6	11
Adolescents only	5	9
Adults only	3	5
Smoking status		
Smokers only	39	68
Non-smokers only	10	18
Mixed sample	8	14
Country		
United States	35	62
Other countries[a]	19	33
Multiple countries	3	5
Sampling		
Convenience	52	91
Probability	2	4
Not reported	3	5
Experimental design		
Between subjects	37	65
Within subjects	20	35
Used theory		
Yes	35	61
No	22	39
Theories used[b]		
Fear appeals	11	31
Extended parallel process model	8	23
Reactance theory	7	20
Cognitive dissonance	3	9
Theory of reasoned action	3	9
Communication model	3	9
Social identity theory	3	9
Commonsense model	2	6
Prototype willingness model	2	6
Other[c]	8	23

Note: $k = 57$. The age groups were categorized with adolescents as those 13–17 years, young adults as those 18–25 years, and adults as those 26+.

[a]Other countries include Belgium, Canada, France, Germany, Greece, Indonesia, Japan, Lebanon, Malaysia, Netherlands, Spain, and Thailand.

[b]These percentages were calculated only on the $k = 35$ that used a theory. The total sums to 50 because some used more than one theory.

[c]Other theories include affective response, dual processes model, exemplification theory, transportation theory, protection motivation, and framing.

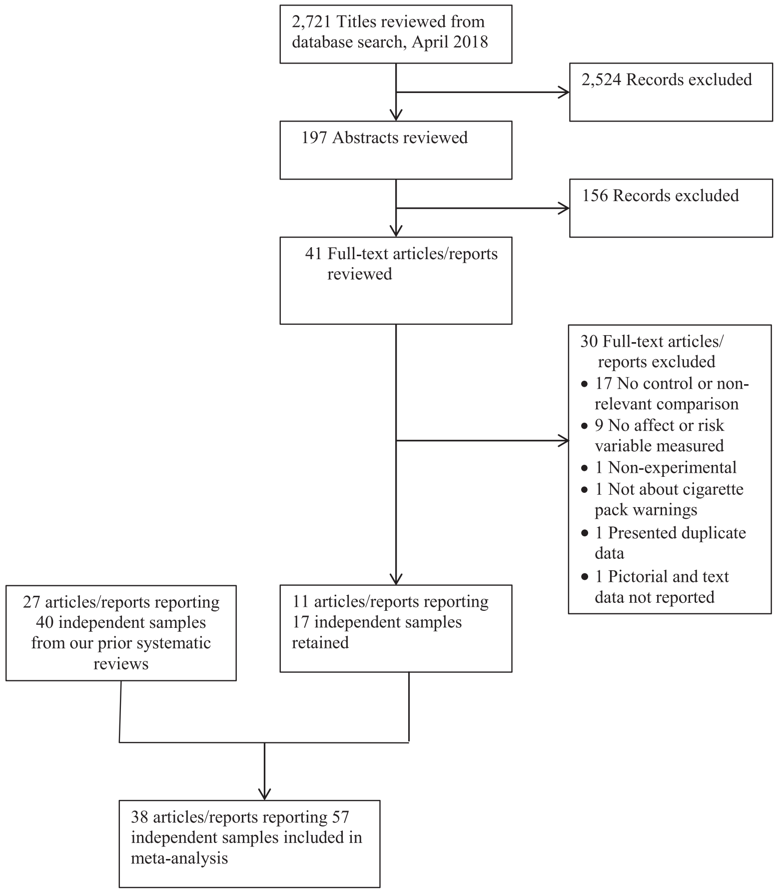

Figure 1 Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram showing the study screening process.

The reviewers and the first author met to discuss each article after it was coded to compare results. All discrepancies were resolved through discussion between the two reviewers and the first author. We calculated inter-coder reliability for each characteristic. Krippendorff's alpha ranged from .86 to 1.0 (percent agreement 93% to 100%). Most categories had perfect agreement.

Effect size extraction and calculation

We characterized the effect size of the benefit of pictorial over text warnings by using the standardized mean difference statistic (*d*; i.e., the difference in treatment and control means, divided by the pooled standard deviation; Lipsey & Wilson, 2001). Because *d* can be upwardly biased when based on small sample sizes (Hedges & Olkin, 1985), we applied the recommended statistical correction for this bias (Lipsey & Wilson, 2001). We calculated effect sizes from data reported in the article (e.g., means and standard deviations; frequencies) using standard formulas (Lipsey & Wilson, 2001). For within-subjects designs, using statistics such as *t* and *F* for effect size computation can bias effect size estimates (Dunlap, Cortina, Vaslow, & Burke, 1996), but using raw statistics, such as means and standard deviations, does not yield this bias (Dunlap et al., 1996; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). Thus, we applied conventional formulas (Lipsey & Wilson, 2001) and computed all within-subjects effect sizes from raw (but not inferential) statistics. If an article did not provide adequate data for an effect size computation, we requested the necessary data from authors.

We computed effect sizes for all outcomes of interest assessed in two or more studies. If studies reported data at more than one time point, we used the last time point reported for the effect size calculation. When studies reported multiple pictorial warning or text-only conditions, we averaged these (text or pictorial) conditions together when computing effects. When studies reported more than one measure of the same variable (e.g., two measures of perceived likelihood of harm), we averaged them together. In order to keep effect sizes consistent and interpretable, we gave a positive sign (+) to effect sizes in which the pictorial warning condition performed better (i.e., yielded a finding conducive to behavior change) than the text-only condition, and a negative sign (−) to effect sizes in which the pictorial warning condition performed worse than the text-only condition.

Meta-analytic approach

Analyses weighted effect sizes by their inverse variance and combined them using random effects meta-analytic procedures (Lipsey & Wilson, 2001). We calculated the Q statistic and I^2 to examine whether heterogeneity existed among the effect sizes. We performed exploratory moderator analyses using mixed-effects analyses, which allowed for the possibility of differing variances across subgroups (Lipsey & Wilson, 2001). We calculated effect sizes for hypothesized categorical moderators, along with their 95% confidence intervals, and we statistically compared those effect sizes using the Q_b statistic. We conducted all analyses using Comprehensive Meta-Analysis software Version 2.2.046, SPSS Version 24, and RStudio.

We examined moderators of negative affect—the only outcome that had both significant heterogeneity and an adequate number of studies for moderator analysis. We examined key characteristics of the samples, warnings, and study designs that we expected could plausibly affect the impact of warnings on this outcome. For instance, since some countries have not yet implemented pictorial warnings, participants in those countries might perceive pictorial warnings as more novel and, thus, respond with stronger emotional responses. Similarly, since warnings are designed for adult smokers, many of whom are addicted to nicotine, adult smokers may have stronger emotional reactions to pictorial warnings than younger people and non-smokers. In addition, the methods of exposure to warnings could lead to greater negative emotional responses to pictorial warnings versus text-only warnings, such as viewing the warning on a package (versus by itself) or viewing the warning in the context of a pack-carrying study (versus on a computer screen). Finally, study design factors could affect the impact of pictorial warnings on emotional reactions, such as convenience (vs probability) samples, pictorial text not matching the control text (vs matched text), and within-subjects (vs between-subjects) designs that have generally shown larger effect sizes in prior research (Noar et al., 2016b).

Results

Study characteristics

The 57 studies were conducted in 13 different countries, with most being conducted in the United States (62%; see Table 2). While the studies were published as early as 2006, a majority of the studies (54%) were published between 2015 and 2017. Of the study samples, 68% were of smokers only, 18% were of non-smokers, and 14% were of a mix of both smokers and non-smokers. Most studies (50%) included both young adults and adults (i.e., 18 years and older), but few studies examined adolescents. Only 11 studies (19%) included adolescents in their sample, with 5 studies (9%) focused solely on adolescents. Study sample sizes ranged from 30 to 4,890 (median = 280), and the cumulative sample size across all studies was 42,854. There were 35 studies (61%) that mentioned a theory as informing the study.

Studies varied considerably in how many different pictorial warnings (range = 1 to 18; $M = 6.47$, $SD = 5.05$) and text warnings (range = 1 to 18; $M = 4.96$, $SD = 4.79$) participants viewed. In most studies, participants viewed a warning only once (pictorial warnings, 80%; text warnings, 75%) and participated in only one viewing session (86%; Table 3). Most studies (77%) assessed participants immediately after viewing the warning labels. Of those that did not (23%), the assessment period ranged from 1 to 56 days. The most commonly used exposure medium for warnings (56%) was a two-dimensional pack. In 39% of studies, the text in the pictorial warning matched the text presented in the comparison condition, and in 47%, the text differed; five studies (9%) did not report this information.

Effects of pictorial warnings on warning reactions

Pictorial warnings led to stronger warning reactions than text-only warnings. Pictorial warnings exhibited large effects relative to text-only warnings on cognitive elaboration ($d = 1.27$; $p < .001$). Pictorial warnings also exhibited moderate-to-large effects on fear ($d = .89$; $p < .001$), fear with other negative affect ($d = .65$; $p < .001$), and other negative affect without fear ($d = .61$; $p < .001$). An overall analysis, including all negative affect data, also showed a moderate-sized effect ($d = .60$; $p < .001$). Figures 2 and 3 display effect sizes for cognitive elaboration and negative affect. Homogeneity analyses indicated that effect sizes for all variables exhibited heterogeneity (i.e., all had an I^2 of greater than 95; Table 4).

Table 3 Characteristics of Warning Manipulations in the Meta-Analysis

Variable	Pictorial		Text	
	k	%	*k*	%
Number of different warnings viewed				
1 warning	14	25	24	42
2+ warnings	43	75	32	56
Not reported	0	0	1	2
Number of times viewed each warning				
1 time	46	80	43	75
2–4 times	4	7	7	12
Not applicable (packs labeled)	6	11	6	11
Not reported	1	2	1	2
Number of exposure sessions				
1 session	49	86	49	86
2–4 sessions	2	3	2	3
Not applicable (pack labeled)	6	11	6	11
Days from exposure to assessment				
0 days (immediate assessment)	44	77	44	77
1–56 days	13	23	13	23
Exposure medium				
Warning on a 2D pack	32	56	32	56
Warning on a 3D pack	16	28	16	28
Just warning	6	11	6	11
Not reported	3	5	3	5
Label order				
Random	18	32	16	28
Fixed	6	11	6	11
Counterbalanced	2	3	2	3
Not reported	17	30	16	28
Not applicable (only showed one warning)	14	24	17	30
Pictorial text vs comparison text				
Did not match completely	27	47	–	–
Matched completely	22	39	–	–
Not reported	5	9	–	–
Not applicable (pictorial condition had no text)	3	5	–	–

Note: $k = 57$; 2D = 2 dimensional; 3D = 3 dimensional; k = number of independent samples.

Given the large number of negative affect studies ($k = 45$) and the heterogeneity across such studies, we performed moderator analyses. Non-U.S. studies in countries that did not require pictorial cigarette pack warnings ($d = .97$) had larger effect sizes than non-U.S. studies in countries that required pictorial warnings ($d = .61$) or studies conducted in the United States ($d = .48$; $Qb = 12.44$; $p = .002$; Table 5).

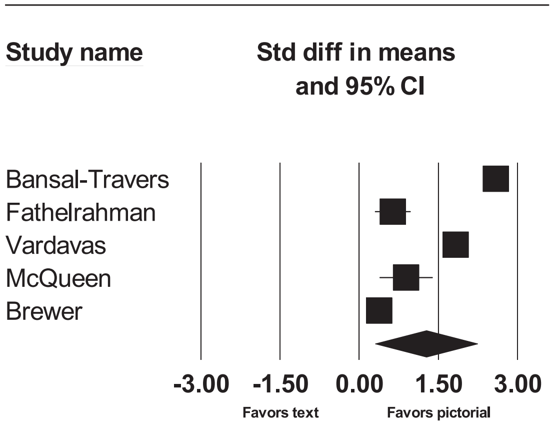

Figure 2 Cognitive elaboration: Forest plot of effect sizes and 95% confidence intervals.

Table 4 Impact of Pictorial Warnings on Risk Appraisals: Mean Weighted Effect Sizes and Heterogeneity Statistics

	N	*k*	*d*	95% CI	*p*	*Q*	*p*	I^2
Warning reactions								
Cognitive elaboration	4,279	5	1.27	[.30–2.24]	.01	604	<.001	99
Fear only	8,306	9	.89	[.58–1.21]	<.001	305	<.001	97
Fear with other negative affect	17,895	26	.65	[.47–.84]	<.001	812	<.001	97
Negative affect without fear	34,497	24	.61	[.47–.75]	<.001	663	<.001	97
Negative affect (overall)	45,280	45	.60	[.49–.71]	<.001	1047	<.001	96
Risk beliefs								
Perceived likelihood of harm	20,772	16	.03	[−.00 to .07]	.064	16	.349	9
Perceived severity of harm	2,773	3	.16	[−.11 to .44]	.244	13	.001	85
Experiential risk	1,011	3	.06	[−.1 to .21]	.449	3	.252	27

Note: CI, confidence interval; d = standardized mean difference (pooled effect size); k = number of effect sizes. This analysis includes all available data on negative affect. Since each sample can only contribute a single effect size to this analysis, multiple measures of negative affect within a single study were averaged together before computing this analysis.

Moderator analyses examining sampling method, sample population (adults vs youth), smoking status, warning exposure method, exposure medium, text matching, and study design found no differences.

Effects of pictorial warnings on risk beliefs

In contrast with warning reactions, pictorial warnings had no impact on perceived risk relative to text-only warnings. Pictorial warnings did not influence the perceived likelihood of harm ($d = .03$; $p = .064$; Figure 4), perceived severity of harm ($d = .16$;

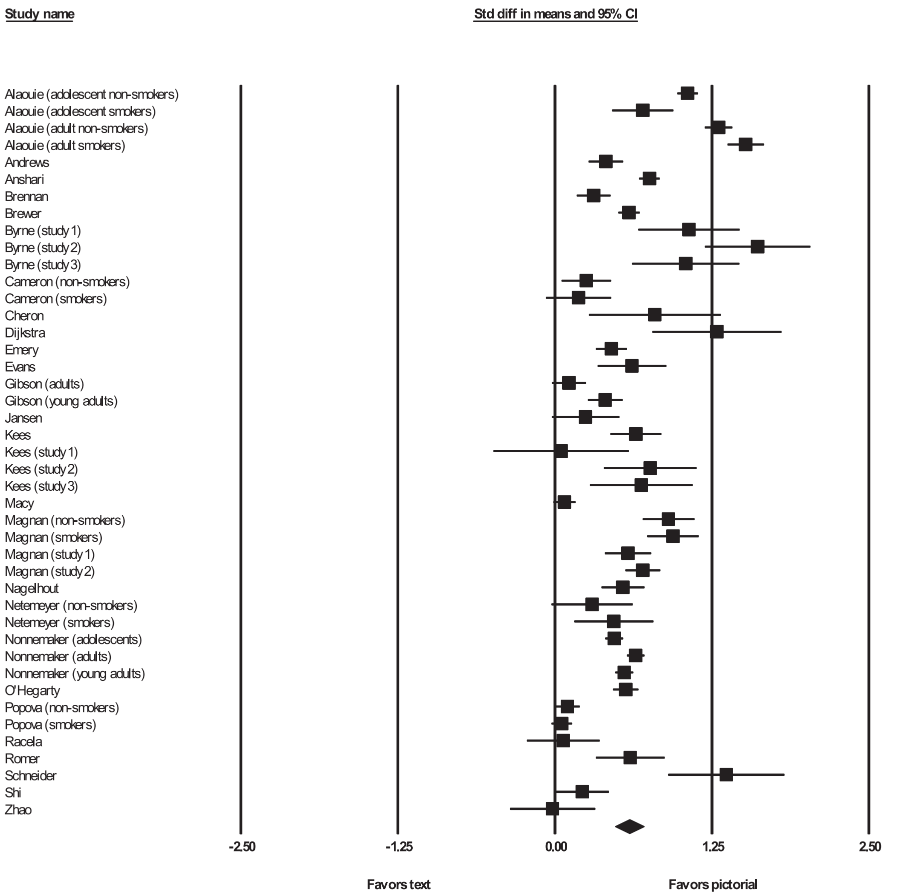

Figure 3 Negative affect (overall): Forest plot of effect sizes and 95% confidence intervals.

$p = .244$), or experiential risk ($d = .06$; $p = .449$). Homogeneity analyses indicated that only perceived severity of harm exhibited heterogeneity ($I^2 = 85$).

Discussion

A large body of experimental and observational research has revealed that warnings achieve their goal of motivating smokers to quit (Noar, Francis, et al., 2016; Noar, Hall, et al., 2016), but the risk appraisals underlying their impact have not been clearly understood. Across a corpus of international experiments, we found no effects of pictorial warnings on risk beliefs, including perceived likelihood of harm, perceived severity of harm, and experiential risk. In contrast, pictorial warnings led to stronger warning reactions, including fear, fear and other negative affect (e.g., guilt, sadness, disgust), and negative affect without fear. Pictorial warnings also led to greater

Table 5 Moderators of negative affect (overall)

	k	*d*	95% CI	Q_b	Q_b *p*-value
Country of sample	–	–	–	12.44	.002
Non-U.S. countries without pictorial warnings	9	.97*	[.72–1.23]	–	–
Non-U.S. countries with pictorial warnings	6	.61*	[.39–.82]	–	–
United States (no pictorial warnings)	29	.48*	[.38–.58]	–	–
Sampling	–	–	–	1.12	.282
Convenience	40	.61*	[.49–.73]	–	–
Probability	2	.34	[−.15–.82]	–	–
Population	–	–	–	.300	.585
Adults (18+)	27	.63*	[.47–.80]	–	–
Youth (13–25)	18	.57*	[.43–.72]	–	–
Smoking status	–	–	–	1.57	.457
Smokers	32	.59*	[.47–.70]	–	–
Non-smokers	8	.73*	[.37–1.10]	–	–
Mixed samples	5	.47*	[.26–.69]	–	–
Warning exposure method	–	–	–	.50	.478
Traditional experiment	41	.59*	[.47–.71]	–	–
Pack carrying	4	.67*	[.48–.86]	–	–
Exposure medium	–	–	–	4.24	.120
Warning on a 2D pack	26	.50*	[.39–.61]	–	–
Warning on a 3D pack	12	.73*	[.49–.98]	–	–
Warning only	4	.68*	[.45–.91]	–	–
Pictorial text vs comparison text	–	–	–	.13	.720
Not match completely	29	.61*	[.45–.78]	–	–
Matched completely	16	.58*	[.49–.67]	–	–
Study design	–	–	–	1.50	.221
Between subjects	27	.52*	[.43–.62]	–	–
Within subjects	18	.67*	[.45–.89]	–	–

Note: 2D = 2 dimensional; 3D = 3 dimensional; CI = confidence interval; *d* = standardized mean difference; *k* = number of studies. $^*p < .001$

cognitive elaboration, such as thinking about the health risks of smoking. Thus, our findings imply that warnings have impacts by eliciting immediate emotional (and to some extent, cognitive) warning reactions, rather than changing risk beliefs about likelihood or severity, as traditional risk perception theories would suggest (Rogers, 1975; Rosenstock, 1974; Witte, 1992).

It is somewhat surprising that pictorial warnings do not change risk beliefs more than text-only warnings, although this finding is consistent with an earlier meta-analysis (Noar et al., 2016b) and a large trial of pictorial warnings (Brewer et al., 2016; Brewer et al., 2018). Several possible explanations may account for these findings. First, while warnings provide risk information—typically in the form of “this

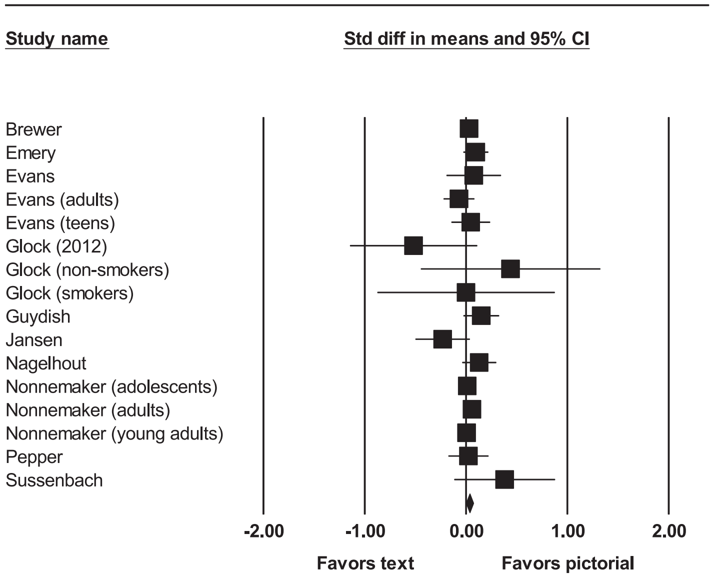

Figure 4 Perceived likelihood of harm: Forest plot of effect sizes and 95% confidence intervals.

behavior causes this illness"—they do not explicitly provide likelihood information. That is, warnings do not tell smokers how much more likely they are to develop a smoking-related illness relative to non-smokers. If warnings did provide such information, some argue that they could result in increases in perceived likelihood of harm (Nagelhout, Janssen, Ruiter, & de Vries, 2016), although there is no guarantee that the presence of likelihood information would lead to more effective warnings (Magnan, Koblitz, Zielke, & McCaul, 2009). In addition, pictorial warnings do appear to provide severity information in the form of graphic images that illustrate the negative consequences of smoking, and yet severity perceptions also did not change.

A second possibility is that likelihood beliefs among smokers are already high, resulting in a "ceiling" effect where such beliefs cannot or are unlikely to increase any higher. However, a close look at mean levels across our primary studies revealed that even though such beliefs were above the mid-point in some studies (Evans et al., 2015; Pepper, Cameron, Reiter, McRee, & Brewer, 2013), they were not at the very top of the scale even in those studies, leaving room for increases. Therefore, this explanation does not seem to be supported by the data. Furthermore, research has suggested that smokers underestimate some of the risks of smoking in terms of both knowledge and perceived likelihood (Oncken, McKee, Krishnan-Sarin, O'Malley, & Mazure, 2005), and yet warnings do not appear to change beliefs about the likelihood of disease.

A third explanation concerns the opposing roles of negative affect and reactance to warnings. Several pictorial warning experiments have shown that negative affect is associated with risk perceptions, which are then associated with quit intentions

(Evans et al., 2015; Hall et al., 2018; Skurka et al., 2018). These studies have suggested that risk perceptions may thus play an indirect role in influencing quit intentions, but only via negative affect. One of these studies, however, found that while negative affect was associated with greater perceived risk, reactance to the warnings (which is largely composed of anger) was simultaneously associated with less perceived risk (Hall et al., 2018). These results suggest that the opposing associations of negative affect and reactance on perceived risk may cancel one another out and help explain why pictorial warnings do not lead to observable changes in perceived risk. Importantly, none of these studies found that pictorial warnings directly influenced risk beliefs and, in that manner, they are consistent with the results we reported here.

Finally, it is possible that pictorial warnings increase risk perceptions to an equivalent amount as text-only warnings and, thus, no differences are seen between the two. Some observational studies have shown that when countries implement new pictorial warning content, knowledge (Green, Driezen, Noar, Hammond, & Fong, 2019; Noar et al., 2016a; Swayampakala et al., 2015) and recall (Noar et al., 2017) of those health risks increase. However, the existing literature, including observational studies (Hammond, 2011; Noar et al., 2016a), has provided little or no data to support the idea that risk perceptions increase after the implementation of pictorial warnings.

In contrast to the lack of impact of pictorial warnings on risk beliefs, pictorial warnings changed several forms of negative affect: fear only, fear and negative affect, and negative affect without fear. In addition, virtually none of our moderator analyses found differences, suggesting that negative emotional reactions are a fairly universal response to pictorial warnings. These findings—along with studies that have found support for the mediational role of negative affect (Brennan et al., 2017; Brewer et al., 2018; Yong et al., 2014)—make a compelling case that negative affect is a primary mechanism by which pictorial warnings have impact. The combination of these findings with those above tell an important story about how warnings have impact. That is, rather than prompting a cognitive reappraisal of beliefs about disease risk, warnings have impact by eliciting negative emotions that include fear, sadness, disgust, and worry, which may directly motivate smokers to change their behavior.

It is important to note that our findings do not imply that any warning could be effective by simply pairing warning text with an image that elicits negative emotions. One study examined the impact of pictorial warnings with emotionally evocative images that were irrelevant to smoking, finding them to be ineffective compared to pictorial warnings with relevant images (Shi et al., 2016). Moreover, studies have found that those images that are most congruent with the warning text are best recalled by smokers (Romer et al., 2017). Therefore, these studies, alongside our findings, suggest that negative affect is a productive process that helps smokers make meaning out of pictorial warnings, rather than simply an attempt to "scare" smokers from engaging in the behavior of smoking (Peters et al., 2016).

It is also worth noting that no studies examined affective beliefs about risk, as conceptualized in the tripartite model (Ferrer et al., 2016). Since affective responses to warnings (e.g., "the warning makes me feel scared") appear to play such a large role in their impact, it may be that affective risk beliefs also change (e.g., "I am fearful about developing lung cancer"). The distinction here is about the target of the negative affect: feeling fear in response to a warning versus feeling fear specifically about the possibility of acquiring a particular disease from smoking. Studies to date have tended to assess the more cognitively oriented risk beliefs, such as perceived likelihood of harm, perhaps because of their origins in traditional risk perception theories (Rogers, 1975; Rosenstock, 1974). Future studies on pictorial warnings should examine whether exposure to warnings changes affective risk beliefs, as well as what role those changes may play in the impact of warnings on quit intentions and cessation behavior.

Pictorial warnings changed cognitive elaboration, suggesting that warnings may also be effective by prompting smokers to think about the impact of smoking on their health. Smokers may deal with the dissonance caused by smoking by putting the health risks out of their minds, but pictorial warnings likely serve as a constant risk reminder. It is notable that since pictorial warnings are on a pack itself, they may be seen at the precise moment a smoker reaches into a pack to pull out a cigarette. This pairing of the message with the risk behavior may help account for the effects of warnings, serving as a reminder of the risks that a smoker is being exposed to at the right moment (Brewer et al., 2018). It is worth noting that few studies in our meta-analysis assessed cognitive elaboration, and yet it had the largest effect size of all outcomes that we examined. Thus, future studies of warnings' effects should measure cognitive elaboration.

Future research could further inform message design for pictorial warnings by providing prescriptions for the kinds of images that most elicit negative emotion and, thus, may have the most impact in the context of pictorial warnings. As noted above, images chosen for pictorial warnings should be highly relevant to the text (Shi et al., 2016) and also show congruency with the text to the greatest extent possible (Lochbuehler et al., 2017). Beyond that, studies have begun to more systematically examine features of pictorial warning images that may increase negative emotion and perceived effectiveness, which include graphic depictions of disease and images of people (Cameron, Pepper, & Brewer, 2015; Hammond et al., 2012; Sutton, Yang, & Cappella, 2019). Moreover, it is worth noting that as warnings research expands to additional tobacco products beyond cigarettes (Cornacchione Ross, Noar, & Sutfin, 2017), the question of risk appraisals will surely re-emerge. Since tobacco users tend to have different perceptions of risk for different products (Pepper, Emery, Ribisl, Rini, & Brewer, 2015), whether warnings change risk perceptions of other tobacco products is a question that future research should address.

Limitations

This meta-analysis had some limitations. First, as is common in meta-analyses, we only examined direct effects of warnings on our outcomes. Thus, we were unable to shed light on the relationships among warning reactions and risk beliefs. While several studies have found relationships among those variables (Evans et al., 2015;

Hall et al., 2018; Skurka et al., 2018), those studies and the current meta-analysis reveal that there appears to be no direct, causal effect of warnings on beliefs about disease risk. Second, the current meta-analysis examined only beliefs about disease risk and did not examine beliefs or attitudinal outcomes about smoking behavior, as that was beyond the scope of this review. One study found pictorial warnings to result in lower ratings of how smokers feel about smoking, relative to text-only warnings (Shi et al., 2016). This suggests that negative emotional arousal could change how smokers' feel about the smoking behavior itself, although other work has not supported this proposition (Brewer et al., 2018; Parada, Hall, Boynton, & Brewer, 2018). Whether pictorial warnings change beliefs about smoking, as well as whether negative affect plays a role in impacting those beliefs (Peters et al., 2016), may be increasingly understood through further research.

Implications for warning implementation

Our meta-analysis has implications for pictorial warning implementation. The World Health Organization Framework Convention on Tobacco Control, an international treaty, recommends that cigarette packs have pictorial warnings to communicate the harms of smoking. Currently, more than 100 countries and jurisdictions require pictorial cigarette pack warnings. Through the 2009 Family Smoking Prevention and Tobacco Control Act, U.S. law requires these warnings. However, the implementation of pictorial warnings in the United States has been stalled due to a 2012 lawsuit by the tobacco industry, in which the U.S. Court of Appeals for the District of Columbia Circuit ruled against the pictorial warnings proposed by the Food and Drug Administration (Kraemer & Baig, 2013). One concern (among others) raised by the court was the emotionally evocative nature of some of the images. Given that we have found evidence to support negative affect as a nearly universal response to pictorial cigarette pack warnings, what are the implications for warning implementation in the United States?

First, the evidence base for the effectiveness of pictorial warnings and their impact on key outcomes—including motivation to quit and quitting behaviors—has grown immensely since the 2012 court ruling. This evidence—including large-scale trials and meta-analyses—will help support implementation regardless of the theoretical mechanisms through which warnings have impact (Cappella, 2016). Second, studies are advancing the science and showing not only (as we have here) that negative affect is a major mechanism of warnings' impacts on intentions and behavior (Brennan et al., 2017; Brewer et al., 2018; Hall et al., 2018), but also that both "low emotion" pictorial warnings (Evans et al., 2016) and graphic, "high emotion" warnings with irrelevant images (Shi et al., 2016) are ineffective or may even backfire. Taken together, this research supports the implementation of pictorial warnings with relevant, graphic images, as long as the images depict factual, health consequences of smoking (Kraemer & Baig, 2013). Finally, a growing body of research supports the notion that the court's distinction between warnings as "factual" or "emotional" is a false dichotomy, as both text-only and pictorial warnings are both factual and emotional (Popova, Owusu, Jenson, & Neilands, 2018). In addition, negative emotional reactions to pictorial warnings increase recall of warning content (Evans et al., 2015; Shi et al., 2016) and are an important source of information about health hazards (Peters et al., 2016).

Conclusion

We sought to clarify the role of risk appraisals in pictorial warnings through a meta-analysis of experimental studies. We demonstrated that pictorial warnings elicited greater emotional and cognitive reactions than text-only warnings, but had no effects on risk beliefs. Our work advances a theoretical understanding of the mechanisms potentially underlying how warnings exert effects, providing guidance to governments and regulatory agencies tasked with developing and selecting warnings for implementation. Our findings suggest that warning designers should choose those pictorial warnings that most elicit negative emotions, including but not limited to fear. Our findings also advise selecting warnings that make smokers think about the risks of smoking, but caution that changing smokers' beliefs about their own health risks is not a goal of warnings nor a key mechanism by which warnings have impact.

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Supporting Information

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