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Effects of Strengthening Cigarette Pack Warnings on Attention and Message Processing: A Systematic Review

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Abstract

The current study sought to examine the impact of strengthening cigarette pack warnings on attention, message processing, and perceived effectiveness, through a systematic review of longitudinal observational studies. The review included 22 studies ($N = 81,824$ participants). Strengthened warnings increased attention to warnings, recall of warnings, and thinking about the health risks of smoking. Strengthened warnings also increased several perceived effectiveness outcomes, including perceptions that warnings reduce smoking and motivate quitting. Strengthened cigarette pack warnings achieve their goal of attracting attention and enhancing motivation to act. Strengthening warning policies should be a priority for tobacco control globally.

Keywords

warning, pictorial, graphic, smoking, global

Tobacco use is the leading cause of preventable disease and death in the world, causing nearly six million deaths each year (World Health Organization [WHO], 2013). Health effects of tobacco use include noncommunicable diseases such as cancer, cardiovascular disease, respiratory disease, and reproductive complications. Tobacco use can also

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exacerbate communicable diseases like tuberculosis and respiratory tract infections (U.S. Department of Health & Human Services, 2004; WHO, 2012). Globally, tobacco use is responsible for 71% of lung cancer deaths and 42% of chronic obstructive pulmonary disease cases (WHO, 2012). In the United States alone, cigarette smoking causes about one in five deaths, or more than 480,000 deaths per year (U.S. Department of Health & Human Services, 2014). Smoking also costs the United States an estimated US$96 billion in direct health care expenditures and US$97 billion in productivity losses each year (Centers for Disease Control and Prevention, 2012).

Cigarette pack warnings are a compelling communication strategy (Hammond, 2011). The combination of high exposure, nearly universal reach, and very low cost has made warnings a core tobacco control strategy globally. Warnings have evolved through several stages over the past four decades—from simple, vague messages on the side of packs to rotating messages on the front of packs focused on specific health effects, often accompanied by color pictures (Hiilamo, Crosbie, & Glantz, 2014). Current guidance from the WHO Framework Convention on Tobacco Control (FCTC) calls for large warnings on tobacco products, with implementation guidance suggesting the addition of pictures (WHO, 2003). While Canada was the first country to implement color pictorial warnings in 2001, by 2015 implementation of pictorial warnings had occurred in 77 countries and jurisdictions that are home to more than 50% of the world's population (Canadian Cancer Society, 2014); an additional 14 countries have finalized pictorial warnings and are preparing for implementation (Campaign for Tobacco-Free Kids, 2016). In the United States, the Food & Drug Administration (FDA) attempted to implement pictorial warnings as outlined in the 2009 Family Smoking Prevention and Tobacco Control Act (2009). To date, however, implementation has been thwarted by tobacco industry lawsuits (Kraemer & Baig, 2013).

Our systematic review examines whether strengthening cigarette pack warnings increases attention, message processing, and perceptions of warning effectiveness. We define *strengthened warnings* as cases where countries improve text warnings, implement pictorial warnings, or improve pictorial warnings. Strengthening warnings often involves several changes to warnings, as they are nearly always larger in size, are on the front (and back) of the cigarette pack, and are typically accompanied by an increase in the number of rotating warnings (i.e., new warning content). Strengthening warnings may more effectively motivate quitting smoking while reducing the appeal of the cigarette pack itself (Hammond, 2011; Noar, Hall, et al., 2016). However, to date, no systematic review has examined the impact of countries strengthening warnings on attention, message processing, and perceptions of warning effectiveness.

Literature Review

According to several communication theories (Kruglanski & Thompson, 1999; McGuire, 1989; Petty & Cacioppo, 1986), attention and cognitive processing are critical early processes in the attitude and behavior change process. For example, McGuire's (1989) persuasion model suggests that the earliest steps in the persuasion continuum consist of exposure and attention to a message; if a message is successful in those

early-stage processes, later-stage processes such as attitude and behavior change may occur. Conversely, in the absence of exposure and attention, a message will fail to have its intended impact given that the target audience will fail to process it. The elaboration likelihood model (Petty & Cacioppo, 1981) suggests that cognitive processing is a key mediating factor that leads to attitude change, with both the type and nature of cognitive processing affecting the extent to which attitude change may occur. These and other (Kruglanski & Thompson, 1999) theories suggest that to have an impact, a message must generate exposure, attract attention, and be processed by members of the target audience.

In the context of the current study, strengthening cigarette pack warnings—by enhancing their size, format, or location on the pack—may attract smokers' attention and elicit message processing. Accordingly, affecting these early-stage processes is, from a theoretical perspective, a prerequisite for behavior change (McGuire, 1989; Petty & Cacioppo, 1986); in the absence of such processes, it is unlikely that warnings will have downstream population-level effects on attitude, intention, and behavior change. Based on previous work in this area (Hammond, 2011; Noar, Hall, et al., 2016), we pose the following hypothesis:

H1: Strengthening cigarette pack warnings will increase attention and message processing.

The current review also examines whether smokers *perceive* that cigarette pack warnings have impact. A growing literature in communication (Brennan, Durkin, Wakefield, & Kashima, 2014; K. C. Davis, Nonnemaker, Duke, & Farrelly, 2013; Dillard, Weber, & Vail, 2007) demonstrates the utility of perceived message effectiveness, which are target audience perceptions of the persuasive potential of a message (Dillard et al., 2007). While perceived message effectiveness has been theoretically under-conceptualized (Yzer, LoRusso, & Nagler, 2015), such ratings of the persuasiveness of messages are widely used across extant health communication studies (Yzer et al., 2015), including cigarette pack warnings (Noar, Hall, et al., 2016). Perceived effectiveness is commonly applied during message pretesting (Atkin & Freimuth, 2013) in its prospective form, as a gauge of the potential future effectiveness of a message (i.e., How much *would* this message motivate you to quit smoking?). Studies demonstrate that warnings vary greatly on perceived message effectiveness, and such data are used to choose particular warnings for implementation (Huang, Thrasher, Reid, & Hammond, 2016; Nonnemaker, Choiniere, Farrelly, Kamyab, & Davis, 2015). Evidence that messages rated more highly on perceived effectiveness have greater impact on attitudes (Dillard et al., 2007), behavioral intentions (K. C. Davis et al., 2013), and even behavior (Brennan et al., 2014) suggest that perceived message effectiveness may have predictive validity.

Perceived message effectiveness can also be applied retrospectively, by asking participants how much they think a given message has affected them (i.e., In the past 30 days, how much *has* the warning on your cigarette pack motivated you to quit smoking?). While lab-based experimental warning studies have commonly used *prospective*

perceived effectiveness (Noar, Hall, et al., 2016), *retrospective* perceived effectiveness has tended to be applied in the observational literature. Such studies examine the extent to which people *believe* the warnings on their cigarette packs have made them think about the health risks of smoking, motivated them to try and quit, or led them to forego cigarettes. Based on previous work (Hammond, 2011; Noar, Hall, et al., 2016), we pose the following hypothesis:

H2: Strengthening cigarette pack warnings will increase perceived message effectiveness.

Meta-analysis of experimental studies has demonstrated that pictorial cigarette pack warnings are superior to text warnings in attracting attention and stimulating cognitive elaboration, and they are consistently perceived as more effective than text warnings (Noar, Hall, et al., 2016). However, the ecological validity of these studies remains uncertain due to the fact that they typically consist of single exposures to warnings on a computer screen (but not smokers' own packs), in the context of an experimental paradigm. However, for an examination of real-world impact, a synthesis of population-level studies is needed. Longitudinal investigations have examined warning effects when countries have strengthened their warning policies; while, in many cases, this constitutes a change from text to pictorial warnings, some countries have strengthened text warnings (e.g., moved text from side to front of pack) or strengthened pictorial warnings (e.g., increased their size).

The purpose of our study was to evaluate the longitudinal impact of strengthened cigarette pack warnings by cumulating the findings of longitudinal observational studies. By synthesizing this global literature, we sought to understand whether strengthening cigarette pack warnings impacts warning attention, message processing, and perceived effectiveness.

Method

Search Strategy

We used a comprehensive search strategy to locate studies relevant to this systematic review. The search strategy involved five steps. First, we searched PsycINFO, PubMed, Embase, Web of Science, and Business Source Complete computerized databases in February 2014. We used the following terms: (cigarette* OR tobacco) AND (warning* OR label* OR pictorial OR graphic). Second, we examined the reference sections of six narrative reviews of cigarette pack warnings (Centers for Disease Control and Prevention, 2011; R. Davis, Gilpin, Loken, Viswanath, & Wakefield, 2008; Hammond, 2011; Hammond, Wakefield, Durkin, & Brennan, 2013; Monarrez-Espino, Liu, Greiner, Bremberg, & Galanti, 2014; National Cancer Institute, 2009). Third, we examined the reference lists of the final set of articles included in our review. Fourth, we searched the first 100 results of our search terms in both Google Scholar and Google. Fifth, we contacted the authors of the final set of articles and posted on five

health communication and tobacco listservs (e.g., Society for Research on Nicotine and Tobacco) to request additional published or unpublished studies. All studies were considered for inclusion—including unpublished/gray literature as well as non-English study reports.

The review had three inclusion criteria. First, a study had to be observational and report data on the impact of a change in the implementation of national cigarette pack warning policy. Second, a study had to report data from at least one assessment (self-report or otherwise) before the change in warning policy and at least one assessment during or after implementation of the change. Third, a study had to report one or more outcomes from the attention and recall, warning reactions, social reactions, or perceived effectiveness categories from the *message impact framework* (Noar, Hall, et al., 2016). Studies that assessed knowledge, attitudes/beliefs, and behaviors were excluded as they were the basis for a separate, companion review article (Noar, Francis, et al., 2016).

Two trained reviewers independently examined all study titles for the 6,241 references we identified (Figure 1), reducing the number to 1,215. They then reviewed abstracts, further reducing the number to 87. During this process, we excluded articles only if both reviewers independently determined the article to not be relevant. The two reviewers independently examined the full text of 87 articles and tracked reasons for study exclusion. If the two reviewers made a different determination about a particular article classification, they consulted with a third referee to resolve the discrepancy (by discussing the disagreement and allowing the third referee to weigh in) and make a final determination. This process identified 21 articles reporting on 22 independent samples.

Article Coding

Study characteristics. Two authors independently coded all articles on several features relevant to this review, including *study characteristics* such as country of policy change and control country (if any) and *sample characteristics* such as age range, income level, and smoking status (Online Appendix 1). The researchers also coded *study design characteristics* such as sample size, sampling and data collection mode, response rate, and design type (Online Appendixes 1 and 2), as well as *warning policy characteristics* such as previous warning description, new warning description, dates of policy implementation, number of warnings on pack, and whether the new warnings met WHO warning criteria (Online Appendix 3).

All discrepancies between coders were resolved through discussion between the two coders and the first author. We calculated intercoder reliability for each characteristic. Most categories had perfect agreement, and mean Cohen's kappa was .93.

Summarizing study findings. We developed a list of outcome variables assessed in warning label studies, with definitions for each, based on the literature and our previous work in this area (Noar, Hall, et al., 2016). We summarized the main results of studies on each of these outcome variables, noting which findings were statistically

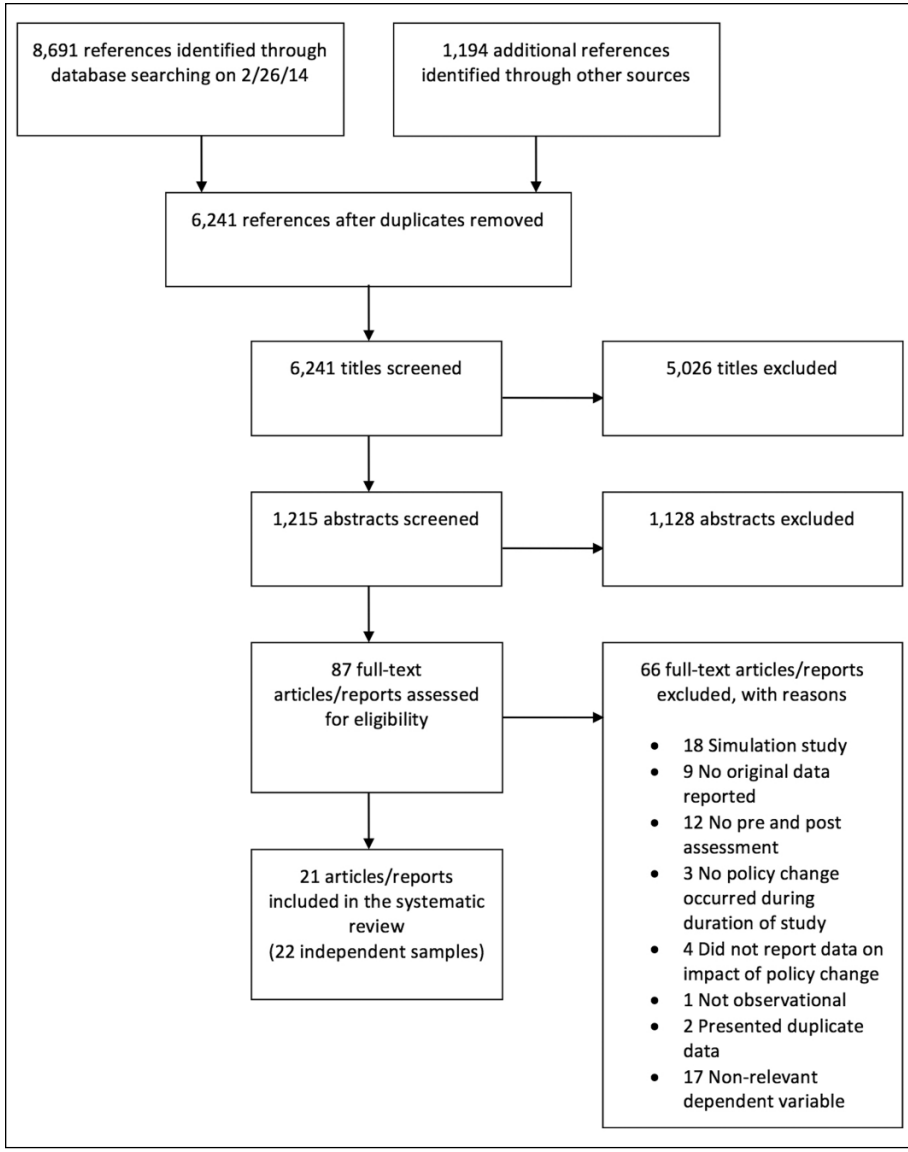

Figure 1. PRISMA flow diagram showing the study screening process.

significant (Online Appendix 4). For the few studies that did not report significance tests (Agar, Craig, Fong, & Quah, 2014; Environics Research Group, 2005; Fathelrahman et al., 2013; Wardle et al., 2010; Zhang et al., 2011), we computed significance tests when the necessary data were reported (Lipsey & Wilson, 2001).

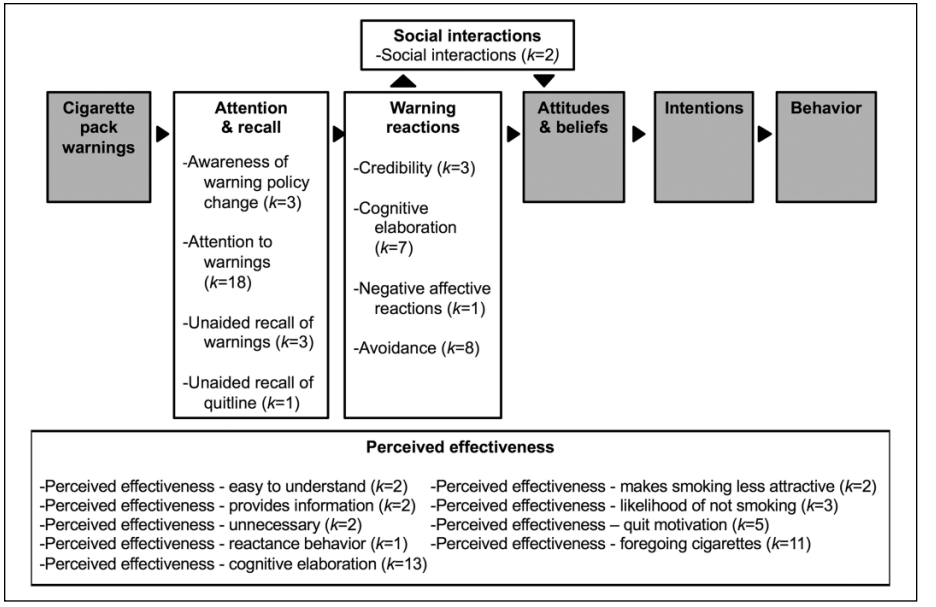

Figure 2. Message impact framework showing outcomes assessed in the set of studies.

Pooled results. We extracted quantitative data directly before and after warning implementation in cases where we had five or more observations and where data were reported in a form that allowed for synthesis. These data represented pre–post changes in intervention countries only. For studies that assessed a construct with multiple measures (e.g., two measures of attention), we averaged the measures together. Also, the extracted data represented the top two response categories of a given variable, as these data were nearly always reported. For example, for attention in Hammond et al. (2007), we extracted the percentage of people who said they noticed or read the warnings "often" or "very often," the top two response categories in the Likert-type response scale (Hammond et al., 2007). For each outcome, we weighted the before, after, and difference proportions by their inverse variance using the logit method and computed random-effects meta-analytic models (Lipsey & Wilson, 2001).

When reporting results, we organized outcome variables using the message impact framework (Figure 2). The first group of outcomes (*attention/recall*) consisted of awareness of warning policy change, attention to warnings, and unaided recall (i.e., asking participants what the warnings say, with no prompts or cues). The second group of outcomes (*warning reactions*) consisted of credibility, cognitive elaboration, negative affective reactions, and avoidance. A third group consisted of social interactions. Finally, perceived effectiveness consisted of a number of perceptions of the warnings—namely, whether they were easy to understand, provided information, caused reactance, enhanced cognitive elaboration, made smoking less attractive, decreased the

likelihood of smoking, increased motivation to quit or stay quit, led to foregoing of cigarettes, and were generally effective. We characterized a change as an increase or decrease that was statistically significant ($p < .05$) in the original study or in our own calculations.

Results

The 22 studies were published between 1997 and 2014, with a median publication year of 2011. Studies were conducted in 11 different countries; the most common were Australia (26%), the United Kingdom/England (20%), Canada (14%), and the United States (12%). The United States was always included as a control country; the next most common control country was Canada (three of five were as a control). All but a single study examined one intervention country; the remaining study had two intervention countries (Borland et al., 2009). While most studies (72%) had no control country, 14% had one, 4% had two, and 10% had three control countries (Table 1).

Most studies (96%) used probability sampling. The most common data collection mode was phone (50%) followed by in-person interview (26%). The most common data type was panels (same participants over time; 50%) or multiple cross-sectional (36%); 14% used both types of data. The cumulative sample size across all studies was $N = 81{,}824$. Studies most commonly examined young adults/adults (50%), although 32% of studies also included adolescents. Only 14% of studies were solely adolescents. While just under half (46%) of studies were of smokers, 50% were of both smokers and nonsmokers, and 4% were of former smokers. Only 18% of studies reported including low-income participants.

The most common policy change was from text to pictorial warning (67%). One study, however, examined the change from pictorial to strengthened pictorial warning (4%), when Australia increased the size of their pictorial warnings from 30% to 75% of the pack face (Zacher et al., 2014). Other studies (29%) examined the change from text to strengthened text, such as when the United Kingdom strengthened text from 6% to 30% on the front and from 6% to 40% on the back of the pack (Hammond et al., 2007). Only one study (of Australia) examined the implementation of plain packs along with strengthened pictorial warnings (Zacher et al., 2014).

When countries implemented new warnings, they also tended to increase the number of warnings that rotated on packs. The mean number of warnings pre–policy change was 5.92 ($SD = 2.84$), whereas post–policy change, it was 10.79 ($SD = 8.6$). Policy changes typically allowed countries to meet the WHO warning criteria. That is, after policy changes took place, all countries had warnings in the country's principal language and on the front and back of packs, while 91% covered at least 30% of the pack and 68% had color pictorials. Also, while English was the most common language for warnings (55%), several warnings were in other languages (23%) or appeared in both English and another language (18%).

Studies ranged from a low of two data points (58%) to a high of nine data points (4%). The mean number of data points across studies was 3.00 ($SD = 1.69$), whereas the mean number of months between data points was 12.00 ($SD = 6.67$).

Table 1. Characteristics of Studies (k = 22) in the Systematic Review.

Variable	*k*	%
Age		
Young adults and adults	11	50
Adolescents, young adults, and adults	7	32
Adolescents only	3	14
Not reported	1	4
Smoking status		
Smokers and nonsmokers	11	50
Smokers only	10	46
Former smokers	1	4
Country[a]		
Australia	9	26
The United Kingdom/England	7	21
Canada	4	12
The United States	4	12
Thailand	3	9
China	2	6
Malaysia	2	6
Other countries (Mexico, Taiwan, Iran)	3	9
Number of intervention countries per study		
One	21	96
Two	1	4
Number of control countries per study		
None	16	72
One	3	14
Two	1	4
Three	2	10
Sampling		
Probability	21	96
Convenience	1	4
Data collection mode		
Phone survey	12	50
In-person interview	7	26
Paper survey	2	10
Observations by field-worker	1	4
Study design		
Multiple cross-sectional (different people)	8	36
Panel (same people) with replenishment	6	27
Panel (same people)	5	23
Both (panel and multiple cross-sectional)	3	14
Number of data points		
2	13	58
3+	9	42

(continued)

Table 1. (continued)

Variable	*k*	%
Warning policy change[b]		
Text to pictorial	15	65
Text to strengthened text	7	31
Pictorial to strengthened pictorial	1	4
Plain packs implemented with warnings change		
No	21	96
Yes	1	4
Warning language		
English only	12	55
Non-English only	5	23
English and non-English language	4	18
Not reported	1	4
WHO warning criteria		
Appear in country's principal language	22	100
No less than 30% of principal display	20	91
Appear on front and back of pack	22	100
Color pictorial	15	68

Note. WHO = World Health Organization.
[a]The country category sums to 34 because some studies included more than one country (this count includes both intervention and control countries). Control countries were the United States (*k* = 4), Canada (*k* = 3), Malaysia (*k* = 2), Australia (*k* = 1), and the United Kingdom (*k* = 1).
[b]Warning policy change sums to 23 because one study reported policy changes for two intervention countries (Partos, Borland, Yong, Thrasher, & Hammond, 2013).

Effects of Warning Policy Changes

Attention and recall. Three studies—from Australia, Canada, and Iran—assessed awareness of the warning policy change. Awareness increased in Australia after strengthening text warnings in 1995 (Borland & Hill, 1997), as well as in Canada (Environics Research Group, 2005) and Iran (Heydari, Ramezankhani, & Talischi, 2011) after implementation of pictorial warnings in 2001 and 2009, respectively (Table 2).

Eighteen studies assessed one or more forms of attention, and 15 studies showed increases in attention to the warnings. Fourteen studies assessed attention in the form of *noticing* the warnings, of which 12 showed increases in noticing. Noticing the warnings increased after implementation of pictorial warnings in eight studies (Chang, Chung, Yu, & Chao, 2011; Environics Research Group, 2005; Hammond et al., 2007; Miller, Quester, Hill, & Hiller, 2011; Partos, Borland, Yong, Thrasher, & Hammond, 2013; Thrasher, Perez-Hernandez, Arillo-Santillan, & Barrientos-Gutierrez, 2012; Wardle et al., 2010; Yong et al., 2013) and after strengthening text warnings in four studies (Agar et al., 2014; Borland, 1997; Hassan, Shiu, Thrasher, Fong, & Hastings, 2008; Li et al., 2014).

Table 2. Impact of Change in Cigarette Pack Warning Policy: Attention and Message Processing.

Study and country	Aware	Attention	Recall	Credibility	Cognitive elaboration	Negative affect	Avoidance	Social interactions
Agar, Craig, Fong, and Quah (2014)—China	—	↑	—	—	—	—	✗	—
Borland (1997)—Australia	—	↑	—	—	✗	—	—	—
Borland and Hill (1997)—Australia	↑	—	↑	—	—	—	—	—
Borland et al. (2009)—Australia	—	↑	—	—	—	—	↑	—
Chang, Chung, Yu, and Chao (2011)—Taiwan	—	↑	—	—	—	—	—	—
Environics Research Group (2005)—Canada	↑	↑	—	—	—	—	—	—
Fathelrahman et al. (2013)—Thailand	—	✗	—	—	—	—	↑	—
Hammond et al. (2007)—The United Kingdom	—	↑	—	—	—	—	—	—
Hassan, Shiu, Thrasher, Fong, and Hastings (2008)—The United Kingdom	—	↑	—	—	↓	—	—	—
Heydari, Ramezankhani, and Talischi (2011)—Iran	↑	—	—	—	—	—	—	—
Li et al. (2014)—China	—	↑	—	—	—	—	—	—
Miller, Quester, Hill, and Hiller (2011)—Australia	—	↑	↑	—	—	—	—	—
Moodie, Mackintosh, and Hastings (2013)—The United Kingdom	—	✗	↑	↑	↑	—	—	✗
Partos, Borland, Yong, Thrasher, and Hammond (2013)—Australia	—	↑	—	—	—	—	—	—
Silpasuwan et al. (2008)—Thailand	—	—	—	—	✗	—	—	—
Thrasher, Perez-Hernandez, Arillo-Santillan, and Barrientos-Gutierrez (2012)—Mexico	—	↑	—	—	—	—	—	—
Wardle et al. (2010; adolescents)—England	—	↑	—	✗	↑	—	↑	—
Wardle et al. (2010; adults)—England	—	↓	—	✗	✗	↑	↑	—
White, Webster, and Wakefield (2008)—Australia	—	↑	—	—	↑	—	—	↑
Yong et al. (2013)—Thailand	—	↑	—	—	—	—	↑	—
Zacher et al. (2014)—Australia	—	—	—	—	—	—	↑	—
Zhang et al. (2011)—Australia	—	↑	—	—	—	—	↑	—

Note. Shaded rows are those studies that examined text-to-pictorial warning changes; all other studies examined strengthened text warnings except Zacher et al. (2014) which examined strengthened pictorial warnings. — = not assessed in study; ↑ = statistically significant increase ($p < .05$); ✗ = no change; ↓ = statistically significant decrease ($p < .05$).

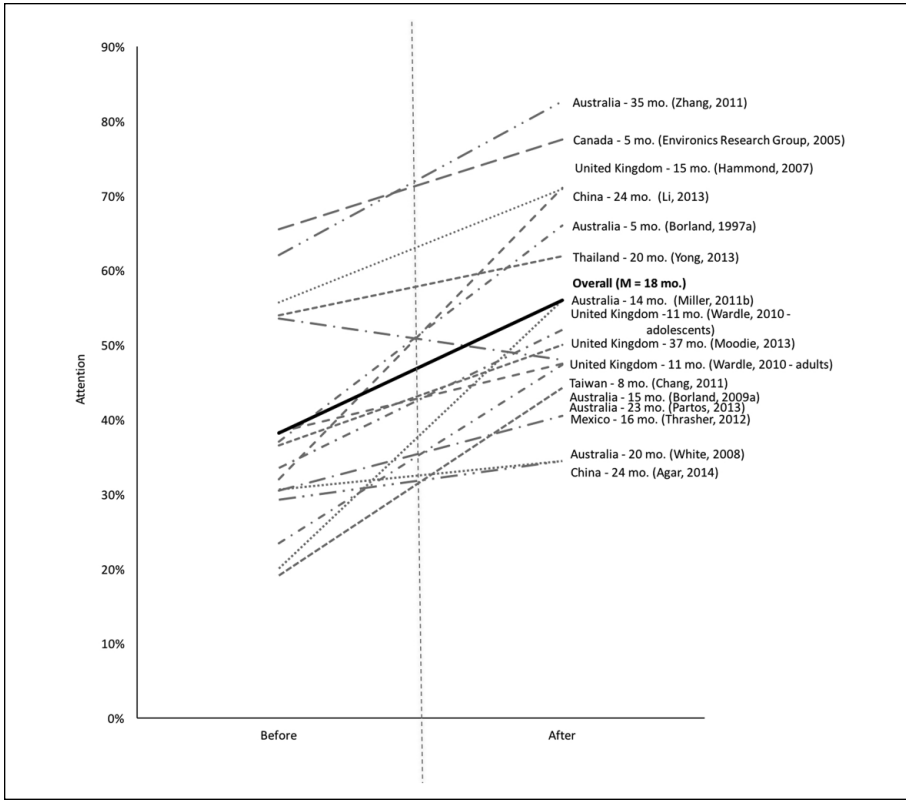

Figure 3. Attention to warnings before and after implementation of strengthened warnings.

Of the nine studies assessing *looking at* and *reading* the warnings, seven observed increases, one observed a decrease, and one observed no change. For instance, looking at and reading the warnings increased after Australia (White, Webster, & Wakefield, 2008), Mexico (Thrasher et al., 2012), Thailand (Yong et al., 2013), and the United Kingdom/England (Moodie, Mackintosh, & Hastings, 2013; Wardle et al., 2010) implemented pictorial warnings, as well as after China strengthened text warnings (Agar et al., 2014). Three studies assessed a composite of noticing, looking at, and reading the warnings (Borland et al., 2009; Fathelrahman et al., 2013; Zhang et al., 2011); two of the studies observed increases (Borland et al., 2009; Zhang et al., 2011). Across all forms of attention in 16 studies that provided suitable data, attention increased from 38% before implementation to 56% after implementation of strengthened warnings (Figure 3). This represented a statistically significant absolute increase of 16% (47% relative increase), which was statistically heterogeneous, indicating variability among the effect sizes (Table 3).

Three studies assessed unaided recall of the warnings, and all three studies showed increases in unaided recall of some text and pictorial warnings (Borland & Hill, 1997; Miller et al., 2011; Moodie et al., 2013). Typically, recall of *new* warnings increased in

Table 3. Effectiveness of Strengthening Cigarette Pack Warnings: Mean Weighted Effect Sizes.

Outcomes	*k*	*n*	%	95% CI	*p*	*Q*	*p*	I^2
Attention	16							
Before		32,343	.38	[.32, .45]	.001	2,216	.001	99
After		31,687	.56	[.47, .64]	.17	3,057	.001	100
Difference		—	.16	[.10, .23]	.001	1,016	.001	99
Cognitive elaboration	5							
Before		5,272	.21	[.12, .34]	.001	375	.001	99
After		5,294	.29	[.18, .45]	.01	454	.001	99
Difference		—	.07	[.03, .10]	.001	22	.001	82
PE: Cognitive elaboration	9							
Before		18,499	.31	[.20, .43]	.003	1,801	.001	100
After		18,148	.45	[.28, .64]	.62	3,292	.001	100
Difference		—	.14	[.05, .23]	.002	752	.001	99
PE: Foregoing cigarettes	9							
Before		19,554	.18	[.11, .28]	.001	750	.001	100
After		19,122	.23	[.16, .31]	.001	940	.001	99
Difference		—	.04	[.01, .06]	.005	88	.001	91

Note. *k* = number of effect sizes; *n* = number of participants; % = weighted proportion (pooled effect size). When the differences analyses were computed only with studies that examined text-to-pictorial changes, results did not substantively change and were as follows: attention (.15 [.09, .20], $p < .001$, $k = 12$), cognitive elaboration (.08 [.02, .13], $p < .01$, $k = 4$), PE—cognitive elaboration (.15 [.04, .26], $p < .01$, $k = 7$), and PE—foregoing cigarettes (.03 [−.02, .08], $p = .17$, $k = 6$). PE = perceived effectiveness; CI = confidence interval.

these studies, whereas recall of warnings that were phased out or retained from older warnings decreased. For example, unaided recall that new warnings had text that said smoking causes emphysema, mouth and throat cancer, and peripheral vascular disease; smoking clogs your arteries; and smoking is a leading cause of death all increased after Australia implemented their first set of pictorial warnings in March 2006 (Miller et al., 2011). Miller et al. (2011), however, found decreases in unaided recall (of older warnings) that had text that said smoking causes heart disease and lung cancer after Australia implemented their second set of pictorial warnings in November 2006. Moodie et al. (2013) observed that unaided recall that warnings had (new) images of healthy/diseased lungs, rotten teeth, and neck tumors increased after the United Kingdom implemented pictorial warnings in 2008, whereas unaided recall that warnings had text (retained in the newer warnings) that said smoking kills and smoking seriously harms you and others around you decreased. Unaided recall of the quitline number, assessed in one study, increased in Australia after implementation of pictorial warnings in 2006 (Miller et al., 2011).

Warning reactions. Three studies assessed credibility (believability and perceived truthfulness), all from the United Kingdom/England (Moodie et al., 2013; Wardle et al., 2010). Moodie et al. (2013) found mixed results: Perceived truthfulness of the warnings

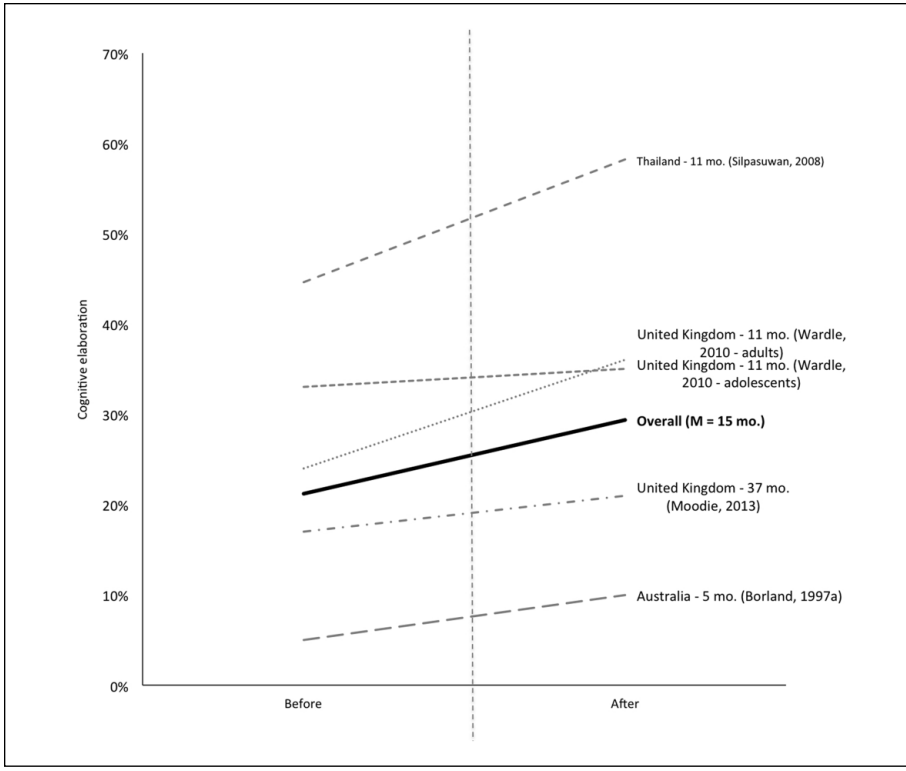

Figure 4. Cognitive elaboration before and after implementation of strengthened warnings.

increased, but believability did not increase after the United Kingdom implemented pictorial warnings in 2008. Wardle et al. (2010) found no change in perceived truthfulness among adults or adolescents after England implemented pictorial warnings in 2008.

Seven studies assessed cognitive elaboration, including thinking about the warnings, thinking about smoking harms, and thinking about quitting. Cognitive elaboration increased in three of seven studies (Moodie et al., 2013; Wardle et al., 2010; White et al., 2008), and decreased in one study (Hassan et al., 2008). There were no changes in three studies (Borland, 1997; Silpasuwan et al., 2008; Wardle et al., 2010). Studies that did see increases were in the wake of implementation of pictorial warnings in Australia (White et al., 2008), England (Wardle et al., 2010), and the United Kingdom (Moodie et al., 2013). Across five studies that provided suitable data, cognitive elaboration increased from 21% before implementation to 29% after implementation of strengthened warnings (Figure 4). This represented a statistically significant absolute increase of 7% (38% relative increase), which was statistically heterogeneous, indicating variability among the effect sizes (Table 3).

Only one study assessed negative affective reactions. Wardle et al. (2010) observed an increase in worry that smoking may damage future health and no change in worry

that smoking would lower quality of life after the United Kingdom implemented pictorial warnings in 2008.

Avoidance of the warnings increased in seven of eight studies (Borland et al., 2009; Fathelrahman et al., 2010; Wardle et al., 2010; Yong et al., 2013; Zacher et al., 2014; Zhang et al., 2011). For example, Zacher et al. (2014) found that concealing the pack and putting the cigarette in a case or tin increased after Australia strengthened pictorial warnings and implemented plain packaging in 2012. Two studies from Thailand assessed avoiding looking at the warnings, and both found increases after implementation of pictorial warnings in 2005 (Fathelrahman et al., 2013; Yong et al., 2013). However, Agar et al. (2014) did not find changes in avoiding (looking at and thinking about) the warnings after China strengthened text warnings in 2008.

Social interactions. Two studies assessed social interactions, both using adolescent samples. One study from Australia found an increase in talking about the warnings after implementation of pictorial warnings in 2006 (White et al., 2008). A study from the United Kingdom did not find changes in talking after implementation of pictorial warnings in 2008 (Moodie et al., 2013).

Perceived effectiveness. Sixteen studies assessed one or more forms of perceived effectiveness (Table 4). Perceptions that the warnings were easy to understand—assessed in two studies—decreased among adults in England but did not change among adolescents after implementation of pictorial warnings in 2008 (Wardle et al., 2010). The perception that the warnings provide information about the risks of smoking—assessed in two studies—increased among adults in England but did not change among adolescents after implementation of pictorial warnings in 2008 (Wardle et al., 2010). Perceptions that the warnings are unnecessary—assessed in two studies—decreased among adults in England but did not change among adolescents after implementation of pictorial warnings in 2008 (Wardle et al., 2010). Among adolescents in Australia, White et al. (2008) found no change in perceived effectiveness of the warnings to make me have a cigarette—an indication of reactance behavior—after implementation of pictorial warnings in 2006.

Thirteen studies assessed perceived effectiveness of the warnings to make me think about quitting or about smoking harms (perceived effectiveness—cognitive elaboration). Of those, 11 studies showed increases (Borland et al., 2009; Chang et al., 2011; Hammond et al., 2007; Hassan et al., 2008; Partos et al., 2013; Thrasher et al., 2012; Wardle et al., 2010; White et al., 2008; Yong et al., 2013; Zhang et al., 2011). For example, perceived effectiveness of the warnings to make me think about *quitting smoking* increased after implementation of pictorial warnings in Taiwan, Mexico, and Australia (Chang et al., 2011; Thrasher et al., 2012; Wardle et al., 2010; White et al., 2008) and strengthened text warnings in the United Kingdom/England (Hammond et al., 2007; Hassan et al., 2008). Perceived effectiveness of the warnings to make me think about the *health risks of smoking* increased after implementation of pictorial warnings in Taiwan (Chang et al., 2011), Australia (Partos et al., 2013), Mexico (Thrasher et al., 2012), and Thailand (Yong et al., 2013). Across the nine studies that provided suitable data, perceived effectiveness—cognitive elaboration increased from 31% before implementation to 45% after implementation of strengthened warnings

Table 4. Impact of Change in Cigarette Pack Warning Policy: Perceived Effectiveness.

Study and country	Easy to understand	Provides information	Unnecessary[a]	Reactance behavior[a]	Cognitive elaboration	Makes smoking less attractive	Likelihood of not smoking	Quit motivation	Foregoing cigarettes
Agar, Craig, Fong, and Quah (2014)—China	—	—	—	—	X	—	—	↑	—
Borland (1997)—Australia	—	—	—	—	—	—	—	—	↑
Borland et al. (2009)—Australia	—	—	—	—	↑	—	—	—	↑
Chang, Chung, Yu, and Chao (2011)—Taiwan	—	—	—	—	↑	—	—	—	—
Fathelrahman et al. (2013)—Thailand	—	—	—	—	X	—	—	—	X
Hammond et al. (2007)—The United Kingdom	—	—	—	—	↑	—	—	—	↑
Hassan, Shiu, Thrasher, Fong, and Hastings (2008)—The United Kingdom	—	—	—	—	↑	—	—	—	↑
Moodie, Mackintosh, and Hastings (2013)—The United Kingdom	—	—	—	—	—	—	↑	—	X
Partos, Borland, Yong, Thrasher, and Hammond (2013)—Australia	—	—	—	—	↑	—	—	↑	—
Silpasuwan et al. (2008)—Thailand	—	—	—	—	—	—	—	↑	—
Thrasher, Perez-Hernandez, Arillo-Santillan, and Barrientos-Gutierrez (2012)—Mexico	—	—	—	—	↑	—	—	—	—
Wardle et al. (2010, adolescents)—England	X	X	X	—	↑	↑	↓	—	—
Wardle et al. (2010, adults)—England	↓	↑	↓	—	↑	↑	↑	X	↑
White, Webster, and Wakefield (2008)—Australia	—	—	—	X	↑	—	—	—	↑
Yong et al. (2013)—Thailand	—	—	—	—	↑	—	—	↑	↑
Zhang et al. (2011)—Australia	—	—	—	—	↑	—	—	—	↑

Note. Shaded rows are those studies that examined text-to-pictorial warning changes; all other studies examined strengthened text warnings except Zacher et al. (2014) which examined strengthened pictorial warnings. — = not assessed in study; X = no change; ↑ = statistically significant increase ($p < .05$); ↓ = statistically significant decrease ($p < .05$).
[a]Decreases on these outcomes indicate beneficial warning effects.

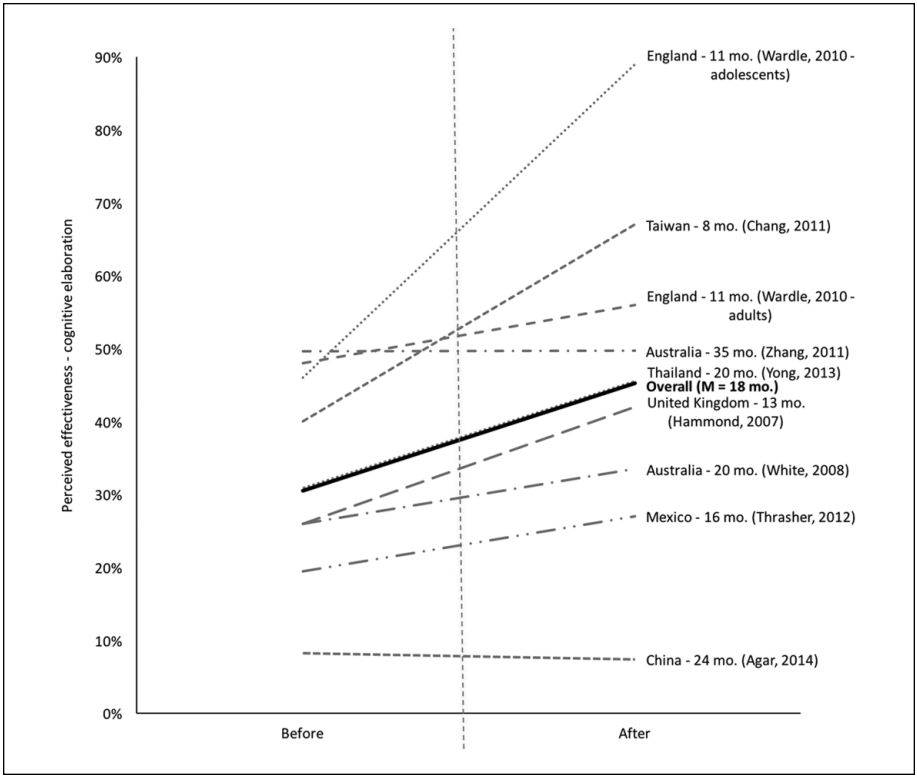

Figure 5. Perceived effectiveness—Cognitive elaboration before and after implementation of strengthened warnings.

(Figure 5). This represented a statistically significant absolute increase of 14% (45% relative increase), which was statistically heterogeneous, indicating variability among the effect sizes (Table 3).

Wardle et al. (2010) found increases in perceptions that the warnings make smoking seem less attractive among adult and adolescent samples in England after implementation of pictorial warnings in 2008. Perceptions that the warnings make people smoke less or discourage people from smoking increased among adolescents after the United Kingdom/England implemented pictorial warnings in 2008 (Moodie et al., 2013). Perceptions that the warnings had *no* impact on smoking behavior decreased among both adolescents and adults (Wardle et al., 2010).

Perceived effectiveness of the warnings to motivate quitting or maintenance of quitting increased in four of five studies (Agar et al., 2014; Partos et al., 2013; Silpasuwan et al., 2008; Wardle et al., 2010; Yong et al., 2013). For example, perceived effectiveness of the warnings to make one want to quit smoking increased after Thailand implemented pictorial warnings in 2005 (Silpasuwan et al., 2008; Yong et al., 2013). Perceived effectiveness of the warnings to make one stay quit also increased

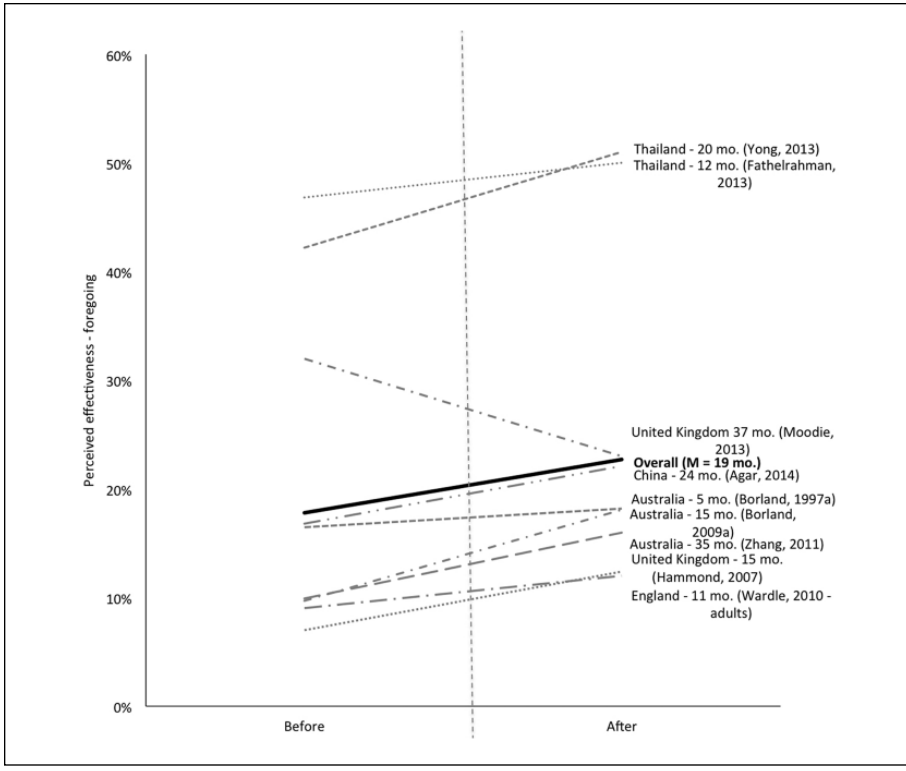

Figure 6. Perceived effectiveness—Foregoing before and after implementation of strengthened warnings.

after China strengthened its text warnings in 2008 (Agar et al., 2014). However, Wardle et al. (2010) found that perceived effectiveness of the warnings to make one want to quit did not change among adults in England after implementation of pictorial warnings in 2008.

Perceived effectiveness of the warnings to make one forego cigarettes increased in eight of 10 studies (Borland, 1997; Borland et al., 2009; Hammond et al., 2007; Hassan et al., 2008; Wardle et al., 2010; White et al., 2008; Yong et al., 2013; Zhang et al., 2011). For instance, perceived effectiveness to make one forego cigarettes increased after Thailand (Yong et al., 2013), Australia (Borland et al., 2009; White et al., 2008; Zhang et al., 2011), and England (Wardle et al., 2010) implemented pictorial warnings in 2005, 2006, and 2008, respectively. Fathelrahman et al. (2013), however, observed no change in perceived effectiveness to increase foregoing after Thailand implemented pictorial warnings in 2005. Across the nine studies that provided suitable data, perceived effectiveness—foregoing increased from 18% before implementation to 23% after implementation of strengthened warnings (Figure 6). This represented a statistically significant increase of 4% (28% relative increase), which was statistically heterogeneous, indicating variability among the effect sizes (Table 3).

Discussion

Across this international body of literature, we found significant support for the proposition that enhancing cigarette warnings increases warning attention and stimulates message processing. We also found significant support for the notion that strengthening cigarette warnings increases perceptions of warning effectiveness. These findings strongly suggest that the way in which we communicate with smokers about the health risks of smoking is consequential; that is, strengthening warnings appears to fundamentally change the way in which smokers attend to, process, and perceive the warning information on their packs.

A key first goal of any health message is to gain attention, as message exposure is critical for garnering effects (McGuire, 1989; Niederdeppe, Avery, Byrne, & Siam, 2014). Our results strongly suggest that strengthening warnings increases attention at the population level. While most of the evidence in our review comes from countries that newly implemented pictorial warnings, there was also evidence that strengthening text warnings (e.g., moving from side to front of pack and increasing size) may increase attention. Furthermore, although our pre–post effects were fairly dramatic, studies demonstrate that attention to warnings ultimately decreases over time as smokers become habituated to warning content (Borland et al., 2009; Hammond et al., 2007; Hitchman, Driezen, Logel, Hammond, & Fong, 2014). However, even with these reductions, research suggests attention levels remain higher than they were before implementation of strengthened warnings (Borland et al., 2009; Hammond et al., 2007). Moreover, given that countries are likely to make only a limited number of major warning policy changes, another way to increase attention to warnings may be to rotate in a new set of warnings under the current policy. This may help sustain the effects of cigarette warnings over time (Abascal et al., 2012; Miller et al., 2011).

We also saw effects of strengthened warnings on message processing. One key effect that we observed was on cognitive elaboration, which refers to thinking about the warnings, the health effects of smoking, or of quitting. We also saw clear effects on perceived effectiveness—cognitive elaboration. The distinction we draw is that cognitive elaboration refers to smokers' reports of thinking about the warnings, harms of smoking, or quitting. In contrast, the perceived effectiveness variable refers to smokers' reports that *the warnings made them think about these topics*; that is, the participant is asked to make an attribution about the impact of the warning. While we found effects on both impact and perceived impact, effects were larger for *perceived* cognitive elaboration. It may be that smokers' *perceptions* of elaboration (perceived effectiveness) were overestimates, and that cognitive elaboration is a more accurate assessment of this variable. This interpretation is consistent with our previous experimental meta-analysis of pictorial warnings in which we found that the *perception* that warnings motivate "me" to quit smoking was larger than actual changes in quit intentions sparked by the warnings (Noar, Hall, et al., 2016). The cognitive elaboration findings are important given that several studies have illustrated that (perceptions of) cognitive elaboration may mediate the effects of warnings on quit attempts (Brewer et al., 2016; Fathelrahman et al., 2013; Thrasher, Abad-Vivero, et al., 2016).

Our results also consistently demonstrated that strengthened warnings increased avoidance. Avoidance can take many forms, including trying not to look at or think about the warnings, as well as behaviors such as covering up the warnings or not buying packs with particular warnings on them. What is intriguing is that avoiding warnings does *not* appear to be an indicator that they are ineffective, and it may even be a marker for impact. For instance, several studies have provided evidence that avoidance does *not* undermine the efficacy of pictorial cigarette warnings, finding a similar impact of warnings among both avoiders and nonavoiders (Hammond, Fong, McDonald, Brown, & Cameron, 2004; Peters et al., 2007). Moreover, one recent study found that avoidance was significantly *positively* associated with attention to warnings, cognitive elaboration, plans to quit, and quit attempts (Thrasher, Abad-Vivero, et al., 2016). Thus, while avoidance has not, on its own, been identified an indicator of warning effectiveness, it does not appear to undermine effectiveness, and in some cases, it may be an indicator that a warning is having impact.

We saw consistent findings of the impact of strengthened warnings on a range of perceived effectiveness outcomes. Participants perceived that strengthened warnings (a) provided information about the risks of smoking, (b) were necessary, (c) made one think about smoking health risks, (d) made smoking less attractive, (e) decreased the likelihood of smoking, (f) increased quit motivation, and (g) made one more likely to forego cigarettes. Virtually all of these findings were in countries that newly implemented pictorial warnings, and they illustrate the value that smokers themselves see in pictorial cigarette pack warnings. Although it is unclear whether perceived effectiveness plays a direct role in the attitude and behavior change process, prospective perceived effectiveness assessments appear to provide valuable information about messages (Huang et al., 2016). For example, at the aggregate level, messages that are rated as more effective are more likely to have greater impact on attitudes (Dillard et al., 2007), quit intentions (Bigsby, Cappella, & Seitz, 2013; K. C. Davis et al., 2013), and smoking behavior (Brennan et al., 2014). While the meaning of retrospective perceived effectiveness measures is less clear, the fact that so many of them increased (concomitant with strengthening warnings) adds to the evidence that strengthening warnings increases their impact (Hammond, 2011; Noar, Hall, & Brewer, 2015; Noar, Hall, et al., 2016). The increases we observed suggest that such measures tell us something meaningful; indeed, it may be that messages that perform poorly on perceived effectiveness have little chance of having *actual* impact on individuals or populations, while higher (aggregate) perceptions of effectiveness are an indicator that messages are likely to have impact. These findings are consistent with experiments that have briefly exposed participants to pictorial warnings in controlled experiments and found increases across a range of perceived effectiveness outcomes (Noar, Hall, et al., 2016).

The meta-analyses we report here provide additional precision as to the size of effects that may result from strengthening warnings. They also revealed heterogeneity of effects across studies and countries; this indicates the need for future research to better understand what factors may lead to greater impact (e.g., particular changes in warning size, content, or format; particular samples or subgroups for which warnings work best). Moreover, the results of the current review, in concert with our companion review (Noar, Francis, et al., 2016), suggest that warnings may have impact according to a

hierarchy-of-effects as proposed by McGuire (1989). The current study found that after implementation of strengthened warnings, attention had an absolute increase of 18% and cognitive processing increased 7% to 14%. Our companion review suggests that after implementation of strengthened warnings, quit attempts had an absolute increase of 4% and smoking prevalence decreased by 2% (Noar, Francis, et al., 2016). At the population level, these are important effects. However, these data suggest that warnings may operate according to a hierarchy-of-effects, with the largest increases in attention and message processing and smaller impact on smoking behaviors. One implication of this is the importance of maximizing attention and messaging processing of warnings given the apparent reduced level of impact at each stage of the hierarchy. Such a hierarchy-of-effects is consistent with effects observed in recent large-scale smoking cessation campaigns (McAfee, Davis, Alexander, Pechacek, & Bunnell, 2013).

Implications for Global Warning Policy

Our findings, as well as other recent work (Brewer et al., 2016; Noar, Francis, et al., 2016; Noar, Hall, et al., 2016), strongly suggest that strengthening warning policies should be a priority for tobacco control globally. While at least 77 countries and jurisdictions have implemented pictorial warnings (Canadian Cancer Society, 2014), many countries still have weak warning policies. Countries that have weaker text warnings should implement larger, more prominent warnings on the front and back of the pack, preferably accompanied by graphic images (i.e., pictorial warnings). This includes the United States where implementation of federal law requiring pictorial warnings has been stalled by tobacco industry lawsuits (Kraemer & Baig, 2013). In addition, the many countries with pictorial warnings should consider ways to strengthen those warnings, including increasing their size and ensuring that a quitline number is prominently featured on the cigarette pack (Miller, Hill, Quester, & Hiller, 2009; Noar, Francis, et al., 2016).

Countries across the globe are also innovating their cigarette packaging policies, and this is a promising trend. For example, in 2012, Australia became the first country in the world to implement a "plain packaging" policy where cigarette packs no longer have brand imagery and a large pictorial warning covers most of the face of the pack (Zacher et al., 2014). Uruguay (in 2010) banned differentiated branding such that each tobacco company can only distribute one type of cigarettes (i.e., no sub-brands), in an attempt to reduce the perception that some cigarette types are less harmful than others (Abascal et al., 2012). Finally, in addition to being the first country to implement color pictorial warnings in 2001, Canada has now required cigarette pack inserts with messages encouraging smokers to quit (Thrasher, Swayampakala, et al., 2016). These and other innovations are important steps forward in strengthening labeling policy and ultimately reducing tobacco's global burden of disease and death.

Limitations

A key limitation of our review was that studies were observational in nature; thus, it is possible that other unknown factors contributed to changes in variables assessed in

these studies, and most studies had no comparison groups. Although these study designs reduced our ability to make firm causal conclusions, the real-world context of the studies is a strength, as previous meta-analytic work has only demonstrated the efficacy of pictorial warnings in controlled experimental contexts (Noar, Hall, et al., 2016). Our review extends this previous work by demonstrating the longer term impact of warnings after real-world implementation in numerous countries. Another limitation has to do with variations in researchers' selection, conceptualization, and measurement of outcome variables (including timing of measurement), which may contribute to additional between-study variability in findings. Studies varied greatly with regard to the number of outcomes assessed, and thus, varying levels of data were available for different outcomes of interest. This limitation lessened our ability to make firm conclusions about some variables, such as negative affect (assessed in one study) and social interactions (assessed in two studies), in the context of policies strengthening cigarette pack warnings.

Conclusion

Cigarette pack warnings, especially pictorial warnings, are an important global tobacco control policy. Our review suggests that strengthening cigarette pack warnings increases attention to warnings, message processing, and perceptions of warning effectiveness. Strengthening cigarette pack warnings should be a priority for tobacco control globally, including in the United States where federal law requires implementation of pictorial warnings on cigarette packs.

Authors' Note

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health (NIH) or the Food & Drug Administration (FDA).

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