

## Research paper

# Effective package warning label systems for communicating relative risks of cigarettes, heated tobacco products, and e-cigarettes: An experimental study with Korean adults



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## ABSTRACT

**Background:** Warning labels are a fundamental public health strategy for communicating about tobacco product risks, but effective warning labels for heated tobacco products (HTPs) and e-cigarettes (ECs) are yet to be determined. We examined the effect of two warning label systems for communicating the relative risks of using cigarettes, HTPs, and ECs.

**Methods:** 1,280 Korean adults were recruited from an online commercial panel, including susceptible non-users of cigarettes, HTPs, or ECs aged 19 to 29 ( $n = 444$ ) and current users of these tobacco products aged 19 or older ( $n = 836$ ). Participants viewed packages for cigarettes, HTPs, and ECs in a  $2 \times 2$  between-subject experiment: “dashboard” icons integrated into warnings vs. no dashboard; different-sized warnings (70% of cigarette packages, 50% of HTP packs, 30% of EC packages) vs. current equal-sized warnings (50% of cigarette/HTP/EC packages).

**Results:** Participants exposed to the dashboard warning system were more likely than those who were not to report higher perceived harm of cigarettes than ECs, cigarettes than HTPs, and HTPs than ECs, as well as perceived benefit of switching from cigarettes to HTPs, cigarettes to ECs, and HTPs to ECs. Participants exposed to the different-sized warning system did not report differences in perceived relative harm or benefit compared to those who were not, and no interaction of dashboard warnings with warning sizes was found.

**Conclusion:** The use of dashboard icons with texts and colors representing different levels of risk may promote public understanding about the continuum of risk across tobacco products.

## Introduction

Due to their low cost and broad reach, warning labels on tobacco products are a fundamental public health strategy for communicating about tobacco product risks. Cigarette warning labels, for example, promote smokers’ understanding of smoking-related risks and cessation behaviors (Cho et al., 2018; Noar, Francis et al., 2016; Yong et al., 2014). In recent years, the tobacco landscape has dramatically changed with the introduction of novel tobacco products, such as e-cigarettes (ECs) and heated tobacco products (HTPs). The rapid growth of ECs and HTPs (Caputi, 2017; Glasser et al., 2017) makes it critical to develop warning labels for ECs and HTPs, but most studies on warning labels have focused on cigarettes, and to a lesser extent, on smokeless tobacco (Ross, Noar, & Sutfin, 2017). While the long-term health effects of HTPs and ECs are still largely unknown, some agencies such as U.S. Food and Drug Administration

have proposed positioning them on a “continuum of risk” relative to cigarettes, where cigarettes present the highest level of exposure to harmful chemicals to the user, with current evidence indicating that HTPs present lower exposures and ECs even lower than that (Leigh, Palumbo, Marino, O’Connor, & Goniewicz, 2018; Leigh, Tran, O’Connor, & Goniewicz, 2018; Stephens, 2018; U.S. Food & Drug Administration, 2020). We aimed to investigate how tobacco warning labels can be used to communicate this continuum of risk while at the same time conveying the idea that all these products are harmful.

Among studies on the effects of warning labels for ECs, most assessed effects on perceived risk of each product separately (Andrews, Mays, Netemeyer, Burton, & Kees, 2019; Berry, Burton, & Howlett, 2017; Bono, Barnes, Lester, & Cobb, 2019; Lee et al., 2016; Mays, Smith, Johnson, Tercyak, & Niaura, 2016; Popova & Ling, 2014; Sanders-Jackson, Schleicher, Fortmann, & Henriksen, 2015). A few studies

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of message effects on perceived *relative* risk found that warnings either increased perceptions that ECs are less harmful than cigarettes (Pepper, Byron, Ribisl, & Brewer, 2017; Yang & Popova, 2020; Yang, Owusu, & Popova, 2018) or did not have any effect (Wackowski et al., 2019). Warning label design elements relevant to relative risks such as size and visual images could enhance the warning label effectiveness (Noar, Hall et al., 2016), but no study has examined their effects or warning label systems that compare more than two tobacco products.

This study uses “dashboard” icons as a novel warning label strategy for communicating the relative risk of tobacco products. Although not empirically tested, health communication literature suggests that “dashboard” icons could effectively communicate relative risks, especially when combined with explanatory text and anchoring information such as arrows (Nelson, Hesse, & Croyle, 2009). Tobacco warning label literature suggests using colors on warnings to attract visual attentions (Lempert & Glantz, 2016; Wackowski, Hammond, O'Connor, Strasser, & Delnevo, 2017). According to food labeling studies, the traffic light system using color codes representing different levels of nutrients, promotes consumer understanding of the relative healthiness of food products (Kunz, Haasova, Rieß, & Florack, 2020; Talati et al., 2017).

Varying the size of warning labels may improve communication about the relative risk of tobacco products by making it easier for consumers to notice and process risk information. Observational studies, for example, have consistently shown that larger warnings strengthen beliefs about the harms of smoking (Borland & Hill, 1997; White, Webster, & Wakefield, 2008; White, Guerin, Williams, & Wakefield, 2019), although it is difficult to solely examine the effect of warning size in these studies because the effect is confounded with simultaneous introduction of graphic warning images. Experimental studies have also found that larger warnings attract more attention (Bansal-Travers, Hammond, Smith, & Cummings, 2011; Klein et al., 2015; Skurka et al., 2017) and increase cognitive elaboration about health risks (Bansal-Travers et al., 2011) or perceived harm (Kotnowski, Fong, Gallopel-Morvan, Islam, & Hammond, 2015). These studies, however, examined the size of warning labels for cigarettes only and excluded other tobacco products, leaving it unknown whether varying the size of warnings among other tobacco products can effectively inform public about relative risks.

Korea provides an ideal setting to test the effects of warning label systems communicating the relative risks of cigarettes, HTPs, and ECs, as it is one of the few countries where all three tobacco products are available and widely used (Kang & Cho, 2019; Kim et al., 2018; Kwon et al., 2019). More than 60% of Korean adult smokers report the perception that ECs are equally or more harmful than cigarettes – a percentage that is substantially higher than most other high-income countries, including Australia, Canada, England and the US (McNeill, Brose, Calder, Bauld, & Robson, 2018), consistent with negative news media environment around ECs in Korea (Kim, Thrasher, Kang, Cho, & Kim, 2017). The recent spike in HTP sales in Korea (Euromonitor, 2019) makes this perception a potential public health concern because smokers interested in reducing their risks from smoking may switch to HTPs rather than to ECs. As both HTPs and ECs are increasingly available in other countries (Health Canada, 2018; Philip Morris International, 2020), this study aimed to provide scientific evidence to guide regulatory decisions around labeling policy, including whether they should differ across product types.

This study examines the effect of graphic warning labels on perceived relative risks of cigarettes, HTPs, and ECs, as well as perceived health benefit of switching between the products. Our hypotheses were as follows:

**H1.** Experimental groups exposed to either dashboard icons (vs. no exposure) or varying sizes of warning labels (vs. equal size) would be more likely to report: (a) perceptions of harms being cigarettes > HTPs > ECs; and that (b) switching from and to cigarettes > HTPs > ECs would reduce harm.

**H2.** Warning label systems would interact, such that compared to experimental and control groups who are exposed to either or none of the two warning label systems, experimental groups exposed to both dashboard icons and different-sized warnings would be more likely to report the perceptions described above.

## Methods

### Sample

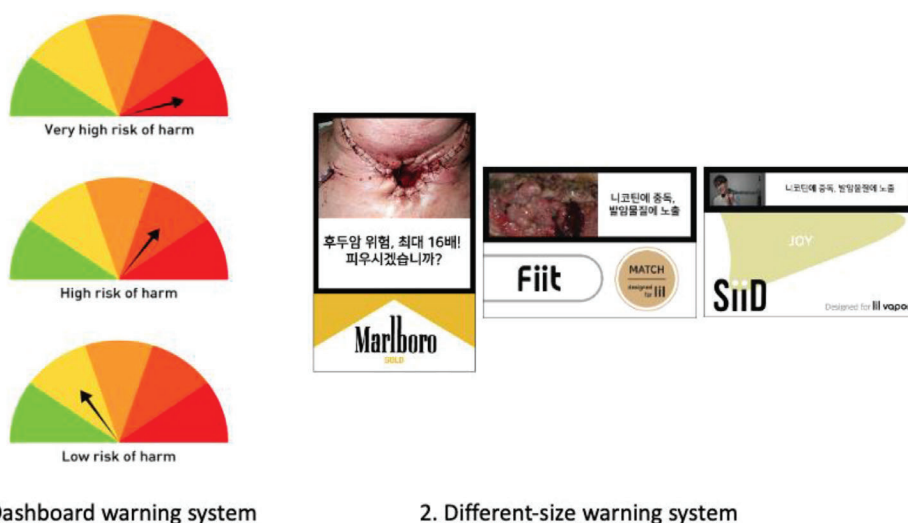
A convenience sample of 1363 participants was recruited through Embrain (www.embrain.com), an online research panel provider in Korea, from December 5, 2019 to December 23, 2019. Eligible participants were adult panel members aged 19 or older who resided in Korea and were current users or susceptible non-users of cigarettes, HTPs, or ECs. Current cigarette smokers were defined as those who reported smoking at least 100 cigarettes in their entire life and smoking cigarettes in the last month. Current users of HTPs or ECs were those who reported using HTPs or ECs in the last month. Non-users were considered open to trying cigarettes, HTPs, or ECs if they responded “definitely” “probably”, or “probably not” instead of “definitely not” to a product use question (i.e., “If one of your best friends offered you cigarettes, ECs, HTPs, would you try it?”) for any of the three products (Evans, Farkas, Gilpin, Berry, & Pierce, 1995). Quotas were used to obtain roughly equal participation from three key groups: (1) young adults aged 19 to 29 who never smoked or used cigarettes, HTPs, or ECs but who were open to trying at least one of these products; (2) young adults aged 19 to 29 who were current users of cigarettes, HTPs, or ECs; and (3) older adults aged 30 or older who were current users of cigarettes, HTPs, or ECs. We excluded 14 participants who reported paying little or no attention to our survey (in the last survey question) and 69 participants who provided inconsistent responses to questions about tobacco product use asked before and after experiment questions, resulting in an analytic sample of 1280 (444 young adult non-users, 430 young adult users, 406 older adult users). All participants who completed the survey received standard compensation for panel participation (approximately \$1.00 USD per 10 min).

### Experimental stimuli

For this study two warning label systems were developed (Fig. 1): (1) dashboard warning label system and (2) different-size warning label system. Dashboard warning system includes a dashboard icon which is a semicircle divided by five color-coded sections to represent different levels of risk for each product type (See Fig. 1). Different-size warning system refers to a warning system that constitutes different percentages of packages depending on the levels of risks of each product, where warnings cover 70% of cigarette packages, 50% of HTP packages, and 30% of EC packages (See Fig. 1). Experimental stimuli and questions were pretested with approximately 15 Korean adults including smokers and non-smokers using cognitive interviewing techniques, where participants showed their understanding of the stimuli by indicating familiarity with dashboard icons (e.g., household appliance labels that represent energy efficiency, vehicle speedometers) and verbally stating the meaning of the stimuli.

### Procedures

Informed consent was obtained for experimentation with human subjects. After reading a description of cigarettes, ECs, and HTPs and completing pre-experiment questions, participants were randomly assigned to one of four (2 × 2) between-subject experimental groups: (1) control — current warning label system in Korea, which has equal-size warning label system where warnings cover 50% of packages across all tobacco products and no dashboard icons; (2) dashboard and different-size warning label systems; (3) dashboard and equal-size warning label system; and (4) different-size warning system with no dashboard icons. Since



**Fig. 1.** Warning systems that communicate relative risks of cigarettes, heated tobacco products (HTPs), and e-cigarettes (ECs). Messages under the dashboard image were translated to Korean. The warning messages in different-size warning system state “Laryngeal cancer risk, 16 times at the most! Will you smoke?” for cigarettes and “Addiction to nicotine, exposure to carcinogens” for HTPs and ECs.



**Fig. 2.** Example Choice set shown to the experimental group exposed to both dashboard icons and varying sizes of warning labels.

this study was part of a discrete choice experiment (DCE) that explored consumer preferences among cigarettes, HTPs, and ECs, each experimental group was again randomized into two blocks of 16 choice sets. During the DCE, participants were presented with 16 sets of three tobacco product packages in a random order, each of which included one package from each of the three product types, for a total of 48 images. The package characteristics, brand (Korean, US), flavor (e.g., tobacco, menthol, fruit, vanilla), and warning image type (symbolic, graphic), were systematically manipulated within participants to ensure that findings were not biased by these factors (See Supplementary Table 1 for an example block of 16 choice sets). For each product, we used two warning image types. One, a symbolic representation of a needle was used for all three products. The graphic image varied across products: image of cancer (cigarette), a graphic image of body tissue (HTP), and a graphic image of chain (EC). Graphic images are current images used for cigarettes, ECs and HTPs in Korea, and the symbolic image was used to contrast with current graphic warning images. The laryngeal cancer image was used for cigarettes because it was rated as being most effective compared to other nine smoking-related diseases (Korean Ministry of health and welfare, 2017). In each choice set, participants were asked to view three packages of each product for as long as they wanted and choose the packages that they prefer the most and least. After completing the choice tasks (see Fig. 2), participants responded to questions on perceived relative harm and benefit of switching.

## Measures

### Relative harm perceptions

Participants answered three questions on relative harm: 1. cigarettes compared to ECs; 2. cigarettes compared to HTPs; and 3. HTPs compared to ECs. All used a Likert scale ranging from 0 (Much less harmful) to 9

(Much more harmful), along with an option to indicate “don’t know.” Due to skewed distributions, responses on the relative harm of cigarettes compared to ECs were dichotomized to indicate whether participants perceived cigarettes to be more harmful than ECs (i.e., 6 - 9). Those who perceived cigarettes to be equally or less harmful than ECs (i.e., 0 - 5) and responded “don’t know” were combined as not perceiving cigarettes to be more harmful than ECs. The relative harm of cigarettes versus HTPs and of HTPs versus ECs were dichotomized in the same way. As shown in Supplementary Table 2, 2% to 7% of participants in each of the four experimental groups provided “don’t know” responses. To assess perceptions of relative harm across cigarettes, HTPs, and ECs, responses on the above three questions were combined and dichotomized into a single variable that indicated whether or not participants reported all three perceptions of harms being cigarettes > HTPs > ECs.

### Perceived benefits of switching

Participants rated the benefits of switching completely from cigarettes to ECs, from cigarettes to HTPs, and from HTPs to ECs on a Likert scale ranging from 1 (“would reduce harm a lot”) to 9 (“would increase harm a lot”), with an option to indicate “don’t know.” Responses on the benefits of switching were skewed and thus dichotomized to indicate whether participants perceived switching would reduce harm. Those who reported perceptions that switching would not change harm or increase harm, as well as those who responded “don’t know” were combined as not perceiving switching would reduce harm. In each of the four experimental groups, 2% to 7% of participants responded “don’t know” to the benefits of switching question (Supplementary Table 3). We also derived a single dichotomous variable indicating whether or not participants reported all three perceptions that switching from and to cigarettes > HTPs > ECs would reduce harm.

### Tobacco product use status

Responses to the pre-experiment questions on tobacco product use in the previous month were used to classify participants into 8 groups: (1) noncurrent users who are open to use, (2) EC-only users, (3) HTP-only users, (4) Dual EC-HTP users, (5) Cigarette-only smokers, (6) Dual Cigarette-EC users, (7) Dual Cigarette-HTP users, and (8) All product users.

### Socio-demographics

We assessed socio-demographic variables including age (20–29; 30–39; 40–49; 50 or more), sex (male or female), and education (low=high school or less; moderate=some college; and high=4-year university degree or higher). We also asked participants about their monthly household income, ranging from 1 (2 million KRW=approximately \$1723 USD

**Table 1**

Sample characteristics: overall and by experimental group,% or mean (SD).

	Experimental Groups				Total	p-value <sup>a</sup>
	Control	Dashboard & different size	Dashboard	Different size		
	N = 316	N = 313	N = 333	N = 318	N = 1280	
Age	30.0 (8.7)	29.9 (8.5)	30.0 (9.0)	30.0 (8.6)	30.0 (8.7)	1.00
Female	59%	59%	59%	54%	58%	0.46
Education						0.52
Low (<High school)	20%	19%	20%	19%	20%	
Middle	18%	14%	16%	13%	15%	
High (>= 4-year uni)	62%	67%	63%	69%	65%	
Income						0.89
Low	33%	31%	34%	35%	34%	
Middle	26%	26%	28%	29%	27%	
High	38%	41%	36%	35%	38%	
Unknown	3%	2%	2%	2%	2%	
Nicotine product use <sup>b</sup>						0.78
Never-use	34%	35%	33%	36%	35%	
EC only	2%	4%	2%	3%	3%	
HTP only	2%	3%	4%	2%	3%	
Dual EC-HTP	3%	4%	2%	3%	3%	
Cig only	15%	11%	11%	15%	13%	
Dual Cig-EC	6%	5%	8%	6%	6%	
Dual Cig-HTP	8%	9%	10%	9%	9%	
All products	29%	29%	31%	26%	29%	

<sup>a</sup> Groups compared using ANOVA (age) and Pearson's chi-squared test (categorical variables).<sup>b</sup> EC: Electronic cigarette. HTP: Heated tobacco product. Smokers are those who had smoked at least 100 cigarettes in lifetime and reported smoking in the past month. EC/HTP users are those who used ECs/HTPs in the past month.

or less) to 6 (10 million KRW=approximately \$8618 USD or more) with a “Don't know” response. Responses to the income question were categorized into tertiles and unknown.

### Statistical analysis

Stata version 16 was used for all analyses. Analysis of variance and Pearson's chi-squared tests were used to examine differences by experimental conditions in socio-demographics and tobacco product use to assess randomization. Logistic regression models were estimated to examine the main and interaction effects of the dashboard and different-size warning label system on perceptions of relative harm and the benefits of switching, adjusting for covariates. Sensitivity analyses were performed to validate the study findings from 1280 participants, after excluding participants who responded “don't know” to questions on relative harm perceptions ( $n = 39$ ) and the benefits of switching ( $n = 39$ ), results from which (See Supplementary Tables 5 and 6) were similar in direction and magnitude to the main results.

## Results

### Sample characteristics

Table 1 shows the sample characteristics, which did not significantly differ across experimental groups. Overall, participants were relatively young (average age of 30) and more than half were female (58%) and graduated from 4-year university (65%). The most common status of tobacco product use was never users of cigarettes, HTPs, and ECs (35%), followed by poly-users of cigarettes, HTPs, and ECs (29%), and cigarette-only smokers (13%).

### Relative risk perceptions

Table 2 shows the results from logistic models regressing perceived relative risks on exposure to relative risk warning label systems, with Supplementary Table 3 providing the number of participants who provided positive responses to each outcome measure by experimental group. Consistent with H1, participants who were exposed to the dashboard warning label system were more likely to report that cigarettes

are more harmful than ECs (Adjusted odds ratio [AOR] = 1.30, 95% Confidence interval [CI] = 1.02, 1.66) and that HTPs are more harmful than ECs (AOR = 1.50, 95% CI = 1.19, 1.88), compared to those who were not. Participants who were exposed to dashboard icons were more likely to report all three perceptions (i.e., cigarettes are more harmful than HTPs AND cigarettes are more harmful than ECs AND HTPs are more harmful than ECs, AOR = 1.55, 95% CI = 1.23, 1.95), compared to those who were not. Exposure to the different-size warning label system did not significantly influence perceived relative risks of cigarettes and HTPs, in contrast to H1. The interaction effect between the dashboard and different-size warning label systems was not statistically significant in any of the models.

### Benefits of switching

Table 3 shows the results from logistic models regressing perceived benefits of switching on exposure to relative risk warning label systems. Consistent with H2, participants who were exposed to the dashboard warning label system were more likely to report that switching from HTPs to ECs would reduce harm (AOR = 1.39, 95% CI = 1.10, 1.77) and to report all three perceptions (i.e., switching from cigarettes to HTPs would reduce harm AND switching from cigarettes to ECs would reduce harm AND switching from HTPs to ECs would reduce harm; AOR = 1.52, 95% CI = 1.18, 1.95), compared to those who were not. There was no significant effect of the different-size warning label system on perceived benefits of switching from cigarettes to ECs or HTPs, contrary to H2. The different-size warning label system did not increase perception that switching from cigarettes to ECs or switching from HTPs to ECs would benefit health but decreased perception that switching from cigarettes to HTPs would benefit health; AOR=0.79, 95% CI = 0.63, 0.99. There was no significant interaction effect between the dashboard and different-size warning label systems on perceived benefits of switching.

## Discussion

This study examined effects of two warning label systems communicating relative risks of three tobacco products in Korea, one of which was the dashboard warning label system that used both color and text to represent the relative risk between tobacco products. Compared to partic-



**Table 2**  
Relative risk warning label system effects on relative harm perceptions ( $n = 1280$ ).

	Cig > HTP		HTP > EC		Cig > EC		Cig > HTP, HTP > EC, Cig > EC	
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR	95% CI	Adjusted OR	95% CI
Model 1: Dashboard								
No	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Yes	1.23	0.97 - 1.56	<b>1.30*</b>	<b>1.19 - 1.88</b>	<b>1.55***</b>	<b>1.02 - 1.66</b>	<b>1.55***</b>	<b>1.23 - 1.95</b>
Model 2: Size								
No	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Yes	0.84	0.66 - 1.06	0.97	0.67 - 1.06	0.9	0.76 - 1.23	0.9	0.72 - 1.14
Model 3: Dashboard x Size								
Dashboard	<b>1.42*</b>	<b>1.01 - 1.98</b>	<b>1.54*</b>	<b>1.06 - 2.01</b>	<b>1.60**</b>	<b>1.09 - 2.17</b>	<b>1.60**</b>	<b>1.15 - 2.20</b>
Size	0.97	0.69 - 1.34	1.15	0.60 - 1.15	0.94	0.82 - 1.61	0.94	0.67 - 1.32
Dashboard x Size	0.75	0.47 - 1.21	0.71	0.66 - 1.65	0.94	0.43 - 1.15	0.94	0.59 - 1.49

\*  $p < .05$ .

\*\*  $p < .01$ .

\*\*\*  $p < .001$ . Models adjusted for age, sex, education, income, and tobacco product use status.

**Table 3**  
Relative risk warning label system effects on perceived benefits of switching ( $n = 1280$ ).

	Cig → HTP		HTP → EC		Cig → EC		Cig → EC, Cig → HTP, HTP → EC	
	Adjusted OR	Adjusted OR	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI
Model 1: Dashboard								
No	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Yes	1.2	<b>1.39**</b>	<b>1.39**</b>	0.96 - 1.51	1.25	0.99 - 1.57	<b>1.52**</b>	<b>1.18 - 1.95</b>
Model 2: Size								
No	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Yes	<b>0.79*</b>	0.81	0.81	<b>0.63 - 0.99</b>	0.81	0.64 - 1.02	0.82	0.64 - 1.05
Model 3: Dashboard x size								
Dashboard	1.21	<b>1.51*</b>	<b>1.51*</b>	0.88 - 1.67	1.31	0.95 - 1.81	<b>1.59**</b>	<b>1.13 - 2.25</b>
Size	0.8	0.89	0.89	0.58 - 1.10	0.85	0.62 - 1.18	0.87	0.60 - 1.27
Dashboard x Size	0.98	0.84	0.84	0.62 - 1.54	0.9	0.57 - 1.42	0.9	0.54 - 1.48

\*  $p < .05$ .

\*\*  $p < .01$ , \*\*\*  $p < .001$ . Models adjusted for age, sex, education, income, and tobacco product use status.

Participants exposed to conventional warning label system, those exposed to the dashboard warning label system were more likely to report perceptions that ECs are less harmful than cigarettes and HTPs and that switching from cigarettes and HTPs to ECs would reduce harm. The finding suggests that presenting dashboard icons is a potential communication strategy for communicating relative risks of more than two products, extending previous literature on communicating relative risks of tobacco products (Pepper et al., 2017; Yang & Popova, 2020; Yang, Owusu, & Popova, 2018).

The warning label system that differentiated the size of warning labels for each product type did not influence participant perceptions about relative harm and benefit of switching to potentially less harmful products. This is contrary to our hypothesis and is counterintuitive in that larger warnings for cigarettes have been generally more effective. Moreover, consistent with our results, experimental studies have found no effect of increasing warning size from 30% to 50% on relative harm perceptions (Skurka et al., 2017) or cognitive elaboration (Bansal-Travers et al., 2011), although increasing warning size to 100% significantly increased cognitive elaboration (Bansal-Travers et al., 2011). These studies suggest that our null findings may be attributed to brand imagery on packs, since the largest warning size in our study was 70% for cigarette packs and brand imagery covered the rest of cigarette packs. Hence, increasing the warning size to 100% for cigarette packs could enhance public understanding about relative risks of cigarettes compared to other tobacco products.

The null findings may also relate to participants' exposure to the symbolic image of a needle across all products, as well as the fact that we manipulated the relative size rather than the absolute size of warnings among product types. Moreover, since our stimuli reflected the standard

size of actual product packaging on the market in Korea, the relative size and shape of packs varied depending on the brand and product type. For instance, cigarette packs had a vertical shape while HTP packs had a horizontal shape, with the size being similar across brands and product types. The size and shape of packs varied between EC brands, with the US brand packages being vertical and larger than cigarette and HTP packages while the Korean EC brands packs were horizontal and smaller. Therefore, the absolute size of warnings shown for the US branded ECs and HTPs was similar even in the different-size warning label system condition.

Our between-subjects experiment did not evaluate the longer-term psychosocial or behavioral effects of the warning systems we evaluated. Future research could enhance ecological validity by examining the impact of repeated or prolonged exposure to the warnings. Furthermore, the use of a convenience sample in Korea limits the generalizability of the results. The sample included a higher proportion of females (56%) compared to 6% of female adult smokers in the general population (Korea Ministry of Health and Welfare 2020), although smoking rates among Korean females are likely to be underestimated due to social desirability bias (Hong, Noh, & Kim, 2018). Moreover, a majority of the sample (65%) had a 4-year university degree or higher while smoking prevalence is lower among higher educated groups (Chang, Kang, Lim, Cho, & Khang, 2019). The results may also not be generalizable to other countries (Hair et al., 2018), although a previous study found consistent responses to warning content across countries (Hammond et al., 2018). In our study, relative harm perception measure assessed participants' general judgements about relative harm of each product type compared to others, whereas perceived benefit of switching measure specified the conditions of use (i.e., daily use). As such, future research would bene-

fit from considering different aspects of risk perception to better ensure their distinctiveness (Kaufman, Persoskie, Twesten, & Bromberg, 2020). Our analysis did not adjust for the impact of packaging elements other than warning labels, such as brand and flavor, although their potential impact should have been minimized by random assignment.

The rapidly changing landscape of tobacco products makes communicating the continuum of risk across products critical yet challenging. This study's attempt to evaluate warning label systems to promote public understanding about relative risks of cigarettes, HTPs, and ECs found that using "dashboard" icons with color codes to classify each product type is a promising approach to tackle the challenge. Given that perceptions are strong antecedents of behavior, the impact of the dashboard warning label system on perceived relative risks warrants further investigation. Given concerns that reduced risk messages may appeal to youth (McKelvey, Baiocchi, & Halpern-Felsher, 2020), an important area of future research is to examine whether dashboard warning increases use of products identified as lower risk among youth. Such research would help policy makers shape the guidelines on warning labels for ECs and other emerging products that are currently not available (Kennedy, Awopegba, De León, & Cohen, 2017), as well as help public make informed decisions about their tobacco product use.

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## Ethics

The University of South Carolina Institutional Review Board approved the study protocol.

## Declarations of Interest

JFT received funding as an expert witness on behalf of governments in litigation involving the cigarette industry. Other authors of this paper have no competing interests to declare.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.drugpo.2021.103468.

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