# Electronic Nicotine Product (ENP) Graphic Warnings: Association between Exposure and Changes in Perceived Susceptibility and Severity of Explosion and Lung Injuries

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**Abstract**

Electronic nicotine products (ENPs) are the most prevalent form of tobacco use among U.S. young adults. Research is needed to investigate how to communicate new risks from ENPs to the public. In this study, we tested the comparative persuasiveness of ENP explosion and lung injury graphic warnings. We recruited a sample of 343 young adults (18 to 28 years; 146 male, 197 female), including both ENP users and nonusers, via Amazon Mechanical Turk in October 2020. We randomly assigned participants to one of six exposure conditions: two images of lung injuries with prevalence statistics, two images of battery explosion injuries with prevalence statistics, and two images of ENPs with messages about chemicals or nicotine/addiction. We measured perceptions and intention to use ENPs before and after exposure. Linear regression models examined whether exposure conditions were associated with post-exposure perceived susceptibility and severity of ENP lung injuries and explosion injuries, perceived intensity, fear, and intention to use, adjusting for baseline values and potential confounders. Compared to the chemicals/nicotine messages, explosion and lung injury stimuli were perceived to be more intense ($p < .001$) and evoked greater fear ($p < .001$). Both explosion injury images were associated with increased perceived susceptibility ($p < .01$) and severity ($p < .001$). One lung injury image was associated with increased perceived susceptibility ($p < .01$) and reduced intention to use ENPs ($p < .05$). Our results show that ENP graphic warnings can increase threat perceptions about ENP lung and explosion injuries among young adults. Similar graphic warnings may be effective for other harms associated with ENPs.

**Keywords:** electronic nicotine products, electronic cigarettes (e-cigs, ECIG), e-cigarette or vaping product use-associated lung injury (EVALI), lithium-ion battery explosions, graphic health warnings

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## Introduction

Electronic nicotine product (ENP) use is a growing public health problem, especially among young adults. As of 2021, 18-to-24-year-olds have the highest prevalence of current ENP use in the United States (US) at 11%, marking an increase from 2020 (Cornelius et al., 2023). Studies conducted among college students show similarly high rates of ENP use (Allem et al., 2015; Saddleson et al., 2015; Boakye et al., 2022). Whereas ENPs are often marketed unlawfully as cessation devices (Soule et al., 2020), their effectiveness for smoking cessation as a retail product has not been demonstrated (Wang et al., 2020) and there are no FDA-approved tobacco cessation ENPs. Additionally, many college ENP users report that their use is not associated with cessation (Saddleson et al., 2015). Rather, research supports that most young adult ENP users were never established smokers, suggesting ENP use is responsible for tobacco use initiation (Cornelius et al., 2020). Furthermore, tobacco product use initiation is increasingly common during young adulthood and is associated with substance use and other risky behaviors (Boakye et al., 2022; Barrington-Trimis et al., 2020), supporting beliefs that this group is critical to target with preventive interventions.

Exposure to tobacco marketing can influence risk perception and subsequent use. Tobacco companies spend billions of dollars annually on marketing, especially targeting adolescents and young adults (CDC, 2020). ENP advertisements appeal to youth (Allem et al., 2019; Padon et al., 2017) and those exposed to advertisements are more likely to experiment with ENPs (Chen-Sankey et al., 2019; Duke et al., 2016). Some ENP manufacturers, such as JUUL, have expanded sales through social media campaigns targeted at young consumers (Huang et al., 2019).

Counter-marketing, or the use of commercial marketing tactics to reduce tobacco use, is an effective tobacco prevention and control strategy. Research shows that large-scale counter-marketing campaigns, such as those from the Truth Initiative and the U.S. Food and Drug Administration (FDA), have been successful in curbing youth cigarette smoking (Duke et al., 2019; Farrelly et al., 2017; Niederdeppe et al., 2004). Consequently, CDC Best Practices include counter-marketing as an important aspect of tobacco prevention and control. (CDC, 2014). To raise awareness about the dangers of ENPs, health departments and organizations have developed a growing body of counter-marketing campaigns, including the FDA's "Real Cost" campaign. However, there is limited research on campaign effectiveness.

One counter-marketing approach is graphic warnings, or vivid images with text, which demonstrate negative health outcomes. Research shows that graphic warnings can increase harm perceptions and decrease intentions to smoke cigarettes (Andrews et al., 2014; Kees et al., 2010). Research supports that graphic warning labels can increase perceived harm of ENPs (Andrews et al., 2019; Li et al., 2021).

The message impact framework examines the extent to which the characteristics of pictorial health warnings influence reactions, attitudes, beliefs, and future behaviors. Research using this framework shows that graphic health warnings are more effective than text warnings alone, impacting intentions not to initiate smoking and intentions to quit smoking (Noar et al., 2016). Although research using this framework shows the effectiveness of cigarette warnings, a gap exists for ENP warnings. Given previous findings, it is important to understand effects of graphic counter-marketing messages associated with new negative ENP health risks.

Currently, the FDA requires manufacturers to include a nicotine warning on ENPs (U.S. FDA, 2016). However, graphic warnings about other ENP-related health outcomes, such as battery explosion and burn injuries (Rossheim et al., 2019) and lung injury associated with e-cigarette use, or vaping (EVALI) (CDC, 2020), may be effective for influencing young adults' perceptions and behaviors. From 2019 to 2020, there were 2,807 documented cases of EVALI and 68 deaths in all 50 U.S. states, Washington D.C. and two territories (CDC, 2020). Although the CDC now reports that the EVALI outbreak was linked with vitamin E acetate and cases have declined since 2020, there may be other unknown lung-related health effects associated with ENP use.

In addition to lung-related health problems, from 2015 to 2019, approximately 3,369 people were hospitalized from ENP battery-explosions, which may occur when lithium-ion batteries overheat (Rossheim, 2020). Explosions are common in ENP devices with larger "tanks" and can damage surrounding people and property (Rossheim, 2020). Whereas existing counter-marketing highlights various physical and mental health effects associated with ENP use, researchers have not evaluated the impact of graphic warnings related to lung or explosion injuries. Furthermore, although there is research on the persuasiveness of nicotine-related warnings for cigarettes, limited studies examine such ENP warnings (Andrews et al., 2019; Wackowski et al., 2017). Findings may help inform researchers about the effectiveness of graphic warnings in communication campaigns that could help prevent ENP use among young people.

In this study, we examine exposure to ENP battery explosion and lung injury graphic warnings and changes in perceived susceptibility to and severity of negative ENP-related harms among 18-to-28-year-olds in the U.S. We predicted that exposure to graphic warnings of ENP lung or battery explosion injury would be associated with greater risk perceptions than warnings with a stock photo of ENPs and text about chemicals or addiction.

## Methods

### Procedure

We used Amazon's Mechanical Turk (MTurk) platform for recruitment. Research shows that Mturk is a useful source of study samples for social science and public health research (Mortensen & Hughes, 2018). Inclusion criteria required being located in the U.S., being between 18 and 28 years of age, having completed at least 500 surveys on Mturk, and having a Human Intelligence Task (HIT) approval rate greater than or equal to 95% – which is an indicator of providing high-quality responses to previous Mturk surveys. We directed participants to complete a Qualtrics survey.

Prior to completing the survey, participants indicated informed consent. To avoid bias, the consent form only shared that the study aimed "to examine how people respond to health-related messages" and the Mturk recruitment link referred to this as a "Health Messages Study." The median time to completion was 8.5 minutes. Upon completion, participants were assigned a random code to collect a $1.50 reward. After removing duplicate responses (i.e., based on Worker ID and/or IP address), 353 participants remained. Among these participants, 343 individuals provided complete data (97.2%) and comprised the final analytic sample.

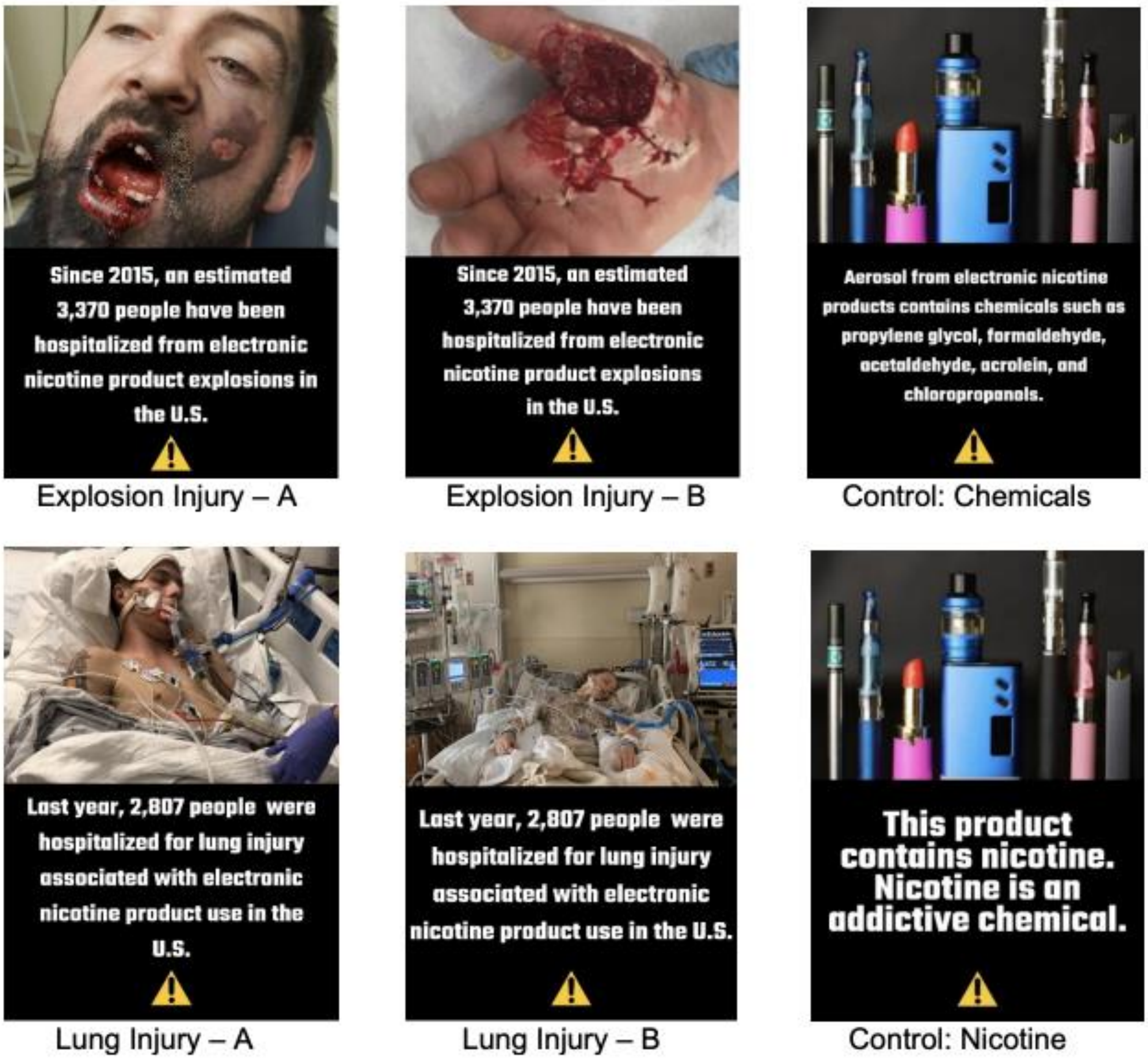
### Stimuli

Participants were randomized to view one of six image conditions (Figure 1). The study's four overarching conditions were (1) lung injury, (2) battery explosion, (3) chemicals, and (4) nicotine. The lung injury and battery explosion conditions were further randomized into images "A" and "B," which depicted different visualizations of the injuries. Images were sourced using Google searches and previous studies.

Both lung injury images depicted an unconscious patient in a hospital bed. The patient in image A was a young man, whereas image B was a young woman. Both images were accompanied by the text, "Last year, 2,807 people were hospitalized for lung

**Figure 1**

*Experimental stimuli conditions*



injury associated with electronic nicotine product use in the U.S."

Battery explosion image A displayed burn and blast injuries to a man's face (Eaton, 2017) whereas image B depicted a severely injured hand – used with permission from Satteson et al.'s (2018) case report. The accompanying text warning read, "Since 2015, an estimated 3,370 people have been hospitalized from electronic nicotine product explosions in the U.S."

The 'nicotine' and 'chemicals' conditions presented an image of ENPs adapted from the California Department of Public Health. The 'nicotine' condition was accompanied by text based on the FDA warning placed on nicotine-containing e-cigarettes: "This product contains nicotine. Nicotine is an addictive chemical" (U.S. FDA, 2016). The 'chemicals' condition read, "Aerosol from electronic nicotine products contains chemicals such as propylene glycol, formaldehyde, acetaldehyde, acrolein, and chloropropanols." These messages were the control conditions and were assigned randomly to participants.

## Survey Measures

### *Demographic Characteristics*

The demographic characteristics we measured included age, sex, and race/ethnicity.

### *ENP Use*

The term "electronic nicotine product" was used throughout the survey questions and in all stimuli conditions because it is specific, relatively neutral, and does not imply novelty nor reduced risk (O'Connor et al., 2021). Previous ENP use was assessed via adapted questionnaire items originally used to assess cigarette use: "During the past 30 days, on how many days did you use an electronic nicotine product?" (Pechacek et al., 1998; Eisenberg & Forster, 2003). Responses were dichotomized to create a variable for past 30-day ENP use (yes/no).

Prior to items assessing ENP use, a message clarified: "The next questions are about electronic nicotine products, such as e-cigarettes, vape pens, personal vaporizers and mods, e-cigars, e-pipes, e-hookahs, and hookah pens. These products are battery-powered and produce vapor instead of smoke. They contain nicotine liquid, sometimes called "e-liquid" or "e-juice," although the amount of nicotine can vary and some may not contain any nicotine. Some can be bought as one-time, disposable products, while others are rechargeable. Common brands include Vuse, Blu, Logic, MarkTen, JUUL, NJOY, eGo, and iTaste."

We also presented participants with a picture of common ENPs with brands such as JUUL and Blu, adapted from the U.S. Food and Drug Administration-developed image depicting common ENPs (U.S. FDA, 2020). Research supports the use of pictures and a preamble describing which products are considered ENPs, because the products and terms are evolving rapidly (Weaver et al., 2018). Respondents were prompted to answer questions regarding how many of their closest friends and peers use ENPs.

### *Perceived Susceptibility to and Severity of Harms from ENP Use*

All perceived susceptibility and severity questions were included in both the pre- and post-stimulus questionnaires. Items about perceived susceptibility to and severity of ENPs were adapted from the Risk Behavior Diagnosis Scale created by Witte, Meyer, & Martell (2001).

The items pertaining to perceived susceptibility were: (1) "If I were to regularly use electronic nicotine products, I would be at risk for experiencing [lung injury/battery explosion]," (2) "If I were to use electronic nicotine products, I would experience [lung injury/battery explosion] in the next 6 months," and (3) "If I were to use electronic nicotine products regularly, what is the likelihood that I would experience [lung injury/battery explosion]?" These items were scored on 5-point scales from "strongly agree" to "strongly disagree" or "extremely likely" to "not at all likely" and added to create a scale from 3 to 15. Responses were reverse coded for analyses.

The perceived severity items included the statements: (1) "Electronic nicotine product associated [lung injury/battery explosion] is a severe threat" and (2) "If I were to experience electronic nicotine product associated [lung injury/battery explosion], how likely is it to cause serious injury or death?" These were scored on 5-point scales from "strongly agree" to "strongly disagree" or "extremely likely" to "not at all likely" and added to create a scale ranging from 2 to 10. Responses were reverse coded for analyses.

### *Perceived Intensity of Image and Evoked Fear*

Questionnaire items about perceived intensity of the images were adapted from Andrews et al.'s study (2019). Participants evaluated their assigned stimulus on four, 5-point scales ranging from *extremely* to *not at all* graphic/vivid/powerful/intense. These items were summed to create a scale from 4 to 20.

The evoked fear measure, also adapted from Andrews et al. (2019), was assessed on a 5-point scale with: "How disturbing was the picture shown?" with the response endpoints ranging from "not at all disturbing" to "extremely disturbing." Participants were asked how the image made them feel with endpoints of "not at all fearful" to "extremely fearful" and "not at all anxious" to "extremely anxious." These items were summed to create a scale from 3 to 15.

### *Intention to use Electronic Nicotine Products*

Intention to use ENPs was assessed in both pre- and post-stimuli questionnaires. Future behavioral intentions were assessed with a 3-item, 5-point scale including the following questions: "If you had the opportunity to use an electronic nicotine product **today**, how likely would you be to use it?" "If you had the opportunity to use an electronic nicotine product **within the next week**, how likely would you be to use it?" and "If you had the opportunity to use an electronic nicotine product **within the next 30 days**, how likely would you be to use it?" (Andrews et. al, 2018; Fishbein and Azjen, 2010). These items were summed to create a scale from 3 to 15.

## Data Analysis

We used Stata version 14.1 for statistical analysis. First, we used bivariate analyses to examine how the study groups (which were randomized to different stimuli conditions) were comparable on baseline characteristics. These bivariate tests included chi-square tests (and corresponding adjusted residuals) for categorical variables and one-way ANOVA F-tests (with Scheffé *post hoc* analyses) for numeric variables. Next, a series of linear regression models examined associations between stimuli conditions and (1) perceived susceptibility to battery explosions, (2) perceived severity of battery explosions, (3) perceived susceptibility to lung injury, (4) perceived severity of lung injury, (5) perceived intensity of image, (6) evoked fear, and (7) intention to use ENPs, adjusting for potentially confounding variables including demographic characteristics, ENP use, and baseline measures of the respective outcome variables. Each regression model was replicated, stratified by ENP use, to examine effects among ENP users and non-users. An examination of quantile-quantile (i.e., Q-Q) plots suggested that residuals did not substantially deviate from normal distribution for any constructed models. For the study sample, internal consistency reliability was strong for all scales (Cronbach's α range = 0.69, 0.97).

## Results

Table 1 provides descriptive information about the overall study sample as well as individuals randomly assigned to each condition. The mean age of participants ($n$ = 343) was 24.7 years; 42.6% of participants were male and 64.1% were non-Hispanic, white only. The Lung Injury – Hand and Battery Explosion – Young Man conditions significantly differed statistically from each other regarding the percentage who were non-Hispanic, white only. However, all groups were comparable on all other baseline characteristics including demographic characteristics, ENP use, intention to use ENP, and perceived susceptibility to and severity of ENP lung and explosion injuries. Regardless, our regression models adjusted for potentially confounding variables including demographics and baseline measures.

Table 2 shows results from multivariable linear regression models of factors associated with perceived susceptibility to and severity of battery explosion images. Compared to participants in the control conditions, those in Explosion Injury conditions scored higher on the Susceptibility to ENP Battery Explosion scale, an average of 0.95 higher for the Face Image (95% CI: 0.49, 1.42, $p < .001$) and 0.66 higher for the Hand Image (95% CI: 0.20, 1.13, $p = .006$). Similarly, participants randomized to Explosion Injury Face Image or Hand Image conditions scored on average 0.94 (95% CI: 0.54, 1.34, $p < .001$) and 0.99 (95% CI: 0.59, 1.38, $p < .001$) higher (respectively) on the Severity of Battery Explosions scale, than participants in the control conditions. Among past 30-day ENP users, those who viewed the Lung Injury (Young Man) condition scored 0.84 higher on the Severity of Battery Explosion scale compared to control conditions (95% CI: 0.03, 1.65, $p = .04$).

Table 3 presents results from linear regression models of factors associated with perceived susceptibility to and severity of lung injury. Compared to participants in control groups, those in the lung injury condition with the image of the young woman scored on average 0.66 (95% CI: 0.19-1.13, $p = .006$) higher on the susceptibility to lung injury scale in the full sample and 0.68 (95% CI: 0.15-1.21, $p = .01$) higher among non-users. However, none of the stimuli conditions were associated with significant differences in perceived severity of lung injury.

As Table 4 shows, for the full sample, explosion injury conditions were associated with a score of 6.90 (95% CI: 5.9, 7.9; $p < .001$) to 7.18 (95% CI: 6.1, 8.2; $p < .001$) higher on the perceived intensity of image scale and 5.04 (95% CI: 4.1, 6.0; $p < .001$) to 5.49 (95% CI: 4.5, 6.5; $p < .001$) higher on the evoked fear scale, compared to controls (Table 4 and 5). For the full sample, lung injury conditions were associated with scores of 4.41 to 4.88 higher on the perceived intensity of image scale and 3.33 (95% CI: 2.3, 4.3; $p < .001$) to 3.40 (95% CI: 2.4, 4.4; $p < .001$) higher on the evoked fear scale, than the control group.

For the full sample and sub-sample of ENP non-users, those who viewed the young woman lung injury message scored 0.51 (95% CI: -1.01, -0.01, $p < .05$) and 0.57 lower (95% CI: -1.10, -0.04, $p = .04$) respectively on the intention to use ENPs scale, compared to the control conditions and adjusting for

**Table 1**

*Pre-exposure group characteristics among study sample*

| | Lung Injury – A (*n* = 56) | Lung Injury– B (*n* = 55) | Battery Explosion–A (*n* = 59) | Battery Explosion– B (*n* = 59) | Chemicals (*n* = 61) | Nicotine (*n* = 53) | Overall (*n* = 343) | Bivariate test *p*-value** |
|---|---|---|---|---|---|---|---|---|
| **Demographic Characteristics** | -- | -- | -- | -- | -- | -- | -- | |
| Mean age (SE) | 25.1 (0.3) | 24.6 (0.2) | 24.5 (0.2) | 24.6 (0.2) | 24.9 (0.3) | 24.6 (0.3) | 24.7 (0.1) | .64 |
| Percent male | 32.1 | 47.3 | 44.1 | 47.5 | 41.0 | 43.4 | 42.6 | .59 |
| Percent white only (non-Hispanic) | 71.4 | 47.3* | 76.3* | 59.3 | 65.6 | 64.2 | 64.1 | .03 |
| **Past 30-day ENP use** | 25.0 | 30.9 | 23.7 | 13.6 | 24.6 | 18.9 | 22.7 | .33 |
| **Pre-exposure Perceptions** | -- | -- | -- | -- | -- | -- | -- | |
| Perceived susceptibility to lung injury (SE) | 11.0 (0.3) | 10.6 (0.3) | 10.3 (0.3) | 10.2 (0.4) | 10.4 (0.3) | 10.5 (0.3) | 10.5 (0.1) | .64 |
| Perceived severity of lung injury (SE) | 7.1 (0.2) | 6.7 (0.2) | 6.5 (0.3) | 6.7 (0.2) | 6.7 (0.3) | 6.6 (0.2) | 6.7 (0.1) | .56 |
| Perceived susceptibility to battery explosion (SE) | 8.8 (0.4) | 7.9 (0.4) | 7.7 (0.4) | 7.7 (0.4) | 8.2 (0.4) | 8.2 (0.4) | 8.1 (0.2) | .36 |
| Perceived severity of battery explosion (SE) | 6.4 (0.3) | 5.3 (0.2) | 5.4 (0.3) | 5.7 (0.3) | 6.0 (0.3) | 6.1 (0.3) | 5.8 (0.1) | .07 |
| **Pre-exposure Intention to Use ENPs** | 5.7 (0.5) | 6.9 (0.6) | 6.9 (0.6) | 5.4 (0.5) | 5.7 (0.5) | 6.2 (0.6) | 6.1 (0.2) | .16 |

Note.

*|adjusted residual| ≥ 2.0

** *p*-value of the overall Pearson Chi-squared or one-way ANOVA tests

**Table 2**

*Linear regression models of factors associated with perceived susceptibility to and severity of battery explosions among ENP users and non-users*

| | **Susceptibility to Battery Explosion** | | | **Severity of Battery Explosion** | | |
|---|---|---|---|---|---|---|
| | B (95% CI) | B (95% CI) | B (95% CI) | B (95% CI) | B (95% CI) | B (95% CI) |
| | Full Sample (*n* = 343) | ENP non-users (*n* = 265) | ENP users (*n* = 78) | Full Sample (*n* = 343) | ENP non-users (*n* = 265) | ENP users (*n* = 78) |
| **Stimuli Condition** | -- | -- | -- | -- | -- | -- |
| Explosion Injury – Image A (Face) | **0.95 (0.49, 1.42)** | **0.93 (0.41, 1.45)** | **1.18 (0.09, 2.27)** | **0.94 (0.54, 1.34)** | **0.86 (0.40, 1.33)** | **1.23 (0.41, 2.05)** |
| Explosion Injury – Image B (Hand) | **0.66 (0.20, 1.13)** | **0.73 (0.23, 1.23)** | 0.55 (-0.78, 1.88) | **0.99 (0.59, 1.38)** | **0.96 (0.52, 1.40)** | 0.80 (-0.19, 1.79) |
| Lung Injury – Image A (Young Man) | 0.06 (-0.42, 0.53) | -0.03 (-0.57, 0.50) | 0.40 (-0.68, 1.49) | 0.24 (-0.16, 0.65) | 0.06 (-0.41, 0.52) | **0.84 (0.03, 1.65)** |
| Lung Injury – Image B (Young Woman) | 0.12 (-0.36, 0.60) | 0.23 (-0.32, 0.79) | 0.06 (-1.01, 1.14) | 0.10 (-0.31, 0.51) | 0.10 (-0.39, 0.59) | 0.27 (-0.52, 1.07) |
| **Demographics** | -- | -- | -- | -- | -- | -- |
| Age | -0.04 (-0.13, 0.04) | -0.07 (-0.16, 0.03) | 0.06 (-0.15, 0.26) | 0.01 (-0.06, 0.08) | -0.02 (-0.11, 0.06) | 0.10 (-0.05, 0.25) |
| Male | **-0.35 (-0.68, -0.03)** | **-0.37 (-0.73, -0.002)** | -0.20 (-0.99, 0.58) | -0.06 (-0.33, 0.21) | 0.01 (-0.30, 0.33) | -0.31 (-0.89, 0.28) |
| Non-Hispanic white | -0.30 (-0.64, 0.04) | -0.36 (-0.73, 0.01) | 0.01 (-0.87, 0.89) | -0.22 (-0.51, 0.0.06) | -0.22 (-0.54, 0.10) | -0.20 (-0.86, 0.45) |
| **Past 30-day ENP Use** | -0.21 (-0.59, 0.17) | -- | -- | -0.28 (-0.61, 0.04) | -- | -- |
| **Susceptibility to Battery Explosion (Pre-stimuli)** | **0.90 (0.85, 0.95)** | **0.93 (0.86, 0.99)** | **0.84 (0.73, 0.94)** | **--** | -- | **--** |
| **Severity of Battery Explosion (Pre-stimuli)** | -- | -- | -- | **0.82 (0.76, 0.88)** | **0.81 (0.73, 0.88)** | **0.83 (0.72, 0.95)** |
| | $F(9,333) = 135$<br>$p < .0001$<br>Adj $R^2 = 0.78$ | $F(8,256) = 113$<br>$p < .0001$<br>Adj $R^2 = 0.77$ | $F(8,69) = 37$<br>$p < .0001$<br>Adj $R^2 = 0.79$ | $F(9,333) = 81$<br>$p < .0001$<br>Adj $R^2 = 0.68$ | $F(8,256) = 57$<br>$p < .0001$<br>Adj $R^2 = 0.63$ | $F(8,69) = 35$<br>$p < .0001$<br>Adj $R^2 = 0.78$ |

Note.

The 'nicotine' and 'chemicals' conditions were the comparison group for the explosion and lung injury stimuli conditions. **Bold** indicates $p < 0.05$

**Table 3**

*Linear regression models of factors associated with perceived susceptibility to and severity of lung injury among ENP users and non-users*

| | **Susceptibility to Lung Injury** | | | **Severity of Lung Injury** | | |
|---|---|---|---|---|---|---|
| | B (95% CI) | B (95% CI) | B (95% CI) | B (95% CI) | B (95% CI) | B (95% CI) |
| | Full Sample (*n* = 343) | ENP non-users (*n* = 265) | ENP users (*n* = 78) | Full Sample (*n* = 343) | ENP non-users (*n* = 265) | ENP users (*n* = 78) |
| **Stimuli Condition** | **--** | **--** | **--** | **--** | **--** | **--** |
| Explosion Injury – Image A (Face) | -0.35 (-0.81, 0.10) | **-0.56 (-1.06, -0.06)** | 0.30 (-0.84, 1.44) | -0.03 (-0.37, 0.32) | -0.24 (-0.62, 0.14) | 0.61 (-0.17, 1.39) |
| Explosion Injury – Image B (Hand) | 0.11 (-0.35, 0.57) | -0.00 (-0.48, 0.48) | 0.51 (-0.87, 1.89) | -0.020 (-0.54, 0.15) | -0.19 (-0.56, 0.18) | -0.56 (-1.52, 0.40) |
| Lung Injury – Image A (Young Man) | 0.13 (-0.33, 0.60) | 0.14 (-0.38, 0.65) | 0.14 (-0.99, 1.28) | 0.10 (-0.25, 0.45) | 0.12 (-0.28, 0.51) | -0.09 (-0.88, 0.70) |
| Lung Injury – Image B (Young Woman) | **0.66 (0.19, 1.13)** | **0.68 (0.15, 1.21)** | 0.70 (-0.43, 1.84) | 0.32 (-0.04, 0.67) | 0.22 (-0.19, 0.62) | 0.52 (-0.24, 1.29) |
| **Demographics** | -- | -- | -- | -- | -- | -- |
| Age | 0.03 (-0.05, 0.11) | 0.03 (-0.06, 0.12) | 0.04 (-0.17, 0.25) | 0.02 (-0.04, 0.09) | 0.03 (-0.04, 0.10) | 0.02 (-0.12, 0.17) |
| Male | -0.14 (-0.46, 0.18) | -0.10 (-0.45, 0.26) | -0.27 (-1.08, 0.55) | **-0.30 (-0.54, -0.06)** | **-0.34 (-0.61, -0.07)** | -0.26 (-0.81, 0.30) |
| Non-Hispanic white | -0.10 (-0.43, 0.23) | -0.14 (-0.49, 0.21) | 0.01 (-0.90, 0.92) | -0.11 (-0.35, 0.14) | -0.12 (-0.39, 0.15) | -0.12 (-0.75, 0.50) |
| **Past 30-day ENP Use** | -0.30 (-0.68, 0.07) | -- | -- | **-0.29 (-0.57, -0.09)** | -- | -- |
| **Susceptibility to Lung Injury (Pre-stimuli)** | **0.92 (0.86, 0.98)** | **0.90 (0.83, 0.98)** | **0.95 (0.82, 1.08)** | **--** | **--** | **--** |
| **Severity of Lung Injury (Pre-stimuli)** | **--** | **--** | **--** | **0.83 (0.76, 0.89)** | **0.78 (0.71, 0.85)** | **0.94 (0.82, 1.07)** |
| | $F(9, 333) = 105$ $p < .0001$ Adj $R^2 = 0.73$ | $F(8,256) = 80$ $p < .0001$ Adj $R^2 = 0.71$ | $F(8,69) = 30$ $p < .0001$ Adj $R^2 = 0.75$ | $F(9,333) = 86$ $p < .0001$ Adj $R^2 = 0.69$ | $F(8, 256) = 61$ $p < .0001$ Adj $R^2 = 0.65$ | $F(8, 69) = 32$ $p < .0001$ Adj $R^2 = 0.77$ |

Note.

The 'nicotine' and 'chemicals' conditions were the comparison group for the explosion and lung injury stimuli conditions. **Bold** indicates $p < .05$

**Table 4**

*Linear regression models of factors associated with perceived intensity of image*

| | **Perceived Intensity of Image** | | |
|---|---|---|---|
| | Full Sample (*n* = 343) | ENP non-users (*n* = 265) | ENP users (*n* = 78) |
| | B (95% CI) | B (95% CI) | B (95% CI) |
| **Stimuli Condition** | -- | -- | -- |
| Explosion Injury – Image A (Face) | **6.90 (5.87, 7.94)** | **6.98 (5.85, 8.11)** | **6.96 (4.55, 9.37)** |
| Explosion Injury – Image B (Hand) | **7.18 (6.14, 8.21)** | **7.64 (6.56, 8.73)** | **4.34 (1.42, 7.25)** |
| Lung Injury – Image A (Young Man) | **4.88 (3.83, 5.93)** | **5.39 (4.22, 6.55)** | **3.20 (0.84, 5.57)** |
| Lung Injury – Image B (Young Woman) | **4.41 (3.34, 5.47)** | **5.01 (3.81, 6.21)** | **2.62 (0.26, 4.98)** |
| **Demographics** | -- | -- | -- |
| Age | 0.04 (-0.14, 0.23) | -0.05 (-0.25, 0.15) | 0.34 (-0.10, 0.78) |
| Male | 0.24 (-0.47, 0.95) | 0.48 (-0.30, 1.26) | -0.22 (-1.94, 1.50) |
| Non-Hispanic white | **-1.28 (-2.03, -0.54)** | **-1.00 (-1.79, -0.21)** | **-2.79 (-4.72, -0.85)** |
| **Past 30-day ENP Use** | -0.25 (-1.09, 0.59) | -- | -- |
| | $F(8, 334) = 36$<br>$p < .0001$<br>Adj $R^2 = 0.45$ | $F(7, 257) = 39$<br>$p < .0001$<br>Adj $R^2 = 0.50$ | $F(7, 70) = 6$<br>$p < .0001$<br>Adj $R^2 = 0.32$ |

Note.

The 'nicotine' and 'chemicals' conditions were the comparison group for each other stimuli condition**.** **Bold** indicates $p < .05$

**Table 5**

*Linear regression models of factors associated with evoked fear*

| | **Evoked Fear** | | |
|---|---|---|---|
| | Full Sample ($n$ = 343) | ENP non-users ($n$ = 265) | ENP users ($n$ = 78) |
| | B (95% CI) | B (95% CI) | B (95% CI) |
| **Stimuli Condition** | -- | -- | |
| Explosion Injury – Image A (Face) | **5.49 (4.53, 6.46)** | **5.65 (4.57, 6.74)** | **5.04 (2.84, 7.23)** |
| Explosion Injury – Image B (Hand) | **5.04 (4.08, 6.01)** | **5.33 (4.29, 6.37)** | **3.72 (1.07, 6.38)** |
| Lung Injury – Image A (Young Man) | **3.40 (2.42, 4.39)** | **3.54 (2.42, 4.65)** | **2.80 (0.65, 4.96)** |
| Lung Injury – Image B (Young Woman) | **3.33 (2.33, 4.32)** | **3.78 (2.63, 4.93)** | 1.67 (-0.48, 3.82) |
| **Demographics** | -- | -- | -- |
| Age | -0.09 (-0.27, 0.08) | -0.11 (-0.31, 0.08) | 0.01 (-0.40, 0.41) |
| Male | 0.05 (-0.61, 0.71) | -0.10 (-0.85, 0.65) | 0.80 (-0.77, 2.37) |
| Non-Hispanic white | -0.58 (-1.27, 0.11) | -0.43 (-1.19, 0.33) | -1.50 (-3.26, 0.27) |
| **Past 30-day ENP Use** | 0.13 (-0.65, 0.92) | -- | -- |
| | $F(8, 334) = 23$<br>$p < .0001$<br>Adj $R^2 = 0.34$ | $F(7, 257) = 23$<br>$p < .0001$<br>Adj $R^2 = 0.37$ | $F(7, 70) = 4$<br>$p = .001$<br>Adj $R^2 = 0.21$ |

Note.

The 'nicotine' and 'chemicals' conditions were the comparison group for each other stimuli condition**.** **Bold** indicates $p < .05$

**Table 6**

*Linear regression models of factors associated with post-stimuli intention to use ENPs*

| | **Intention to Use ENPs** | | |
|---|---|---|---|
| | Full Sample (*n* = 343) | ENP non-users (*n* = 265) | ENP users (*n* = 78) |
| | B (95% CI) | B (95% CI) | B (95% CI) |
| **Stimuli Condition** | -- | -- | -- |
| Explosion Injury – Image A (Face) | -0.04 (-0.53, 0.44) | -0.05 (-0.55, 0.46) | -0.03 (-1.35, 1.29) |
| Explosion Injury – Image B (Hand) | -0.25 (-0.73, 0.23) | -0.09 (-0.57, 0.40) | -1.06 (-2.66, 0.54) |
| Lung Injury – Image A (Young Man) | -0.13 (-0.62, 0.36) | -0.08 (-0.60, 0.44) | -0.40 (-1.70, 0.90) |
| Lung Injury – Image B (Young Woman) | **-0.51 (-1.01, -0.01)** | **-0.57 (-1.10, -0.04)** | -0.56 (-1.86, 0.75) |
| **Demographics** | -- | -- | -- |
| Age | 0.01 (-0.08, 0.10) | 0.02 (-0.07, 0.11) | 0.03 (-0.21, 0.28) |
| Male | 0.30 (-0.04, 0.63) | 0.16 (-0.19, 0.51) | 0.67 (-0.27, 1.62) |
| Non-Hispanic white | -0.05 (-0.40, 0.30) | -0.08 (-0.43, 0.28) | -0.04 (-1.11, 1.03) |
| **Past 30-day ENP Use** | 0.08 (-0.41, 0.57) | -- | -- |
| **Intention to Use ENPs (Pre-stimuli)** | **0.90 (0.85, 0.96)** | **0.89 (0.84, 0.95)** | **0.93 (0.81, 1.05)** |
| | $F(9, 333) = 214$ $p < .0001$ Adj $R^2 = 0.85$ | $F(8, 256) = 119$ $p < .0001$ Adj $R^2 = 0.78$ | $F(8, 69) = 31$ $p < .0001$ Adj $R^2 = 0.76$ |

Note.

The 'nicotine' and 'chemicals' conditions were the comparison group for each other stimuli condition**.** **Bold** indicates $p < .05$

pre-stimuli intention to use ENPs among other factors (Table 6).

## Discussion

This study is one of the first to test exposure to ENP graphic health warnings for lung and battery explosion injuries in a young adult population and changes in perceived severity and susceptibility. Most graphic health warnings tested demonstrated promise as a counter-persuasive tactic for ENP use. Participants who viewed battery explosion injury warnings reported greater perceived susceptibility to and severity of related injuries. However, we found no change in intention to use ENPs from exposure to the battery explosion injury warnings. Viewing the young woman's lung injury image was associated with both increased perceived susceptibility to lung injury and reduced intent to use ENPs, both in the full sample and among non-users. No such effects were observed for the lung injury image of the young man. Neither lung injury image condition was associated with increased perceived severity of lung injury. All explosion and lung injury warnings were perceived to be more intense and evoked more fear than control conditions.

Current ENP use was associated with lower perceived severity of lung injury adjusting for baseline perception levels, suggesting that targeted approaches may be needed for increasing related risk perceptions among ENP users. However, ENP use was not significantly associated with any other risk perceptions, nor perceived intensity of image or evoked fear, after adjusting for baseline levels, suggesting these factors may be similarly attenuated among users and non-users through graphic warnings.

Our findings demonstrate that a single exposure to graphic warnings of ENP-related negative health outcomes was able to produce detectable changes in risk perceptions and/or behavioral intentions. This speaks to the promise of graphic warnings for ENP prevention and education. Second, it appears that effects of graphic images on risk perceptions and behavioral intentions depend on both injury type and the images used. Only one of the images –the young woman treated for lung injury– was associated with reduced intention to use ENPs. Furthermore, this reduced intention was only statistically significant for the overall sample and the sub-sample of non-users. This is intriguing, given all images evoked strong emotional responses and both explosion images were associated with increased susceptibility and severity risk perceptions, whereas the effects of lung injury images on risk perceptions were relatively limited. The reasons for this are likely multifaceted and await further investigation. The gory nature of the explosions might have evoked too high of a degree of fear, resulting in emotion management rather than constructive consideration of prevention. Researchers have found that a critical point exists at which a threatening message yields unproductive "fear control" versus productive "danger control" (Witte, 1994). It is possible that less gory images of lung injuries resulted in an optimal level of fear for shaping behavioral intention, whereas the explosion injury images induced revulsion that impeded message processing, and therefore, yielded no statistically significant change in intention to abstain from ENPs. Finally, it should be considered that the text differed between lung and explosion injury conditions. The lung injury estimates were from the previous year, whereas the explosion injury estimates were since 2015. The narrower timeframe perhaps induced urgency and willingness to reconsider behavioral decisions.

Interestingly, non-Hispanic white participants rated all messages significantly less intense relative to participants of other races and ethnicities. This is an interesting finding that warrants more research. One possible explanation is that the messages tested depicted short-term rather than long-term effects, and research shows long-term tobacco use consequences are more effective than short-term risks for non-Hispanic white adolescents (Smith & Stutts, 2003).

## Limitations

The experimental design to test novel ENP graphic warnings is a considerable strength of this study. Nevertheless, there are some limitations. First, although the sample size was reasonably large, there were relatively few ENP users, reducing our ability to detect statistically significant associations within that sub-group. Other unadjusted but potentially confounding factors include obesity status, stress level, and alcohol use. Nonetheless, we randomly assigned participants to different experimental conditions, which minimizes the potential for systematic bias or confounding variables that might otherwise impact the comparability of groups. Our findings suggest that the randomization process produced groups that were comparable on all measured factors, which suggests that we had an adequate sample size for these randomized groups to be comparable with regard to other, unobserved factors. Furthermore, the study sample was obtained through Amazon MTurk. Although scholars have found that data from MTurk samples are high quality and cost-effective (Mortensen & Hughes, 2017), others argue that MTurk has similar limitations as other convenience samples (e.g., Western, educated, industrialized, rich, and democratic) (Harms & DeSimone, 2015). Thus, questions can be raised regarding external validity. Moreover, there are questions regarding the validity of data collected through MTurk including the potential use of ChatBots that may provide inaccurate data. However, the aggregated demographic and baseline information is consistent with what is expected. Moreover, the experimental outcomes match what we would theoretically expect, including the effects specific to the visual stimuli, which support that data collected were valid and from human participants. However, future researchers should be cautious of related potential pitfalls, as they may increase, and should take appropriate measures to mitigate related issues (Mellis & Bickel, 2020). In our study, the product images with text about chemicals and nicotine were the control condition, and participants' risk perceptions may have shifted in response to these messages. Thus, results need to be interpreted in this context. Finally, we measured outcomes immediately after viewing messages. Thus, their long-term impact is unknown.

## Implications for Health Behavior Research

This study may inform professionals in the fields of health communication, education, and public health to advocate for ENP regulations including the development of evidence-based policies and education around ENPs. Health behavior scientists could consider incorporating graphic health warnings into future counter-marketing efforts on social media and other communication channels for young people. As new negative health impacts associated with ENP use emerge, researchers should continue to consider graphic warnings as a tool that may help prevent or stop ENP use among young people. Graphic health warnings also may impact threat perceptions of health risks associated with drug and alcohol use in this population. When developing new health communication campaigns, health behavior scientists may consider tailoring messaging to current ENP users and non-users, particularly with information addressing perceived severity, which emerged significant for lung injury between these two groups in this study.

Future research could investigate the long-term impact of exposure to graphic warnings. Additionally, the demographic differences in reported perceptions of susceptibility and severity could be researched further, to see if demographically targeted communications reduce intention to use. These studies could explore differences between susceptible individuals and non-susceptible individuals to further understand the dynamics of risk perception and behavioral change.

## Conclusions

This study examined the association between exposure to counter-marketing messages and risk perceptions and future behavioral intentions to use ENPs. The messages contained informational text about the prevalence of health threats and related graphic images. Most of the graphic health warnings demonstrated effectiveness in increasing perceived threat and discouraging ENP use. The causes behind EVALI and ENP battery explosions have been addressed, and therefore, are not imminent public health threats. However, increasing intention to abstain from ENPs with a short, simple-to-administer intervention is notable and the effectiveness of graphic warnings should be explored in future communication campaigns as additional negative ENP effects are discovered. Researchers should examine how these effects might be enhanced with repeated exposures over time in a target population, which are factors in the success of many health campaigns (Snyder & Hamilton, 2002; Wakefield et al., 2010).

## Ethical Approval

Institutional Review Board approval was obtained before data collection in October 2020. Prior to completing the survey, participants indicated informed consent.

## Conflict of Interest

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## Discussion Questions

This study focused on perceptions immediately after exposure and behavioral intentions in the short term – i.e., the next 30 days. Will similar perceptions and intentions hold over the long term? Why and why not?

How has the rise of social media use including Snapchat and TikTok impacted the marketing of substances to young people and their perceptions and use of these products? What opportunities do these platforms present for health behavior marketing campaigns?

Will graphic health warnings still be effective when people are constantly exposed to such images? Will perceptions of susceptibility and severity change as a result of heavy and prolonged exposure?

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