


# US Adult Smokers' Perceived Risk of Fire or Explosion-Related Injury Caused by Electronic Nicotine Delivery Systems

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Amy L. Nyman, MA<sup>1</sup> ; Scott R. Weaver, PhD<sup>1,2</sup>; Jidong Huang, PhD<sup>1,3</sup>;  
Paul Slovic, PhD<sup>4</sup>; David L. Ashley, PhD<sup>1,3</sup>; and Michael P. Eriksen, ScD<sup>1,3</sup>

## Abstract

**Objectives:** Publicity on incidents of electronic nicotine delivery systems (ENDS) exploding or catching fire may influence smokers' risk perceptions and decisions about using ENDS for quitting smoking. We examined combustible cigarette smokers' perceptions of the possibility of injury from exploding ENDS and the relationship of those perceptions to ENDS use, perceived risk relative to smoking, and perceived costs and benefits of ENDS use.

**Methods:** We used data from the 2017 Tobacco Products and Risk Perceptions Survey of a national probability sample of US adults, conducted online in August and September 2017. The analytic sample consisted of 1181 current combustible cigarette smokers aware of ENDS.

**Results:** Among combustible cigarette smokers aware of ENDS, a medium/high perceived risk of injury from exploding ENDS was associated with lower odds of current ENDS use (adjusted odds ratio [aOR] = 0.50; 95% confidence interval [CI], 0.30-0.86;  $P = .01$ ), perceiving ENDS to be at least as harmful as cigarettes (aOR = 3.22; 95% CI, 2.11-4.93;  $P < .001$ ), and feeling that the negatives of ENDS use outweighed the positives (aOR = 3.50; 95% CI, 2.00-6.14;  $P < .001$ ).

**Conclusions:** Product standards, improved product labeling, and education about how to properly use, charge, and store ENDS can help protect consumers from injury. Communication efforts should seek to fully inform combustible cigarette smokers about both the absolute health risks of ENDS, including risk of explosions, and their relative risks compared with those of cigarette smoking.

## Keywords

electronic nicotine delivery systems, ENDS, smoking cessation, tobacco control, risk perceptions

Although the public health community is divided on the health impact of using electronic nicotine delivery systems (ENDS),<sup>1-4</sup> many have concluded that exclusively using ENDS is safer than using combustible tobacco products.<sup>5-8</sup> Several studies further suggest that ENDS may have the potential to aid cessation efforts and help reduce rates of combustible cigarette smoking,<sup>9-11</sup> although other studies indicate that ENDS are not fulfilling this promise.<sup>12,13</sup>

Whereas the health risks of cigarette smoking are well established,<sup>14</sup> the health risks of ENDS use are less known.<sup>15,16</sup> Studies of health risks of tobacco products generally focus on the potential for illness or disease resulting from use. However, in addition to environmental contamination hazards<sup>17</sup> and the possibility of accidental poisoning,<sup>18</sup> ENDS have recently been associated with the risk of exploding or catching fire, thereby causing thermal, chemical burn, and blast injuries to users.<sup>19-25</sup> Many of these events were reported in the media<sup>26-30</sup> and prompted US Senator Chuck

Schumer to request review and action (eg, recall) by the US Consumer Product Safety Commission and the US Food and Drug Administration (FDA) to prevent future incidents.<sup>31</sup> Some explosions are caused by battery failures,<sup>19-23,25,32,33</sup> whereas others can be attributed to user behaviors, such as

<sup>1</sup> Tobacco Center of Regulatory Science, School of Public Health, Georgia State University, Atlanta, GA, USA

<sup>2</sup> Department of Population Health Sciences, School of Public Health, Georgia State University, Atlanta, GA, USA

<sup>3</sup> Department of Health Policy and Behavioral Sciences, School of Public Health, Georgia State University, Atlanta, GA, USA

<sup>4</sup> Decision Research, Eugene, OR, USA

## Corresponding Author:

Amy L. Nyman, MA, Georgia State University, Tobacco Center of Regulatory Science, School of Public Health, PO Box 3995, Atlanta, GA 30302, USA.

Email: anyman@gsu.edu

product modification<sup>20</sup> or improper storage or charging.<sup>23,26,32</sup> ENDS products do not usually convey warnings about the risk of injury from overheating or explosion,<sup>34</sup> and products ordered online may be shipped with leaking fluids and minimal instructions or product information.<sup>35</sup>

Reports of explosions have mainly been anecdotal and have not been systematically documented over time. In 2012, the FDA's Center for Tobacco Products (CTP) began documenting ENDS explosions occurring in the United States. CTP identified 92 such events that occurred between 2009 and 2015. However, CTP acknowledges that because of a lack of regulation on reporting by manufacturers, underreporting, and search methodology issues, these data cannot be used to calculate the prevalence of explosions.<sup>26</sup> To gather more data, CTP held a public workshop on ENDS battery safety in April 2017 and established a public docket on this issue.<sup>36</sup>

Media coverage of exploding ENDS began in 2012 and has increased.<sup>26</sup> Reports of these incidents tend to be accompanied by graphic photos or videos of severe burns and other injuries.<sup>28-30</sup> This graphic and news-making risk of injury from explosion may present a prohibitive risk to some combustible cigarette smokers beyond that of illness or disease risks, thereby discouraging the use of ENDS to attempt cessation. Research on risk perception indicates that most persons rely not on statistics but on emotion and intuition to decide whether an activity is too risky to pursue. The more uncontrollable or catastrophic the risk appears, the less likely the user is to accept it. The factor comprising these characteristics is known as "dread risk." A prime example of a hazard with a high level of perceived dread risk is a nuclear war or accident.<sup>37</sup> A study of perceived risk of automobile defects found that one automobile defect, namely a fuel tank rupture upon impact, produced a dread risk similar to that for nuclear events.<sup>38</sup> The resulting possibility of fire, explosion, and burn injury from this structural defect parallels the possible result of ENDS explosions, which may lead to a similar dread among consumers. Even if the actual risk of an ENDS product exploding or catching fire is low, the graphic nature of the event and media coverage could lead potential users to believe that ENDS carry a greater risk of exploding or catching fire than statistics suggest. Thus, smokers who might otherwise consider using ENDS to help them quit smoking may be deterred by reports of ENDS explosions.

The objective of this study was to examine how consumers perceive the risks of injury caused by explosion or fire from using ENDS and whether beliefs about the possibility of injury from exploding ENDS are associated with use of ENDS, perceptions of harm, and costs and benefits of ENDS use among combustible cigarette smokers.

## Methods

### Study Sample and Procedures

We used data from the 2017 Tobacco Products and Risk Perceptions Survey (unpublished data, 2017), which is

conducted annually by the Georgia State University Tobacco Center of Regulatory Science. This cross-sectional survey of a probability sample and representative oversample of pre-identified combustible cigarette smokers is drawn from GfK's KnowledgePanel, a web panel representative of non-institutionalized US adults. Survey participants were selected with probabilities proportional to the size of their sociodemographic group within the population after application of the panel demographic post-stratification weight, which corrects panel base weights for sources of sampling and nonsampling error. GfK provided a computer with internet access to those recruited panelists who did not have one. Data collection occurred from August 1 through September 21, 2017. The Georgia State University Institutional Review Board approved this study.

In total, GfK invited 8229 KnowledgePanel members to participate in the survey: 7270 members from the general population sample, of whom 5463 (75.1%) completed the screener and 5455 qualified for the survey by providing information on their cigarette smoking status; and 959 members from the smoker oversample, of whom 653 (68.1%) completed the screener and 578 qualified for the main survey by confirming their current smoking status. Of the 6033 qualified completers, 41 were excluded for the following reasons: refusing to answer more than half of the survey questions, low survey duration (ie, a survey completed in <3 minutes), or improbable or incompatible responses. The final analytic sample consisted of 5992 (72.8%) respondents. GfK computed a study-specific post-stratification weight by using an iterative proportional fitting (raking) procedure to adjust for survey nonresponse and for oversampling of smokers. GfK used demographic and geographic distributions from the most recent Current Population Survey<sup>39</sup> as benchmarks for adjustment and included sex, age, race/ethnicity, education, annual household income, census region, and metropolitan area. The analytic sample for this study was the 1181 current combustible cigarette smokers who reported awareness of ENDS. We defined awareness of ENDS by a "yes" response to the following question: "Have you ever seen or heard of any type of electronic vapor product, such as e-cigarettes, e-cigars, e-hookahs, e-pipes, vape pens, hookah pens, or personal vaporizers/mods before this study?" We provided descriptions and images of these products before the awareness question.

### Measures

**Perceived risk of injury from exploding ENDS.** Participants who were aware of ENDS were shown the following statement: "Imagine that you just began using electronic vapor products every day. What do you think your chances are of having each of the following happen to you if you continue to use electronic vapor products every day?" Participants were then presented several possible consequences of daily ENDS use, including "injury from electronic vapor products catching fire or exploding," and asked to rate their perceived chances

of each on a 7-point scale, from 0 (no chance) to 6 (very good chance). For analyses, a rating of 0 or 1 was classified as low perceived risk, and a rating  $\geq 2$  was classified as medium or high perceived risk. Responses of “I don’t know” were retained as a third category.

**Perceptions of comparative harm from ENDS and cigarettes.** Participants aware of ENDS were asked, “Is using electronic vapor products less harmful, about the same, or more harmful than smoking regular cigarettes?” Response options were: much less harmful, less harmful, about the same level of harm, more harmful, much more harmful, and I don’t know. For analyses, we combined responses of much less harmful and less harmful into 1 category (“less harmful”), and we combined responses of more harmful and much more harmful into 1 category (“more harmful”). We then combined the “more harmful” category with “about the same level of harm” to compare with the “less harmful” category.

**Perceptions of costs and benefits of ENDS use.** To assess perceptions of the costs and benefits of ENDS use, participants were shown the following statement: “Using electronic vapor products may have some positive aspects and some negative aspects. We would like you to think about the positive and negative aspects of using electronic vapor products. Do the positive aspects outweigh the negative or do the negative aspects outweigh the positive, or are they about the same?” Response options included, “The negative aspects outweigh the positive,” “The negative and positive aspects are about equal,” and “The positive aspects outweigh the negative.”

**ENDS product use.** Before answering questions about ENDS, participants were shown generic images of various ENDS products and provided the following description: “Next, we’d like to ask about electronic vapor products, such as e-cigarettes, e-cigars, e-hookahs, e-pipes, vape pens, and personal vaporizers/mods. These devices are battery-powered and usually contain a nicotine-based liquid that is vaporized and inhaled. Some can be bought as one-time use, disposable products, while others are reusable with a rechargeable battery and a cartridge or tank system. Disposable electronic vapor products, cartridges, and e-liquids come in many different flavors and nicotine concentrations. Some common brands include Fin, NJOY, Blu, e-Go, and Vuse.” ENDS use was assessed by asking respondents who were aware of ENDS if they had ever used ENDS, even 1 or 2 times. Those who had ever used ENDS were asked if they now used them every day, some days, rarely, or not at all. Those who responded “not at all” were classified as former ENDS users, and those who responded every day, some days, or rarely were classified as current ENDS users.

**Cigarette smoking.** Respondents who reported smoking  $\geq 100$  cigarettes in their lifetime were asked, “Do you currently smoke cigarettes every day, some days, or not at all?” Those who responded “every day” or “some days” were considered current smokers, and those who responded “not at all” were

considered former smokers. Those who had not smoked 100 cigarettes in their lifetime were considered never smokers.

**Participant characteristics and other covariates.** Participant characteristics examined in analyses, including sex (male, female), age (18-29, 30-44, 45-59,  $\geq 60$  years), education level (<high school diploma, high school diploma, some college,  $\geq$ college degree), race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other, Hispanic, non-Hispanic  $\geq 2$  races), and annual household income (<\$15 000, \$15 000-\$24 999, \$25 000-\$39 999, \$40 000-\$59 999, \$60 000-\$84 999, \$85 000-\$99 999,  $\geq$ \$100 000), were obtained from profile surveys administered by GfK to KnowledgePanel panelists. Two additional measures of perceived risk were included as covariates in analytic models. These included a composite of the number of medium or high perceived risk responses of risk of lung cancer, lung disease, and heart disease from daily ENDS use, and perceived level of risk of injury from house fire caused by cigarettes with daily cigarette smoking.

### Statistical Analysis

We conducted all analyses by using IBM SPSS with Complex Samples module version 25<sup>40</sup> to obtain weighted point estimates and 95% confidence intervals (CIs) for perceptions of risk of injury from ENDS catching fire or exploding as a result of daily use, overall and by ENDS use and cigarette smoking status. We measured associations among perceptions, product use, and participant characteristics by using weighted multivariable, multinomial logistic regression to obtain odds ratios, adjusting for sex, age, education, race/ethnicity, annual household income, and several perceived risks of ENDS use and combustible cigarette use. We used a *t* test of adjusted logistic regression coefficients and considered  $P < .05$  to be significant.

### Results

More than one-third (37.7%) of 328 smokers who currently used ENDS and 16.5% of 431 smokers who had never used ENDS perceived a low risk of fire or explosion-related injury if they were to use ENDS daily. More than one-third (37.2%) of smokers who had never used ENDS and 10.6% of smokers who currently used ENDS were uncertain about their perceived risk of injury if they were to use ENDS daily (Table 1).

Combustible cigarette smokers who were aware of ENDS ( $n = 1181$ ) and perceived a medium or high risk of fire or explosion-related injury from ENDS had half the odds of being current ENDS users (adjusted odds ratio [aOR] = 0.50; 95% CI, 0.30-0.86) compared with those who perceived a low risk of fire or explosion-related injury from ENDS. Combustible cigarette smokers who were uncertain about their perceived risk of fire or explosion-related injury were also less likely to be former ENDS users (aOR = 0.38;

**Table 1.** Perceived risk of fire or explosion-related injury from ENDS if used daily, among adult combustible cigarette smokers aware of ENDS (n = 1181), United States, August-September 2017<sup>a</sup>

Perceived Risk of Injury	Never ENDS User, % <sup>b</sup> (95% CI) (n = 431)	Former ENDS User, % <sup>b</sup> (95% CI) (n = 418)	Current ENDS User, % <sup>b</sup> (95% CI) (n = 328)
Low	16.5 (12.5-21.6)	29.0 (23.8-34.7)	37.7 (31.0-44.8)
Medium/high	46.3 (40.5-52.2)	47.2 (41.2-53.3)	51.7 (44.6-58.7)
Don't know	37.2 (31.6-43.1)	23.8 (19.0-29.4)	10.6 (7.4-15.1)

Abbreviation: ENDS, electronic nicotine delivery systems.

<sup>a</sup>Data source: 2017 Tobacco Products and Risk Perceptions Survey (unpublished data, 2017).

<sup>b</sup>All percentages are weighted to the 2017 US population of noninstitutionalized adult smokers.

95% CI, 0.22-0.64) or current ENDS users (aOR = 0.15; 95% CI, 0.08-0.28) than those who perceived a low risk of injury (Table 2).

After we adjusted for participant characteristics and belief in a similar type of risk from cigarettes (ie, risk of injury from house fire caused by cigarettes), we found that smokers who perceived a medium or high risk of fire or explosion-related injury from ENDS had more than 3 times the odds of believing ENDS were equally harmful or more harmful than cigarettes (aOR = 3.22; 95% CI, 2.11-4.93) than those who perceived a low risk of injury from ENDS. Being uncertain about the perceived risk was significantly associated with uncertainty about the comparative harm of ENDS and combustible cigarettes (aOR = 8.36; 95% CI, 4.59-15.21;  $P < .001$ ; Table 3).

Perceiving a higher risk of fire or explosion-related injury from ENDS was significantly associated with increased odds of believing that the negatives of ENDS use outweighed the positives (aOR = 3.50; 95% CI, 2.00-6.14) or the costs and benefits were about equal (aOR = 2.64; 95% CI, 1.57-4.42). Being uncertain about the risk was also significantly associated with increased odds of believing that the negatives of ENDS use outweighed the positives (aOR = 3.63; 95% CI, 1.85-7.12) or the costs and benefits were about equal (aOR = 3.49; 95% CI, 1.89-6.44), compared with those who believed in a lower risk of injury from fire or explosion-related injury from ENDS (Table 4).

## Discussion

The findings of this study suggest that perceived risk of injury from exploding ENDS may be associated with other perceptions and use of ENDS. Smokers who perceived a higher risk of injury from fire or explosion-related ENDS, or who were uncertain about the risk, were less likely to use ENDS than those who perceived a lower risk, even after we controlled for perceptions of other illness and disease risks. Publicized incidents of ENDS exploding or catching fire and associated injuries may be deterring smokers from using these products, despite the widely held belief that continuing smoking has greater health risks than exclusive use of ENDS.<sup>5-8</sup> Graphic media coverage and the high-dread nature of these events may evoke strong negative emotions in smokers and lead them to place a disproportionate weight on the risk of these events relative to their true rate of occurrence.<sup>37,41-43</sup> The growing misperception that ENDS are as harmful as combustible

cigarettes<sup>44</sup> might be, in part, driven by the publicized occurrence of these explosions and associated injuries. Our finding that combustible cigarette smokers who feel they are more likely to be injured by fire or explosions related to ENDS use were also more likely to perceive ENDS to be at least as harmful as combustible cigarettes supports this conclusion.

A necessary condition for achieving the ideal public health potential of ENDS requires not only that ENDS are less harmful than cigarettes but that smokers make the decision to use and switch to ENDS use exclusively if they are otherwise unable or unwilling to quit all nicotine products entirely. Our finding that greater perceived risk of injury because of exploding ENDS was associated with smokers' feeling that the negatives of ENDS use outweighed the positives implicates these explosion events and their media coverage in smokers' risk perceptions and decision not to use them, thereby undermining their possible harm-reduction potential. Efforts to correct misperceptions about the relative risk of ENDS use compared with cigarette smoking may help address this issue, although such efforts should ensure that smokers understand the risks of dual use and that both smokers and nonsmokers understand the absolute risk of e-cigarette use. Caution in the way corrective messages are presented is crucial, because simple publicity of quantitative risks of other hazards has not been successful in changing public perceptions.<sup>37</sup> Similar to the concern associated with blood transfusions or nuclear power plants, where the benefits outweigh the risks statistically but both have been linked to dreaded consequences,<sup>37,41,43</sup> incidents of exploding ENDS are viewed as too great a risk by some, despite scientific consensus that use of ENDS is less risky than combustible cigarette smoking.<sup>8</sup> Once public negative effect (or emotion) toward a hazard is substantial, it is difficult for experts to counter that emotion with facts.<sup>43</sup> However, focusing on the qualitative benefits of blood transfusions,<sup>41</sup> or in this case ENDS use among smokers, could help reduce negative effect. In addition, research supports the existence of availability bias, in which persons overestimate the risks of hazards that are disproportionately visible, such as hazards or events that are given extensive media coverage.<sup>42</sup> Thus, communication about the relatively low incidence of ENDS explosions may also help assuage consumers' fears in response to media coverage of these extreme events. Journalists covering these events could be counseled to place such

**Table 2.** Association among perceived risk of fire or explosion-related injury from ENDS, demographic characteristics, and former and current ENDS use among adult combustible cigarette smokers aware of ENDS (n = 1181), United States, August-September, 2017<sup>a</sup>

Characteristics	aOR <sup>b</sup> (95% CI) [P Value] <sup>c</sup>	
	Former ENDS User <sup>d,e</sup>	Current ENDS User
Perceived risk of injury from ENDS catching fire or exploding with daily use		
Low	1 [Reference]	1 [Reference]
Medium/high	0.65 <sup>f</sup> (0.39-1.07) [.09]	0.50 (0.30-0.86) [.01]
Don't know	0.38 (0.22-0.64) [<.001]	0.15 (0.08-0.28) [<.001]
Sex		
Female	1 [Reference]	1 [Reference]
Male	0.66 (0.47-0.94) [.02]	0.94 (0.64-1.39) [.76]
Age, y		
18-29	1 [Reference]	1 [Reference]
30-44	0.83 (0.47-1.47) [.52]	0.57 (0.32-0.99) [.047]
45-59	0.46 (0.26-0.81) [.007]	0.22 (0.13-0.39) [<.001]
≥60	0.48 (0.27-0.85) [.01]	0.09 (0.05-0.17) [<.001]
Education		
≥College degree	1 [Reference]	1 [Reference]
Some college	1.23 (0.74-2.03) [.42]	0.90 (0.52-1.56) [.71]
High school diploma	1.49 (0.86-2.59) [.16]	0.89 (0.48-1.63) [.70]
<High school diploma	1.79 (0.90-3.56) [.10]	1.38 (0.67-2.84) [.38]
Race/ethnicity		
Non-Hispanic white	1 [Reference]	1 [Reference]
Non-Hispanic black	0.89 (0.52-1.52) [.66]	0.68 (0.35-1.30) [.24]
Non-Hispanic other	0.97 (0.36-2.61) [.94]	1.49 (0.59-3.75) [.40]
Hispanic	0.52 (0.29-0.94) [.03]	0.92 (0.53-1.61) [.78]
Non-Hispanic ≥2 races	0.59 (0.14-2.49) [.47]	0.24 (0.05-1.17) [.08]
Annual household income, \$		
≥100 000	1 [Reference]	1 [Reference]
85 000-99 999	0.63 (0.25-1.59) [.33]	0.56 (0.18-1.75) [.32]
60 000-84 999	0.72 (0.39-1.34) [.30]	1.09 (0.55-2.16) [.81]
40 000-59 999	0.61 (0.33-1.14) [.12]	1.17 (0.60-2.28) [.64]
25 000-39 999	0.62 (0.32-1.19) [.15]	0.70 (0.33-1.46) [.34]
15 000-24 999	0.95 (0.47-1.91) [.88]	0.88 (0.39-1.98) [.75]
<15 000	0.43 (0.23-0.80) [.008]	0.61 (0.30-1.23) [.16]
Perceived risks of ENDS from daily use: lung cancer, lung disease, heart disease	0.95 (0.81-1.12) [.55]	1.00 (0.83-1.19) [.97]

Abbreviations: aOR, adjusted odds ratio; ENDS, electronic nicotine delivery systems.

<sup>a</sup>Data source: 2017 Tobacco Products and Risk Perceptions Survey (unpublished data, 2017).

<sup>b</sup>Odds ratios were adjusted for all characteristics.

<sup>c</sup>T tests were used to obtain significance levels, with  $P < .05$  considered significant.

<sup>d</sup>Former ENDS users were those who had ever used ENDS but currently used them not at all. Current ENDS users were those who currently used ENDS every day, some days, or rarely.

<sup>e</sup>"Never ENDS use" is the reference category for ENDS use status.

<sup>f</sup>Estimates were weighted to the 2017 US population of noninstitutionalized adult smokers.

events in the context of both their low likelihood of occurrence and the potentially greater risk of injury from fires and burns caused by smoking.

In addition to messaging about the low incidence of explosions and the greater harms of combustible cigarette smoking compared with ENDS use, steps to prevent incidents of explosion are critically important. In 2016, the FDA deemed ENDS to be under its regulatory authority, including their manufacture, marketing, and distribution.<sup>45,46</sup> This authority includes new product review and the promulgation of product standard regulations. Development and implementation of new product review and standards to improve safety may include steps to evaluate and require design features that prevent battery failures, concurrent with any

voluntary efforts to improve safety that are currently being undertaken by manufacturers.<sup>33,34,47</sup> CTP's study of 92 explosion events concluded that more surveillance is necessary, along with strategies that maintain proper manufacturing and product function.<sup>26</sup> Studies of package labeling have concluded that current labeling practices provide insufficient information on risks.<sup>21,34,48</sup> Consideration of the human factors associated with ENDS use, which was included as part of FDA's draft guidance on Premarket Tobacco Product Applications for Electronic Nicotine Delivery Systems,<sup>49</sup> is a logical and underused step in understanding the potential causes of explosions.<sup>34</sup> In April 2017, CTP posted tips for consumers to help avoid battery explosions.<sup>50</sup> As a precautionary measure, the Federal Aviation Administration prohibits

**Table 3.** Association among perceived risk of fire or explosion-related injury from ENDS, demographic characteristics, and perceptions of the comparative harm of combustible cigarettes and ENDS, among adult combustible cigarette smokers aware of ENDS (n = 1181), United States, August-September 2017<sup>a</sup>

Characteristics	Perceptions of Comparative Harm From ENDS and Combustible Cigarettes, aOR <sup>b</sup> (95% CI) [P Value] <sup>c</sup>	
	ENDS Are More Harmful or About the Same Level of Harm as Combustible Cigarettes <sup>d</sup>	Don't Know
Perceived risk of injury from ENDS catching fire or exploding with daily use		
Low	1 [Reference]	1 [Reference]
Medium/high	3.22 <sup>e</sup> (2.11-4.93) [ $<.001$ ]	1.31 (0.78-2.22) [.31]
Don't know	2.77 (1.54-4.98) [ $.001$ ]	8.36 (4.59-15.21) [ $<.001$ ]
Sex		
Female	1 [Reference]	1 [Reference]
Male	0.73 (0.51-1.04) [.08]	0.80 (0.52-1.22) [.29]
Age, y		
18-29	1 [Reference]	1 [Reference]
30-44	1.33 (0.79-2.24) [.28]	1.62 (0.86-3.06) [.14]
45-59	1.38 (0.82-2.32) [.23]	1.48 (0.79-2.75) [.22]
$\geq 60$	1.23 (0.73-2.10) [.44]	1.84 (0.97-3.50) [.06]
Education		
$\geq$ College degree	1 [Reference]	1 [Reference]
Some college	1.03 (0.60-1.78) [.91]	1.76 (0.97-3.20) [.06]
High school diploma	1.35 (0.76-2.39) [.30]	2.24 (1.14-4.36) [.02]
<High school diploma	1.13 (0.56-2.28) [.73]	1.99 (0.87-4.58) [.11]
Race/ethnicity		
Non-Hispanic white	1 [Reference]	1 [Reference]
Non-Hispanic black	0.79 (0.42-1.47) [.45]	1.96 (0.99-3.89) [.05]
Non-Hispanic other	1.99 (0.77-5.19) [.16]	2.61 (0.94-7.28) [.07]
Hispanic	1.42 (0.80-2.52) [.23]	2.42 (1.28-4.59) [.01]
Non-Hispanic $\geq 2$ races	0.87 (0.22-3.40) [.84]	2.75 (0.47-15.95) [.26]
Annual household income, \$		
$\geq 100\,000$	1 [Reference]	1 [Reference]
85\,000-99\,999	1.97 (0.67-5.83) [.22]	1.56 (0.53-4.57) [.42]
60\,000-84\,999	0.93 (0.49-1.76) [.82]	1.10 (0.48-2.49) [.82]
40\,000-59\,999	1.18 (0.62-2.25) [.61]	1.19 (0.56-2.54) [.65]
25\,000-39\,999	1.05 (0.54-2.05) [.88]	1.36 (0.60-3.04) [.46]
15\,000-24\,999	0.87 (0.41-1.85) [.72]	1.42 (0.58-3.47) [.44]
<15\,000	2.41 (1.23-4.74) [.01]	1.57 (0.69-3.56) [.29]
Perceived risk of injury from house fire caused by cigarettes		
Low	1 [Reference]	1 [Reference]
Medium/high	1.11 (0.76-1.62) [.59]	1.00 (0.64-1.56) [.99]
Don't know	1.65 (0.72-3.77) [.23]	1.82 (0.77-4.33) [.18]

Abbreviations: aOR, adjusted odds ratio; ENDS, electronic nicotine delivery systems.

<sup>a</sup>Data source: 2017 Tobacco Products and Risk Perceptions Survey (unpublished data, 2017).

<sup>b</sup>Odds ratios were adjusted for all characteristics.

<sup>c</sup>T tests were used to obtain significance levels, with  $P < .05$  considered significant.

<sup>d</sup>"Less harmful" is the reference category for perceptions of comparative harm from ENDS and combustible cigarettes. This table examines the associations between perceived risk of fire or explosion-related injury from daily ENDS use and other user characteristics with perceiving ENDS as more harmful than or equally as harmful as combustible cigarettes, or being uncertain about the level of harm.

<sup>e</sup>Estimates are weighted to the 2017 US population of noninstitutionalized adult smokers.

ENDS products from checked baggage and provides warnings about lithium batteries used in ENDS.<sup>51</sup>

### Limitations

This study had several limitations. Because the data were cross-sectional, any inferences about causation must be

highly qualified. Randomized experiments are needed to evaluate the causal effect of these adverse events on smokers' perceptions and decisions to use ENDS. Although this study used a probability sample and weighting adjustments, panel conditioning, in which participation in past surveys can affect responses, may have rendered the sample less representative of the US adult population than it would be without

**Table 4.** Association among perceived risk of fire or explosion-related injury from ENDS, demographic characteristics, and perceived costs and benefits of ENDS use, among adult cigarette smokers aware of ENDS (n = 1181), United States, August-September 2017<sup>a</sup>

Characteristics	Perception of Costs and Benefits of ENDS Use, aOR <sup>b</sup> (95% CI) [P value] <sup>c</sup>	
	Negative Outweighs Positive <sup>d</sup>	About Equal
Perceived risk of injury from ENDS catching fire or exploding with daily use		
Low	1 [Reference]	1 [Reference]
Medium/high	3.50 <sup>e</sup> (2.00-6.14) [<.001]	2.64 (1.57-4.42) [<.001]
Don't know	3.63 (1.85-7.12) [<.001]	3.49 (1.89-6.44) [<.001]
Sex		
Female	1 [Reference]	1 [Reference]
Male	1.12 (0.72-1.74) [.63]	1.19 (0.79-1.77) [.41]
Age, y		
18-29	1 [Reference]	1 [Reference]
30-44	1.00 (0.51-1.98) [.99]	0.78 (0.42-1.43) [.42]
45-59	1.28 (0.66-2.49) [.47]	0.74 (0.41-1.34) [.32]
≥60	1.96 (0.95-4.04) [.07]	1.35 (0.68-2.67) [.39]
Education		
≥College degree	1 [Reference]	1 [Reference]
Some college	0.74 (0.36-1.54) [.42]	0.76 (0.37-1.54) [.44]
High school diploma	0.60 (0.28-1.29) [.19]	0.94 (0.45-1.99) [.88]
<High school diploma	0.53 (0.22-1.32) [.17]	0.77 (0.33-1.77) [.54]
Race/ethnicity		
Non-Hispanic white	1 [Reference]	1 [Reference]
Non-Hispanic black	0.58 (0.29-1.19) [.14]	0.88 (0.48-1.62) [.69]
Non-Hispanic other	0.65 (0.18-2.32) [.51]	1.32 (0.42-4.10) [.63]
Hispanic	0.69 (0.33-1.44) [.32]	1.08 (0.53-2.23) [.83]
Non-Hispanic ≥2 races	1.39 (0.31-6.14) [.67]	0.78 (0.18-3.39) [.74]
Annual household income, \$		
≥100 000	1 [Reference]	1 [Reference]
85 000-99 999	0.86 (0.25-2.95) [.81]	1.34 (0.38-4.70) [.65]
60 000-84 999	1.16 (0.53-2.57) [.71]	1.02 (0.46-2.24) [.97]
40 000-59 999	0.99 (0.44-2.23) [.98]	1.53 (0.72-3.27) [.27]
25 000-39 999	0.48 (0.21-1.10) [.08]	1.34 (0.61-2.96) [.46]
15 000-24 999	1.42 (0.59-3.46) [.44]	1.21 (0.50-2.92) [.67]
<15 000	0.52 (0.22-1.24) [.14]	1.41 (0.65-3.06) [.39]
Perceived risks of ENDS from daily use: lung cancer, lung disease, heart disease	1.33 (1.08-1.62) [.007]	1.15 (0.97-1.37) [.12]

Abbreviations: aOR, adjusted odds ratio; ENDS, electronic nicotine delivery systems.

<sup>a</sup>Data source: 2017 Tobacco Products and Risk Perceptions Survey (unpublished data, 2017).

<sup>b</sup>Odds ratios were adjusted for all characteristics.

<sup>c</sup>T tests were used to obtain significance levels, with  $P < .05$  considered significant.

<sup>d</sup>“Positive outweighs negative” is the reference category for cost/benefit of ENDS use. This table examines the associations between perceived risk of fire or explosion-related injury from daily ENDS use and other user characteristics with thinking the negatives of ENDS use outweigh the positives, or being uncertain about whether the negatives outweigh the positives.

<sup>e</sup>Estimates are weighted to the 2017 US population of noninstitutionalized adult smokers.

panel conditioning effects. In addition, the survey did not include a measure of whether participants were familiar with media reports of ENDS explosions, which is a factor that might affect perceptions of risk. The study also did not use a measure of whether smokers believed in the efficacy of ENDS for smoking cessation; this factor might have influenced decisions to use ENDS.

## Conclusions

This study demonstrates that belief among combustible cigarette smokers in a greater possibility of injury from exploding

ENDS is associated with lower odds of current ENDS use and the perception that ENDS are at least as harmful as cigarettes. Communication about the relative benefits of exclusive use of ENDS compared with cigarettes, as well as clearer guidance on proper usage, charging, storage, and warnings about improper ENDS use, is necessary. Product standards that include better design, manufacturing practices, and labeling are essential to improve the safety of these products.

## Authors' Note

Per the data sharing agreement with the National Institutes of Health (NIH), the data that support the findings of this study will

be made publicly available via a third-party data repository upon conclusion of the grant funding period. The data are also available from the principal investigator (Dr. Michael Eriksen) on reasonable request.


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### ORCID iD

Amy L. Nyman, MA  <https://orcid.org/0000-0002-3424-9491>

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