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## Youth Perceptions of E-Cigarette-Related Risk of Lung Issues and Association With E-Cigarette Use

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### Abstract

**Objective:** E-cigarette use is associated with increased risk of negative health outcomes, including respiratory problems such as Coronavirus Disease 2019 (COVID-19). Nevertheless, adolescents and young adults (AYAs) continue to use e-cigarettes at alarming rates. We examined AYA's perceptions of the health harms of e-cigarettes in relation to respiratory problems and the associations between these perceptions and e-cigarette use.

**Method:** In May 2020, we conducted an online, national cross-sectional survey of AYAs aged 13 to 24 years old ( $N = 4,315$ ; 65% female; 50% ever-users, 50% never-users) to assess e-cigarette use and perceptions of the risk of respiratory problems, COVID-19, and severe lung disease for AYAs with different levels of e-cigarette use.

**Results:** In comparisons between AYAs with different levels of e-cigarette use, e-cigarette-related health risk perceptions were lower among ever-users compared to never-users and among ever-users who used e-cigarettes in the past 30 days compared to ever-users who did not use in the past 30 days. After controlling for demographics, AYAs were less likely to have used in the past 30 days if they agreed that young people are at risk of respiratory problems due to e-cigarette use (adjusted Odds Ratio [aOR] = .68, 95% confidence interval [CI; .59, .78]) and e-cigarettes are harmful for their health (aOR = .52, 95% CI [.30, .90]). AYAs were more likely to have used in the past 30 days if they believed that there is no hard evidence that e-cigarette use with nicotine increases risk of severe lung disease (aOR = 1.61, 95% CI [1.42, 1.82]) and that e-cigarette use is safer than smoking cigarettes (aOR = 1.26, 95% CI [1.11, 1.42]).

**Conclusions:** Among AYAs who had ever used e-cigarettes, those who did not believe that e-cigarette use increases the risks of respiratory problems were more likely to have used e-cigarettes in the past month. To bridge the gap between youth perceptions and emerging scientific evidence on e-cigarette-related health risks, prevention messaging should seek to explain how e-cigarette use is linked to respiratory problems and could affect COVID-19 outcomes.

## Keywords

e-cigarette; COVID-19; adolescent; young adult; risk perceptions

Youth use of *e-cigarettes* (also referred to as *vapes* or *vaping*) has increased dramatically over the last five years, with latest national data showing that nearly two million high school students and over 300,000 middle school students reported using an e-cigarette in the past month (Wang et al., 2020). Emerging evidence shows that tobacco use is associated with vulnerability to and progression of Coronavirus Disease 2019 (COVID-19), which is an infectious respiratory illness caused by the SARS-CoV-2 virus that has caused millions of deaths globally (Adams et al., 2020; Patanavanich & Glantz, 2020). Since e-cigarette use has negative effects on lung function (Gotts et al., 2019; McConnell et al., 2017), of immediate concern for current e-cigarette users is their susceptibility to respiratory problems including COVID-19. Given this evidence about the harmful effects of e-cigarettes on the lungs and concerns that e-cigarette use may also be linked to COVID-19 (McAlinden et al., 2020; Gaiha et al., 2020a), an updated understanding of how youth perceive risks associated with e-cigarettes is needed.

Research shows that adolescent and young adult (AYA) perceptions of tobacco- and e-cigarette-related health risks are associated with future use of these products (Cooper et al., 2018; Kong et al., 2015; Manzione et al., 2020; Morrell et al., 2010; Song et al., 2009; Strong et al., 2019). These studies are in line with several theories of health behavior. The theory of planned behavior argues that attitudes and subjective norms predict behavioral intentions, which in turn predict behavior (Ajzen, 1991). The health belief model shows that perceived susceptibility, severity, benefits, and barriers are precursors to behavior (Champion & Skinner, 2008). AYA's misperceptions about e-cigarettes likely increase intentions to use and actual use by underplaying health-related risks, including believing that e-cigarettes are "safer" than combustible cigarettes, do not contain nicotine, and are just flavored water vapor (Gorukanti et al., 2017). Tobacco-naïve AYAs who perceive e-cigarettes as less harmful than combustible cigarettes are more likely to experiment with e-cigarettes (Choi & Forster, 2014). Because studies show that lung toxicity and respiratory harm caused by e-cigarettes may be en par with combustible cigarettes (Glynos et al., 2018; Reinikovaite et al., 2018), there is a need to further study AYA's perceptions about relative safety of e-cigarettes and whether these perceptions are linked to use. Thus, based on empirical evidence and health behavior theories, tobacco and specifically e-cigarette prevention aims to inform AYAs about health-related risks to modify their perceptions on the pathway to ultimately changing tobacco use behaviors.

Although a few studies have examined perceptions of COVID-19-related risks among adult e-cigarette users (Grummon et al., 2020; Kelly et al., 2020; Klemperer et al., 2020), limited studies focus on AYA's respiratory-health-related risk-perceptions from using e-cigarettes. Given existing misperceptions about the true health risks of e-cigarettes, such information will provide timely and relevant insights to update prevention programs and public health messages to lower AYA's intent to use e-cigarettes and prevent future use. The current study uses data from a national sample of AYAs to examine perceptions of e-cigarette-related risks

of respiratory problems and assess the relationship between these perceptions and e-cigarette use during the COVID-19 pandemic.

## Method

### Design and Participants

Data were collected through a cross-sectional online survey in May 2020 from 4,351 U.S. adolescents and young adults (13 to 24 years old). We recruited participants from Qualtrics' online panels. These panels include individuals who have been recruited through various sites, including gaming sites, social media (e.g., Instagram, TikTok, Facebook, Snapchat), customer loyalty portals related to their interests in automotive, beauty, finance, media, shopping, sports and travel; they also use website intercept recruitment. Prospective participants received a link to the survey, which informed them about the study aim to understand perceptions and health risks of COVID-19 from e-cigarette use (vaping). Additionally, the study would query about their knowledge of specific vaping products, perceptions on health of people using these products and about recent experiences related to COVID-19. Participants were also informed that they could withdraw from the study at any time without any consequences. Panelists interested in completing our survey provided online consent and assent before beginning the self-administered survey, and all panelists received financial compensation. Additional details about the original sample are described elsewhere (Gaiha et al., 2020a, 2020b). The Stanford University Institutional Review Board approved study procedures.

### Measures

Measures included participant demographics, e-cigarette use (ever-use and past 30-day use), and perceptions about the health risks of e-cigarettes. Using a 4-point Likert-type scale, ranging from 1 (strongly disagree) to 4 (strongly agree), participants rated how much they agreed with the following statements: "Vaping increases risk of COVID-19 because it affects lungs," "Young people are at risk of respiratory problems due to vaping," "No hard evidence that vaping nicotine increases risk of severe lung disease," and "Vaping is safer than smoking cigarettes." Participants were also asked about the health harms of using an e-cigarette/vaping product in the question, "Imagine you use these products [disposable e-cigarette/pod-based e-cigarette/any other e-cigarette, like mods] two to three times per day, every day. How harmful would this be for your health? [even 1 or 2 puffs]." For all e-cigarette device types (disposable/pod-based/any other like mods), participants rated the three items on a 4-point Likert-type scale ranging from (1) *not at all harmful* to (4) *extremely harmful*. Participant responses were combined for all e-cigarettes into two categories: either *not at all harmful* (0) or *slightly/quite/extremely harmful* (1).

### Analysis

Cross-tabulations compared perceptions about health risks of e-cigarette use by whether the participant had ever used an e-cigarette, and if so, whether the participant had used an e-cigarette in the past 30 days. Differences were tested using the chi-square statistic. To analyze the association between perceptions about health risks of e-cigarette use and having used an e-cigarette product in the past 30 days, we conducted multivariable logistic

regression among ever-users only. Univariate analyses were conducted to examine the association of demographics and health-risks perceptions of e-cigarette use with past 30-day e-cigarette use. Significant variables were included in the final model. Missing data were present for the outcome variables (e-cigarette ever use = .2%; past 30-day e-cigarette use = 8.1%). Less than 1% of responses were missing for all other variables. The final sample for this study was 4,315.

## Results

Participant characteristics are described in Table 1 ( $M_{\text{age}} = 19.1$ ,  $SD = 2.9$ ; 65.3% female; 17.4% Hispanic, 60.0% Non-Hispanic White, 13.9% Non-Hispanic African American/Black, 8.8% Non-Hispanic other; past 30-day use of: e-cigarettes (26.9%), cigarettes (14.3%), cigars or cigarillos (9.8%), and hookah (9.2%). As noted in Table 2, 70.4% of 4,315 participants agreed that e-cigarette use increases the risk of COVID-19 because it affects the lungs, 85.7% believed that young people are at risk of respiratory problems due to e-cigarette use, and 28.9% agreed that there is no hard evidence that nicotine in e-cigarettes increases risk of severe lung disease. Compared with never e-cigarette users, fewer ever-users agreed with the statement that e-cigarette use increases the risk of COVID-19 because it affects the lungs (never-users = 77.7%; ever-users = 63.2%) and that young people were at risk of respiratory problems due to e-cigarette use (never-users = 90.7%; ever-users = 81.2%). In addition, ever-users were more likely to agree than never-users that there is no hard evidence that e-cigarettes increase the risk of severe lung disease (never-users = 19.9%; ever-users = 37.8%) and using e-cigarettes is safer than smoking cigarettes (never-users = 34.7%, ever-users = 58.6%). Among e-cigarette ever-users, 97.9% of AYAs who had not used e-cigarettes in the past month believed that e-cigarettes were harmful to their health, compared with 93.2% of AYAs who had used in the past month.

Among ever e-cigarette users, regression analyses indicated that those who were less likely to have used e-cigarettes in the past month (during the COVID-19 pandemic) believed that young people are at risk of respiratory problems due to e-cigarette use (adjusted odds ratio [aOR] = .68, 95% CI [.59, .78]) and that e-cigarettes are harmful for health (aOR = .52, 95% CI [.30, .90]; see Table 3). Ever-users were more likely to have used e-cigarettes in the past month if they agreed that there was no hard evidence that e-cigarette use increases risk of severe lung disease (aOR = 1.61, 95% CI [1.42, 1.82]) and that e-cigarettes were safer than cigarettes (aOR = 1.26, 95% CI [1.11, 1.42]). Finally, adolescents aged 13 to 17 years old were less likely to have used an e-cigarette in the past 30 days compared with young adults aged 22 to 24 years old (aOR = .52, 95% CI [.40, .67]).

## Discussion

This study shows that while a majority of AYAs believed that e-cigarettes posed a risk for respiratory problems, a substantial proportion of AYAs held misperceptions about e-cigarette-related respiratory health risks. Similar to other studies (Bernat et al., 2018; Gorukanti et al., 2017), our study shows that e-cigarette-related misperceptions were more prevalent among past 30-day e-cigarette users compared to ever-users, and among ever-users compared to never-users. Further, past 30-day use of e-cigarettes was associated with

other health-related misperceptions; specifically, findings indicated that AYAs who reported beliefs that e-cigarettes do not increase the risk of severe lung disease and were safer than cigarettes were more likely to have used e-cigarettes in the past month. Thus, not all AYA perceptions align with the growing evidence that e-cigarette use is associated with respiratory problems (Gotts et al., 2019; McAlinden et al., 2020; McConnell et al., 2017) and findings that e-cigarette use may be related to COVID-19-related outcomes, including from this dataset (Gaiha et al., 2020a). Taken together, these findings highlight the need to make all AYAs (non-users, those experimenting, and regular users) aware of emerging scientific evidence about the health risks of e-cigarettes to prevent current and future use.

Our findings showing an association between past 30-day use and misperceptions about e-cigarette-related health risks of respiratory problems align with health behavior theories. For example, supporting the theory of planned behavior (Ajzen, 1991), e-cigarette-related attitudes that these products are not harmful to health (e.g., beliefs that there is no hard evidence that e-cigarettes are linked to severe lung illness) were associated with an increased likelihood of AYA's past-30-day use in our study. Similarly, as described in the Health Belief Model (Champion & Skinner, 2008), low perceived susceptibility and severity of health risks were factors related to AYA e-cigarette use, with one fourth of past 30-day AYA e-cigarette users perceiving that young people are not at risk of respiratory problems due to e-cigarette use. At the time this study was conducted, most reported cases of COVID-19 among adolescents and younger adults were asymptomatic or mild (Kim et al., 2020); in addition, AYA e-cigarette use appeared to have decreased in 2020 (Wang et al., 2020). Thus, AYAs in our sample likely did not perceive themselves as susceptible to respiratory problems even during the COVID-19 pandemic, and some self-reported that their e-cigarette use reduced during the COVID-19 pandemic in part because they were concerned about lung health (Gaiha et al., 2020b). Thus, it is plausible that AYAs who became aware of e-cigarette-related respiratory problems either in connection with e-cigarette, or vaping, product use-associated lung injury (EVALI) or the COVID-19 pandemic had already stopped or reduced e-cigarette use or were considering doing so in the near future. Since e-cigarette education has been associated with higher e-cigarette knowledge, lower AYA intent to use e-cigarettes (Gaiha et al., 2021) and reduced e-cigarette use (Kelder et al., 2020), timely and tailored prevention messaging is needed to modify attitudes and perceptions of susceptibility and severity of e-cigarette-related risk of poor lung health, to ultimately reduce AYA e-cigarette use.

To our knowledge, this is the only study to-date to report on the relationship between AYA use of e-cigarettes during the COVID-19 pandemic and perceptions about e-cigarette-related health harms, particularly lung health. Study strengths include a large, diverse national sample of AYAs. Our study's convenience sample and cross-sectional design limits generalizability of our findings. In addition, we do not know how perceptions about removing masks or meeting socially to use e-cigarettes may have interacted with perceived risk of poor lung health and COVID-19 alongside continued use of e-cigarettes during the COVID-19 pandemic. We do not know if AYA's perceptions of the risk of respiratory problems from using e-cigarettes has changed since May 2020; with more parents, teachers, doctors and young people discussing severity and susceptibility to COVID-19, and about maintaining respiratory health. E-cigarette ever-users in this sample reported reasons for

reduced e-cigarette use, such as being at home with parents who would know about their e-cigarette use and inability to access e-cigarettes (approximately 80% were sheltering-in-place during this study), and few who found it easier to access e-cigarettes reported using their parents' e-cigarettes (Gaiha et al., 2020b). The role of parenting and access to e-cigarettes and how these factors affect past 30-day use should be examined in future studies. We also do not know whether e-cigarette use will revert to prepandemic levels as AYAs start socializing again and/or are able to access e-cigarettes more easily.

More research is needed, including longitudinal studies across time periods before and during the COVID-19 pandemic, to fully understand AYA's perceptions of e-cigarette-related health risks and benefits and how such perceptions influence use over time. Most measures in this study refer to using e-cigarettes generally, and therefore the specific risk of using e-cigarettes containing nicotine, THC or vitamin E acetate could not be separated. To inform prevention education, future research should test the impact of traditional prevention messages that e-cigarettes are generally harmful to AYA health compared with messages that explicitly address lung health, similar to research among adults (Grummon et al., 2020).

## Conclusions

AYAs using e-cigarettes perceived lower risk of respiratory problems and illness from using e-cigarettes compared to non-users. Past month use of e-cigarettes was more likely among those believing that e-cigarettes were safer than combustible cigarettes and that there was no hard evidence that e-cigarette use with nicotine increases risk of severe lung disease. Past month use of e-cigarettes was less likely among younger AYAs (i.e., individuals <21 years of age) and those perceiving risk of respiratory problems from using e-cigarettes. These findings suggest that e-cigarette prevention strategies and youth information campaigns may need to update messages on e-cigarette-related health risks and safety.

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Shivani M. Gaiha and Bonnie Halpern-Felsher conceptualized the project; Shivani M. Gaiha was responsible for data curation; Anna E. Epperson performed formal analysis; Bonnie Halpern-Felsher acquired funding; Shivani M. Gaiha, Anna E. Epperson, and Bonnie Halpern-Felsher conducted the investigation; Anna E. Epperson, Shivani M. Gaiha, and Bonnie Halpern-Felsher developed the methodology; Shivani M. Gaiha and Bonnie Halpern-Felsher performed project administration; Bonnie Halpern-Felsher provided supervision; Shivani M. Gaiha and Anna E. Epperson wrote the original draft; and Shivani M. Gaiha, Anna E. Epperson, and Bonnie Halpern-Felsher reviewed and edited the manuscript.

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**Table 1**  
Sample Characteristics by E-Cigarette Use and Percent who Agree with Health Risk Perceptions

Characteristic	Overall n (%)	E-cigarette use increases risk of COVID-19 because it affects lungs n (%)	Young people are at risk of respiratory problems due to e- cigarette use n (%)	No evidence e-cigarette use increases risk of lung disease n (%)	E-cigarette use is safer than smoking cigarettes n (%)
Age					
13—17 years	1,442 (33.4)	1,043 (34.4)	1,277 (34.5)	385 (30.9)	669 (33.2)
18—21 years	1,810 (41.9)	1,280 (42.2)	1,547 (41.8)	526 (42.3)	867 (43.1)
22—24 years	1,063 (24.6)	713 (23.5)	875 (23.7)	333 (26.8)	477 (23.7)
Gender					
Male	1,402 (32.5)	888 (29.1)	1,120 (30.3)	499 (40.1)	778 (38.6)
Female	2,816 (65.3)	2,090 (68.8)	2,502 (67.6)	707 (56.9)	1,188 (59.0)
Other	96 (2.2)	64 (2.1)	77 (2.1)	37 (3.0)	47 (2.3)
Race/ethnicity					
Non-Hispanic White	2,590 (60.0)	1,918 (63.2)	2,315 (62.6)	625 (50.2)	1,204 (59.8)
Non-Hispanic African American/Black	598 (13.9)	366 (12.1)	470 (12.7)	221 (17.8)	266 (13.2)
Hispanic	749 (17.4)	490 (16.1)	596 (16.1)	271 (21.8)	340 (16.9)
Non-Hispanic other	378 (8.8)	262 (8.6)	318 (8.6)	127 (10.2)	203 (10.1)
Mother's level of education					
High school or less	986 (22.9)	663 (21.9)	803 (21.8)	313 (25.3)	441 (21.9)
Some college	601 (13.9)	383 (12.7)	494 (13.4)	170 (13.7)	274 (13.6)
College degree	1,420 (32.9)	1,072 (35.4)	1,280 (34.7)	367 (29.6)	682 (33.9)
Graduate degree	883 (20.5)	637 (21.1)	765 (20.7)	259 (20.9)	429 (21.3)
Unknown	408 (9.5)	271 (9.0)	345 (9.4)	130 (10.5)	184 (9.2)

Note. N = 4,315. COVID-19 = Coronavirus Disease 2019. The four columns from the right indicate the count and percentage of participants agreeing with different health risk perceptions related to e-cigarette use. Participants rated items on a 4-point Likert-type scale, on which 1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*. We then collapsed and coded responses as follows: *strongly disagree/disagree* (1) and *agree/strongly agree* (2).

**Table 2**  
Adolescent and Young Adult E-Cigarette Users' Perceptions of E-Cigarette-Related Health Risk: Overall and by Ever and Past 30-Day Use Status

Perception	Overall n (%)	Never used (n = 2,148) n (%)	Ever used (n = 2,167) n (%)	Ever-users only	
				Has not used in past 30 days (n = 906) n (%)	Has used in past 30 days (n = 1,086) n (%)
E-cigarette use increases risk of COVID because it affects lungs	3,036 (70.4)	1,667 (77.7)	1,369 (63.2)	644 (71.1)	623 (57.4)
Young people are at risk of respiratory problems due to e-cigarette use	3,699 (85.7)	1,942 (90.7)	1,757 (81.2)	818 (90.5)	811 (74.7)
There is no hard evidence that nicotine use in e-cigarettes increases risk of severe lung disease	1,244 (28.9)	425 (19.9)	819 (37.8)	218 (24.1)	533 (49.1)
E-cigarette use is safer than smoking cigarettes	2,013 (46.7)	744 (34.7)	1,269 (58.6)	461 (50.9)	721 (66.4)
Believe e-cigarettes to be harmful for their health <sup>a</sup>				884 (97.9)	1,010 (93.2)

Note. N = 4,315. COVID = Coronavirus Disease. Values in bold type denote significant group differences for e-cigarette-related health risk perceptions between ever-users and never-users (columns 2 and 3 from left) and ever users who used in the past 30 days and ever users who did not use in the past 30 days (columns 4 and 5 from left) ( $\chi^2_p < .05$ ). Unless otherwise noted, participants rated items on a 4-point Likert-type scale, on which 1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*. We then collapsed and coded responses as follows: *strongly disagree/disagree* (1) and *agree/strongly agree* (2).

<sup>a</sup> Participants rated items on a 4-point Likert-type scale, from 1 = *not at all harmful*, 2 = *slightly harmful*, 3 = *quite harmful*, 4 = *extremely harmful*. We then collapsed and coded responses as follows: *slightly/quite/extremely harmful* (1) and *not at all harmful* (0).

**Table 3** Regression Model of Association Between Health Perceptions and E-Cigarette Use in the Past 30 Days Among Ever E-Cigarette Users (n = 1,988)

Characteristic	Used an e-cigarette in past 30 days	
	OR [95% CI]	aOR [95% CI]
Age range		1.00
22–24 years (reference)		
18–21 years	<b>0.71 [0.56, 0.89]</b>	0.86 [0.67, 1.11]
13–17 years	<b>0.44 [0.35, 0.56]</b>	<b>0.52 [0.40, 0.67]</b>
Gender		1.00
Male (reference)		
Female	<b>0.52 [0.43, 0.63]</b>	<b>0.75 [0.61, 0.93]</b>
Other	0.72 [0.38, 1.35]	0.87 [0.43, 1.75]
Race/ethnicity		1.00
Non-Hispanic White (reference)		
Non-Hispanic African American/Black	<b>1.42 [1.08, 1.86]</b>	1.24 [0.92, 1.66]
Hispanic or Latino	<b>1.33 [1.07, 1.67]</b>	1.19 [0.93, 1.53]
Non-Hispanic Other	<b>1.40 [1.05, 1.86]</b>	1.21 [0.89, 1.65]
E-cigarette use increases the risk of COVID-19 because it affects the lungs	<b>0.70 [0.63, 0.77]</b>	0.89 [0.79, 1.01]
Young people are at risk of respiratory problems due to e-cigarette use	<b>0.54 [0.47, 0.60]</b>	<b>0.68 [0.59, 0.78]</b>
There is no hard evidence that e-cigarette use with nicotine increases risk of severe lung disease	<b>1.92 [1.72, 2.15]</b>	<b>1.61 [1.42, 1.82]</b>
E-cigarette use is safer than smoking cigarettes	<b>1.51 [1.36, 1.68]</b>	<b>1.26 [1.11, 1.42]</b>
E-cigarette harmfulness perception <sup>a</sup>		1.00
Not at all harmful (reference)		
Harmful	<b>0.29 [0.18, 0.49]</b>	<b>0.52 [0.30, 0.90]</b>

Note. COVID-19 = Coronavirus Disease 2019; OR = odds ratio; CI = confidence interval; aOR = adjusted odds ratio. Values in bold type are significant, controlling for all other variables. Unless otherwise noted, participants rated items on a continuous 4-point Likert-type scale, on which 1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*.

<sup>a</sup>Harmfulness perceptions were rated on a 4-point Likert-type scale, on which 1 = *not at all harmful*, 2 = *slightly harmful*, 3 = *quite harmful*, 4 = *extremely harmful*. We then collapsed responses into a binary variable, indicating *not at all harmful*/compared with all other responses.