

# Vaping in a Time of Pandemics: Risk Perception and Motivations for Electronic Cigarette Use

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## Abstract

**Introduction:** Prior studies on the association between the intensity of and motives for vaping e-cigarettes have highlighted the psychological dynamics of motivational changes, but less about how vaping motives may shift as a function of risk perceptions exacerbated by unanticipated events. This study frames the COVID-19 pandemic as an exacerbating threat to pulmonary health, and tests how e-cigarette users' risk perceptions of COVID-19 are related to different motives for vaping and ultimately the intensity of e-cigarette use.

**Aims and Methods:** An online survey of e-cigarette users in the United States ( $n = 562$ ) was conducted during April 2020 when much of the United States was under "lockdown" conditions. We distinguished three types of vaping motives (health, socialization, and dependence) and established the classification with confirmatory factor analysis. Structural equation modeling was conducted for path analyses and mediation tests.

**Results:** All three vaping motives were significantly associated with greater use intensity. A heightened risk perception of e-cigarette users' vulnerability to COVID-19 was inversely associated with use intensity ( $-.18, p < .01$ ) and health motives for vaping ( $-.27, p < .001$ ), but not associated with socialization and dependence motivations. Health motives for vaping mediated 35% of the association between COVID-19 risk perceptions and use intensity.

**Conclusions:** Our findings indicate that risk perceptions of exacerbated threats may reduce e-cigarette use directly, and also indirectly through shifting certain types of motivations for vaping. Beyond elucidating the relational dynamics between vaping psychology and health risks, these results also indicate health professionals may leverage the pandemic to promote nicotine cessation or reduced use.

**Implication:** Little is known about how vaping motives shift after unanticipated events such as pandemics. This study contributes to knowledge of how the use of e-cigarettes is motivated by different dimensions of rationales and exogenous risks. Exploiting the emergence of the COVID-19 pandemic, we found risk perceptions are associated with the intensity of e-cigarette use indirectly specifically through health motivations. Risk perceptions are not associated with socialization and dependence motives for vaping.

## Introduction

Electronic nicotine delivery systems (hereafter e-cigarettes) are non-combustible nicotine delivery devices that transmit aerosol mixed with vaporized nicotine and sometimes flavored chemicals. Globally, the number of people using e-cigarettes grew from 7 million to over 40 million between 2011 and 2018.<sup>1</sup> E-cigarettes have been advertised broadly to adults as a harm reduction alternative to combustible tobacco. Further, while smoking tobacco is prohibited in many public spaces in many countries, public vaping's current status involves a great deal of ambiguity.<sup>2,3</sup> In part due to the lack of inconsistency in regulations between combustible tobacco and e-cigarettes, e-cigarette users may hold beliefs that vaping is safer, noninvasive, and a fashionable alternative that helps them socialize or quit smoking conventional tobacco products.<sup>4,5</sup>

Yet, the popular beliefs about e-cigarettes were destabilized by a host of informational uncertainty following the onset of the COVID-19 pandemic; some favorable beliefs about e-cigarettes may have been curtailed. On one hand, early evidence suggests that e-cigarette users may be less vulnerable to COVID-19 pathogen,<sup>6–8</sup> largely due to nicotine's

occupation of the angiotensin-converting enzyme responsible for binding coronavirus.<sup>9,10</sup> However, during late 2019, the US CDC warned about lung injuries brought by e-cigarette additives.<sup>11</sup> With the emergence of the COVID-19 pandemic, threats to pulmonary health rose given that the disease primarily impairs the respiratory system in patients with severe symptoms. Beyond concerns related to the known pulmonary vulnerabilities of tobacco use, the pandemic instigated concerns that e-cigarette users may be at a greater danger.<sup>9,12</sup> Little is known about how e-cigarette users' risk perceptions responded to the pandemic under such uncertainty. Thus, the COVID-19 pandemic as a natural event offers an opportunity to explore how health motives and behavior can align with risk perceptions potentially exacerbated by an external environmental stressor.

While motives for smoking and vaping have been examined within models that build upon the contemporaneous constituents of health beliefs, less is known about how an externally imposed event such as the introduction of a virus,<sup>13–15</sup> may affect such motivations for consumption and, ultimately, health behaviors. While such events writ large may affect mo-

tivations, environmental threats directly linked to respiratory health, such as COVID-19, may alter motivations and subsequent behaviors.

### Motivations for Using E-cigarettes

Motivations are multidimensional; individuals often possess a constellation of motives related to different aspects of life. The motives for vaping may vary across several domains of key concerns. Studies have shown that the most common motives for using e-cigarettes include perceived health benefits, smoking cessation, aesthetic preferences, social acceptability, and circumventing legal regulations such as smoking bans.<sup>4,5,16,17</sup> For the use of an addictive substance such as nicotine, motivation also may arise outright from physiological dependence, adding a dependence motive for users.<sup>17,18</sup> Absent the combustion of tars and other compounds in combustible tobacco, e-cigarettes are often perceived as less harmful, which stimulates motivations for e-cigarettes as a cessation tool or healthier alternative for smokers.<sup>13,19</sup> In addition, the social learning perspective suggests that a major motivation for using substances, including nicotine products, relates to the substance's facilitative role in occasions of recreation and socializing. Thus, some e-cigarette users have developed stronger social motives and formed communal solidarity with other e-cigarette users.<sup>5,16,20</sup>

### Risk Perception and Motivations for Vaping

Several theories may elucidate how externally imposed threats (eg, COVID-19) may change motivations for using e-cigarettes, particularly motivations related to health promotion. Scientists have long recognized that external stimuli can potentially alter health motives as a part of ongoing interaction between actors and the environment. For instance, studies show that heavier air pollution elevates awareness for stricter tobacco control policy.<sup>21</sup> Additionally, exposure to anti-smoking media promotes anti-smoking attitudes.<sup>22</sup> Since motives for a health behavior come in multifaceted dimensions, the impact of risk factors in the environment on specific motives may also be heterogeneous, depending on the operative mechanism between the motive and the behavioral outcome. Several theories have elaborated on how risk perception may alter the motivations for health behaviors. As examples, we briefly consider aspects of the health belief model, protective motivation theory, and theories of health communication; all point to the susceptibility of motivations for e-cigarette use to change given perceived COVID-19 risk.

#### Health Belief Model

Motivations for vaping may be accommodated within the Health Belief Model, which suggests that people become motivated to change their behavior when they perceive an increased risk relative to its benefits.<sup>23</sup> For tobacco control, the health belief model has stressed the critical role of raising people's risk awareness when conducting behavioral interventions such as smoking cessation programs.

Studies have shown that existing beliefs about risks and benefits to substances may shift in response to the influences of peers, health education, implicit association, and role models, among a variety of signaled information or symbolic representations.<sup>24-27</sup> Although many e-cigarette users believe e-cigarettes are less harmful than combustible tobacco, the emergence of severe lung injuries due to illicit vaping addi-

tives during late 2019 as well as e-cigarettes' purported role in shaping severe cases of COVID-19 may impact certain motives for vaping in response to changes in these beliefs.

#### Protection Motivation Theory

Roger's Protection Motivation Theory,<sup>28</sup> revised from the earlier fear appraisal theory, aims to explain how externally imposed threats change health behaviors. The theory also proposes that the cognitive assessment of danger should affect health behavior via mediation by changing motivations for engaging in risk activities.

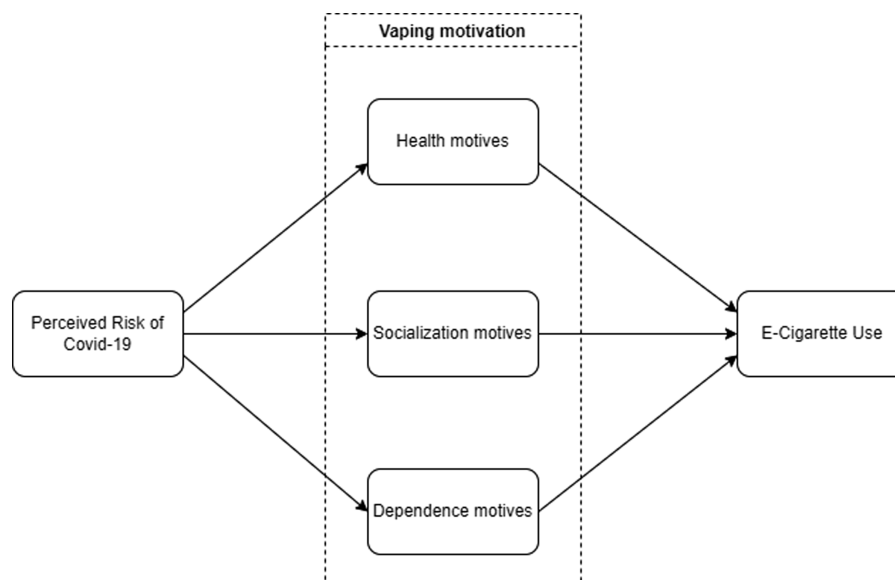
Protection Motivation Theory's proposition may help explain how perceived COVID-19 risk may reduce motivations for using e-cigarettes. There is a strong association between risk perception and considerations to quit vaping<sup>29</sup>; the experience of smoking-related health problems directly affects smoking motivations with increases in the perceived threat of smoking.<sup>30,31</sup> Longitudinal research also identified that protection motivation accounted for 35% of the variance in subsequent motivations for health behaviors.<sup>32</sup> In this way, e-cigarette users may incorporate new negative information related to the pandemic as threats that exacerbate e-cigarette risks and accordingly shift their motivations for vaping.

#### Health Communication and Education

The rich literature in health communication elaborates on processes of communication about the severity of risk behaviors and the role of communication in educating people about risks, which in turn may reduce motivations.<sup>33</sup> Carefully designed health communication can vastly heighten anti-smoking beliefs and in doing so suppress smoking motivations.<sup>22,34</sup> Health information diffused via social media platforms, even infused with uncertainty, may considerably impact health beliefs and behavioral motivations.<sup>35</sup> Regarding tobacco use, globally-coordinated health communication is responsible for increased awareness of tobacco harms, which reduced smokers' motivations to smoke and encouraged cessation.<sup>34,36</sup> However, countervailing efforts also occur as corporations utilize social media to instill favorable beliefs and positive motives for e-cigarette use.<sup>37,38</sup>

### Current Study

As shown in [Figure 1](#), this study explores how e-cigarette users' perceived vulnerability to an external threat (COVID-19) is associated with three different types of vaping motivations, which ultimately indirectly shape the intensity of e-cigarette use. Although we do not make a direct test of any of the theories described above, we draw upon components of them to consider how the changing risk environment may lead to shifts in motivations to consume e-cigarettes. We note that these considerations also cohere with Rhodes' conceptualization of risk environments, wherein risk perception originates from and intersects with social and natural spaces.<sup>39</sup> More specifically, we examine the mediating role of multiple motivations in the links between COVID-19 risk perceptions with e-cigarette users and the intensity of vaping. As depicted in [Figure 1](#), motivations for vaping may become susceptible to new events that compel e-cigarette users to update their belief systems. While smoking and vaping were suspected of potentially worsening the pulmonary damages of COVID-19, we note that scientific evidence is ambiguous regarding e-cigarettes' impact on COVID-19 prognosis.<sup>6,7,9</sup>



**Figure 1.** Conceptual pathways of perceived risk of COVID-19, e-cigarette use, and motivation.

At this point, although some have examined how disruptions of the COVID-19 pandemic are associated with motivations for smoking and vaping, these studies have focused on the motivation to quit vaping,<sup>40,41</sup> or general perceived risk,<sup>42,43</sup> irrespective of the different types of motives that may not be equally present in each person. However, as people draw from different domains to produce information, motivation for a behavior is a complex psychological process that can rarely be reduced to a single dimension. We know little about how divergent motives for vaping—a sociopsychological construct—may shift as a function of COVID-19 risk perception and in turn how these motivations subsequently how e-cigarette users adapt their vaping behaviors. Building on components of theories of health beliefs, we examine the mediating role of motivations for e-cigarette use in the relationship between COVID risk perceptions and e-cigarette use intensity. Using structural equation modeling (SEM), we identified three types of vaping motivations (socialization, health, and dependence), then tested whether risk perceptions of COVID-19 were directly and indirectly (via motives for vaping) associated with intensity of vaping among e-cigarette users.

## Methodology

### Sample

The research team distributed a rapid assessment survey during April 2020 to a panel of US adults via the panel platform of Prolific Academic, yielding a final analytic sample of 562 e-cigarette users. Web-based panels are especially useful for rapid assessment of population groups and Prolific offers advantages over alternative online sources such as Amazon's mTurk.<sup>44</sup> Researchers can specify a battery of background characteristics to narrow down the target population. Research on causal inference has explicated why non-representative samples are meritorious<sup>45</sup> and we have summarized in the [Supplementary Appendix](#) why our study's inference is not invalidated by the main issues of non-representativeness. The sampling frame initially targeted individuals indicating to Prolific they used e-cigarettes at least 20 times during their lifetime; inclusion criteria for

the study is that subjects have used e-cigarettes during the past 30 days. This criterion allowed us to sample a broad spectrum of current users beyond daily users. Within the survey, e-cigarettes were defined for subjects as “any electronic nicotine delivery system that creates vaporized nicotine to inhale.” The Institutional Review Board approved the project prior to data collection. [Table 1](#) displays detailed information about the sample; characteristics approximate those found for current e-cigarette users in nationally representative samples such as the Population Assessment of Tobacco & Health (PATH) study.

## Measurement

### E-cigarette Use

We asked respondents to report vaping intensity in two forms<sup>46</sup>: the number of vaping days during the past 30 days, and average number of vaping instances per day of use.

### COVID-19 Risk Perceptions

Participants responded to questions assessing their attitudes that e-cigarette use increases the risk and progression of COVID-19, which were rated on scales ranging from 0 (not at all) to 10 (Q1 definitely/Q2 extremely concerned). The two questions are: “Do you believe e-cigarette users are at greater risk from the coronavirus?” and “How much are you concerned you are at increased risk for serious problems if you caught the coronavirus.”

### Motives to Use E-cigarettes

There are a variety of motivations for using e-cigarettes. E-cigarette users sometimes adopt e-cigarette use to avoid stigma from tobacco emitting second-hand smoke, the aesthetic values of e-cigarettes, or as a healthier alternative to tobacco.<sup>4,5,16</sup> The variety of motives may be further categorized into different epistemological pursuits, with some emphasizing the functional values of vaping whereas others have more of a social identification with vaping.<sup>5,20</sup> The survey deployed 15 items based upon issues identified within a literature review,<sup>16,19,20</sup> covering a range of common motives for vaping. We conducted exploratory factor analysis and retained 13 items

based on uniqueness and explained proportion of variance. Based on the results from exploratory factor analysis and *prima facie* conceptual validation, we categorized these items

**Table 1.** Demographic Descriptive Statistics ( $n = 562$ )

	Mean/%	SD/ $n$
Age	35.43	13.44
Education attainment		
<HS Degree	0.9%	5
HS Diploma	14.8%	83
GED Recipient	2.1%	12
Some College	29.0%	163
Associates/2 year degree	12.5%	70
Bachelors/4 year degree	31.7%	178
Masters degree	8.2%	46
Doctorate	0.9%	5
Male gender	57.7%	324
White race	67.8%	381
Smoking tobacco		
Current smoker	38.3%	215
Former smoker	41.8%	235
Never smoker	19.9%	112
Income group		
<\$25k	34.9%	196
\$25k–\$50k	24.2%	136
\$50k–\$75k	23.5%	132
\$75k–\$100k	8.9%	50
Over \$100k	8.4%	47
Per day e-cigarette use	20.54	32.52
Past 30-day e-cigarette use	19.20	11.29
Risk for COVID-19	5.98	3.20
Risk for severe COVID-19 problems	5.42	3.22

HS = higher secondary.

into three motivational types: health concerns, dependence on nicotine, and socialization purposes. Confirmatory factor analysis then validated the fitness of the three-factor configuration. The manifest indicators to measure these latent constructs are all listed in [Table 2](#) along with their estimates.

Demographic characteristics, including gender, income, years of attained education, and race (coded as "white" or "non-white"), were utilized as controls for background information. We also included covariates for tobacco use divided into three types: current smoker, former smoker, and never-smoker.

### Statistical Analyses

This study focused upon identifying associations between COVID-19 perceived risk, motives for vaping, and intensity of e-cigarette use. Prior to these analyses, we employed factor analyses to establish the validity and reliability of measuring these constructs by a series of manifest items. Motives for vaping were categorized into three distinct types. Mediation analyses were employed to test which type(s) of motivation mediates the effect of risk concerns on intensity of e-cigarette use.

We employed SEM using R's lavaan package<sup>47</sup> for exploratory factor analysis, confirmatory factor analysis, and path analysis. For psychometric measurement involving both manifest items and latent constructs such as attitudes and beliefs, SEM offers the advantages of conducting both measurement reliability tests and regression techniques simultaneously and tests the data's fitness to the configured conceptual model. Thus, SEM improves over single-equation regressions when a construct is measured by multidimensional items.<sup>48</sup> For mediation analysis, SEM also tests multiple dependent variables and provides a comprehensive comparison of direct effects, indirect effects, and total effects. The model obtains estimates of indirect, direct, total effects, and their ratios by using bootstrap resampling. We allow covariance between the residuals of latent constructs of motivation based on the study design, which theoretically had assumed that different subtypes of motivation belong in the same spectrum.<sup>49</sup> We adopted four commonly used goodness-of-fit indices to

**Table 2.** Exploratory Factor Analysis for Motives of E-cigarette Use Under Three Latent Factors

Manifest items	Mean (SD)	Latent factor loadings		
		Factor 1	Factor 2	Factor 3
1. I would find it really hard to stop using e-cigarettes	5.94 (3.31)	<b>.71</b>	.21	.15
2. After not using e-cigarettes for a while, I need to vape to be less irritable	5.74 (3.33)	<b>.93</b>	.16	.16
3. After not using e-cigarettes for a while, I need to vape to be comfortable	5.57 (3.36)	<b>.90</b>	.12	.18
4. E-cigarettes help me feel better if I'm feeling down	6.27 (3.15)	<b>.54</b>	<.10	.47
5. Vaping helps me think better	5.78 (3.22)	<b>.54</b>	<.10	.42
6. E-cigarettes might be less harmful to me than cigarettes	8.41 (2.61)	.12	<b>.72</b>	<.10
7. E-cigarettes might be less harmful to others around me than cigarettes	8.59 (2.51)	<.10	<b>.80</b>	.18
8. Using e-cigarettes helps people quit smoking cigarettes	8.23 (3.03)	.12	<b>.53</b>	<.10
9. I can use e-cigarettes when smoking cigarettes is prohibited	7.29 (3.27)	.14	.18	<b>.28</b>
10. E-cigarettes come in flavors I like	8.26 (2.77)	<.10	.27	<b>.47</b>
11. E-cigarettes are more acceptable to non-smokers	7.98 (2.66)	<.10	.42	<b>.44</b>
12. I like socializing when using an e-cigarette	6.79 (3.18)	.12	<.10	<b>.64</b>
13. Advertising for e-cigarettes appeals to me	4.23 (2.98)	.12	<.10	<b>.61</b>
Proportional variance		.190	.142	.142

Bold font for the highest comparative loading of each manifest item.

evaluate the model's fit<sup>50,51</sup>: The Tucker-Lewis Index (TLI) above 0.9 suggests a good fit; the goodness of fit index close to 1 indicates very good fit; the root mean square error of approximation (RMSEA) below 0.05 indicates good fit, and 0.08 acceptable fit.<sup>52</sup>

## Results

**Table 1** provides descriptive statistics of key sample characteristics. As displayed, average age was 35.4 years (SD = 13.4), and the sample was comprised of 57.7% males, 67.8% whites, 40.8% having earned at least a Bachelor's degree, and 40.8% earning over \$50 000 US dollars. The sample includes a number of current (38.3%) and former (41.8%) smokers of tobacco cigarettes, only 19.9% have never smoked. The population inferred from this sample has a higher educational level than the US average, but other differences are not pronounced. Mean daily vaping occasions is 20.5 (SD = 32.5), and the average days of vaping in the last month are 19.2 days (SD = 11.3). Out of 10 points, perceived risk for e-cigarette users to contract COVID-19 is 5.98 (SD = 3.2) and perceived risk for e-cigarette users to develop severe COVID-19 problems is 5.42 (SD = 3.2).

Exploratory factor analysis with a tri-factors configuration shows the correlational magnitude between manifest items and latent factors in **Table 2**. We determined the proper allocation of each manifest item to a latent factor by the magnitude

of the correlation between the manifest item and all three latent factors. We also considered the semantic face validity of whether the manifest items grouped together share a common understandable theme. Here the exploratory factor analysis grouped the first five items together, which we later labeled "dependence motives". These five items registered relatively low means in comparison to other items. The items for dependence motives have means from 5.57 to 6.27, whereas items in the other two latent constructs typically range around 0.7 or 0.8. Items 6, 7, and 8 were grouped together under Factor 2, indicating need to improve health by using e-cigarettes, named "health motives". The last five items were grouped for commonality in non-physical benefits of using e-cigarettes, named "socialization motives". Factor 3 highlights the motivation of e-cigarette users' social and aesthetic reasons.

**Table 3** shows two types of information related to confirmatory factor analysis of the latent constructs. The right side of the table indicates to what degree the manifest items significantly load onto their respective latent constructs. For the purposes of identification, we have set to 1 the item with the strongest loading for each latent construct as a reference. The squared factor loadings in the right show the explained proportion of the variance of a manifested item by the latent construct. All manifested measures significantly loaded on the latent construct with a coefficient of at least .50. Combined with the goodness of fit indices presented at the bottom of **Table 2** (comparative fit index [CFI] > .90, TLI > .90, RMSEA

**Table 3.** Confirmatory Factor Analysis Results by Correlation Matrix and Measurement Estimates

Correlation between latent factors					Loadings of manifest indicators			
Socialization	Health	Dependence	Use	COVID Risk	Latent constructs	Manifest indicators	Estimates (SE)	Squared loading
				1	COVID risk	<i>Do you believe e-cigarette users are at greater risk from the coronavirus?</i>	.98(.30)***	.69
						<i>How much are you concerned you are at increased risk for serious problems if you caught the coronavirus</i>	1	.72
			1	-.27**	E-cigarette use	<i>Average number of vaping per day</i>	1	.21
						<i>Days of past month e-cigarette use</i>	.56(.08)***	.55
	1	.53***	.12*		Dependence motives	<i>I would find it really hard to stop using e-cigarettes #1</i>	.79(.03)***	.57
						<i>After not using e-cigarettes for a while, I need to vape to be less irritable #2</i>	1	.91
						<i>After not using e-cigarettes for a while, I need to vape to be comfortable #3</i>	.99(.02)***	.85
						<i>E-cigarettes help me feel better if I'm feeling down #4</i>	.56(.04)***	.31
						<i>Vaping helps me think better #5</i>	.55(.05)***	.26
	1	.33***	.55***	-.26***	Health motives	<i>E-cigarettes might be less harmful to me than cigarettes #1</i>	1	.62
						<i>E-cigarettes might be less harmful to others around me than cigarettes #2</i>	.96(.07)***	.54
						<i>Using e-cigarettes helps people quit smoking cigarettes #3</i>	.85(.09)***	.33
1	.36***	.38***	-.05	.04	Socialization motives	<i>I can use e-cigarettes when smoking cigarettes is prohibited #1</i>	.59(.08)***	.16
						<i>E-cigarettes come in flavors I like #2</i>	.62(.07)***	.25
						<i>E-cigarettes are more acceptable to non-smokers #3</i>	.66(.09)***	.25
						<i>I like socializing when using an e-cigarette #4</i>	1	.52
						<i>Advertising for e-cigarettes appeals to me #5</i>	.80(.07)***	.39

N = 560, degree of freedom = 136. = 3927.1, CFI = .93, TLI = .91, RMSEA = .07, SRMR = .07. Constraints (~~: covariance): feel\_better~~think\_better, harm\_others~~acceptable.

CFI = comparative fit index; RMSEA = root mean square error of approximation; TLI = Tucker-Lewis Index.

\*p < .05.

\*\*p < .01.

\*\*\*p < .001.

< .08, standardized root mean square residual [SRMR] < .08), we conclude that our theoretical constructs, including identifying all motives into the three subtypes, are also reliable and internally valid.

The left panel of Table 3 displays a correlation matrix for all latent constructs. The shaded diagonal line contains full correlations of 1, when a latent construct in the row corresponds to itself in the column. The construct of socialization motives significantly correlates with health motives (.36,  $p < .001$ ) and dependence motives (.38,  $p < .001$ ), but its correlations with perceived COVID-19 risk and e-cigarette use are not significant.

In Table 4, we present the stepwise strategies resulting in our final SEM configuration. The first model is a raw path analysis without modification or control variables. This first model (M1) represents the basic conceptual pathways in Figure 1. However, goodness of fit of the first model is not entirely satisfactory, with indices below conventional thresholds for model fit (CFI < .90, TLI < .90, RMSEA > .08, SRMR > .08). As explained in the methods section, there is likely an unmeasured source of correlation between the three types of vaping motives since these subtypes, theoretically, form a common underlying spectrum. Therefore, M2 allowed the residuals of the latent constructs of motivation to freely co-vary. M2 improves goodness of fit. As suggested by modification indices, we freed two pairs of manifest items within the same latent construct to retain substantive meaning. The modeled structure of M3 is considered a good fit with the data by all four indices (CFI > .90, TLI > .90, RMSEA < .08, SRMR < .07). Finally, M4 incorporated all covariates: smoking status, gender, race, age, income, and educational level. The fit remain on par with M2, which is normal when the model starts to include background variables of heterogeneous information. Two of the fitness indices remained satisfactory in M4 (RMSEA < .08, SRMR < .08). Nevertheless, M3 indicates that our model's main constructs are a reasonable fit to the actual data, whereas M4 shows that controlling a host of background information does not invalidate the preceding model.

The SEM configuration of M4 and its standardized coefficients were presented in Figure 2. Correlations between the residuals of three motivation types were approximately equal in strength (.38,  $p < .001$ ; .37,  $p < .001$ ; .38,  $p < .001$ ). All three motivation types were associated with more intensive use of e-cigarettes. By order of coefficient magnitude, dependence motives are most strongly associated with e-cigarette use intensity (.50,  $p < .001$ ), followed by health motives (.39,  $p < .001$ ) and socialization motives (.32,  $p < .001$ ). Substantively these estimates indicate that for every SD increase in motivation, the intensity of e-cigarette use would change by 0.50, 0.39, and 0.32 SDs, respectively. Perceived risk of COVID-19 is significantly associated with health motives (-.27,  $p < .001$ ), but not socialization motives or dependence motives. Perceived COVID-19 risk itself is negatively associated with e-cigarette use (-.20,  $p < .01$ ), meaning that e-cigarette users with greater concerns for personally contracting COVID-19 use e-cigarettes at reduced intensity. Among covariates, education is positively associated with greater perceived risk of COVID-19 (.15,  $p < .01$ ), older age is negatively associated with the perceived risk of COVID-19 (-.17,  $p < .001$ ), and identifying as White is positively associated with more intensive use (.17,  $p < .01$ ). For a SD increment in education and age, the perceived risk of COVID-19 would change by 0.15 and -0.17 SDs. The intensity of e-cigarette use would increase by 0.17 SD if the e-cigarette user is white, compared to other races.

**Table 4.** Hierarchically Nested Model Comparison

	N	Degree of Freedom	CFI	TLI	RMSEA	SRMR	BIC
M1	560	112	.82	.78	.10	.14	49431
M2	560	109	.86	.82	.09	.08	49305
Covariance in latent resid.			796.2				
M3	560	107	.93	.91	.07	.07	49054
Covariance in latent resid. Covariance in manifested resid.			387.3				
M4	559	212	.85	.82	.07	.08	48962
Covariance in latent resid.			844.6				
Covariance in manifested resid.							
Control variables (gender, race, age, income, education, smoking status)							

Constraints on the residuals of latent measures (~-): covariance): social~--health, social~--dependence, health~--dependence. Covariance between residuals of manifested items: feel\_better~--think\_better, harm\_others~--acceptable.

BIC = Bayesian information criteria; CFI = comparative fit index; RMSEA = root mean square error of approximation; TLI = Tucker-Lewis Index.

\* $p < .05$ .

\*\* $p < .01$ .

\*\*\* $p < .001$ .

Compared to never-smokers, ex-smokers show reduced risk perception of COVID-19 ( $-.14, p < .05$ ) and increased intensity of e-cigarette use ( $.37, p < .001$ ), but current smokers show no difference in these outcomes.

Informed by the results in Figure 2, we used bootstrap resampling for tests of indirect effects. Table 5 confirms the preliminary findings from Figure 2 that health motives constitute a mediator between perceived COVID-19 risk and e-cigarette use intensity. There is a significant direct effect between perceived COVID-19 risk and e-cigarette use ( $-.94, p < .05$ ), as well as a significant indirect effect via the mediating role of health motives ( $-.50, p < .01$ ). The indirect to total effect ratio is  $.35 (p < .01)$ , indicating that 35% of the association between perceived COVID-19 risk and e-cigarette use was mediated by health motives. This finding implies that a portion of the effect of risk beliefs about COVID-19 threats to e-cigarette users on vaping behaviors is due to how such risk beliefs alter health motivations. However, we find no evidence the other two types of motives have a mediating role.

### Discussion

To date, prevailing health psychology models of health beliefs have focused more on endogenous psychological attributes

than environmental factors' involvement in the production and maintenance of such motivations. This study investigated how health motives are related to a disruptive event—the COVID-19 pandemic. More specifically, we explored whether motivations for vaping e-cigarettes were associated with perceived risk of COVID-19, and whether such motivations mediate the relationship between COVID-19 risk beliefs and the intensity of e-cigarette use.

Motivation is a significant psychological predictor of actual vaping behavior. Motivation for specific conduct involves gathering supportive evidence from multiple domains, thus constituting a multidimensional psychological process that requires typological analysis. We classified vaping motivation into three types: health, socialization, and dependence. This study found that all three types of motivations for using e-cigarettes are significantly associated with the intensity of e-cigarette use. The standardized coefficients of all three dimensions of vaping motives were in similar magnitude ranging from  $.40$  to  $.54 (p < .001)$ . When the perceived risk increases, motivation to engage in a risk behavior declines and people adapt to the new belief system by cessation (eg, quit vaping) or, as in the case of self-exempting beliefs, they may innovate their knowledge and replace beliefs.<sup>26,27</sup> As viral epidemics and negative information about lung injuries emerge,

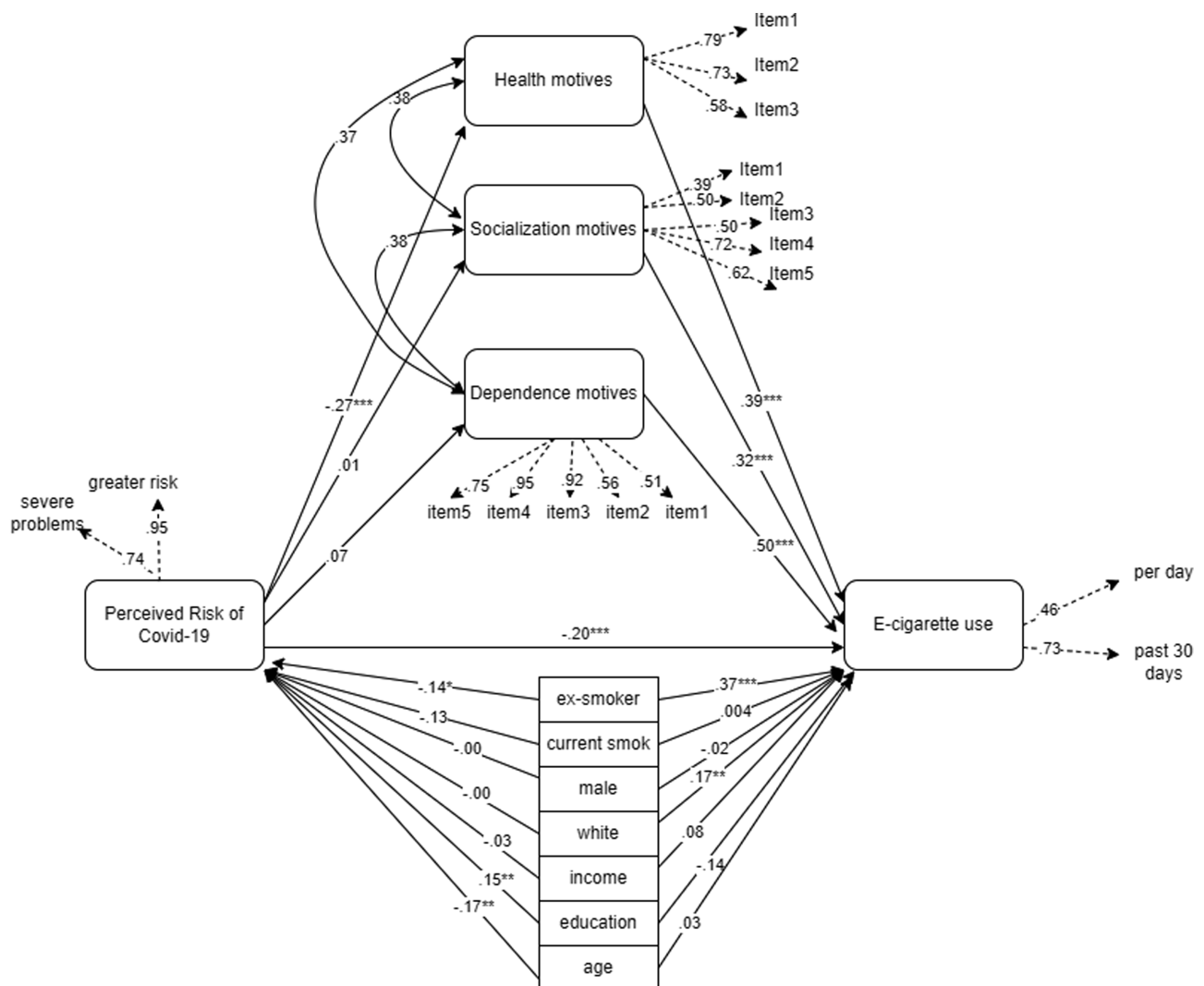


Figure 2. Structural equation modeling results.

**Table 5.** Direct and Indirect Effects (Unstandardized Coefficients)

Pathways	Effect estimates	Indirect/direct effect ratio	Indirect/total effect ratio
Covid risk → e-cigarette use	-.94 (.42)*		
Covid risk → health motives →e-cigarette use	-.50 (.18)**	.53 (.62)	.35 (.13)**
Covid risk → dependence motives →e-cigarette use	.28 (.24)	-.30 (.91)	-.43 (.47)
Covid risk → socialization motives →e-cigarette use	-.07 (.17)	.07 (1.29)	.07 (.24)

\* $p < .05$ .\*\* $p < .01$ .\*\*\* $p < .001$ .

e-cigarette users may incorporate these external threats into their beliefs and accordingly shift their motivations for vaping.

We argued the perceived risk has a different impact on each of the vaping motivation. While some prior studies have divided and categorized vaping motivation into subtypes, few have studied how specific dimensions of vaping motivations differentially vary with other risk factors. We found that COVID-19 risk perception is *only* associated with health motives ( $-.27, p < .001$ ), after accounting for the correlation between different motive subtypes. This result suggests diversity in the composition of vaping motivations. As a strategy of stigma management and social resistance, some have adopted e-cigarettes as a performative tool and to foster community without inviting the suspicion of non-smokers.<sup>20</sup> In this way, a viral pandemic with disease implications does not render much opportunity for health intervention work on socialization motivations. Instead, by working on health motives, health education and communication efforts promoting risk awareness may prove effective. For example, a study found that, given their relatively younger age, e-cigarette users preferred health communication messages relying on scientific evidence and individual agency.<sup>53</sup> Thus, spreading evidence-based medical research on the harms of vaping not only avoids marginalizing e-cigarette users, it may more effectively reduce health motives for some e-cigarette users.

Further, the findings also indicate ex-smokers, compared to never-smokers, vaped e-cigarettes more intensely and held less risk perceptions of COVID-19. Classifying e-cigarette users into three categories in terms of their tobacco use, we may consider ex-smokers those who completely transitioned from tobacco cigarettes to e-cigarettes. Compared to both current smokers and never-smokers, these e-cigarette users show greater preference for e-cigarettes. Thus, while e-cigarettes may be important smoking cessation tools for these individuals, ex-smokers should receive greater attention from health intervention experts. Health policies may leverage this study's finding to conduct more targeted intervention. Because the health motives of vaping were most often cited as a reason to quit smoking,<sup>54,55</sup> perceived environmental risks that weaken the utility of health motives of e-cigarettes may unintentionally prompt a reverse back to smoking tobacco. Tobacco control efforts must consider the COVID-19 pandemic as an environmental trigger and carefully tailor health communication to demonstrate the harms of tobacco cigarettes, while encouraging reduced use of e-cigarettes. For former smokers who switched to e-cigarettes, further harm reduction can be achieved by demystifying the health motives they rely on to continue vaping.

### Limitations

Although these results provide early information on e-cigarette use and motivations in light of COVID-19, we

note some limitations. First, although this rapid assessment survey reached a national sample of e-cigarette users, it is not a probability-based sample. While the data cannot be fully generalized, such data collection techniques provide opportunities to assess relationships between variables among substance-using populations.<sup>56</sup> Further, the data cohere well with demographic characteristics of e-cigarette users in probability-based samples such as the PATH dataset. Second, as the data are cross-sectional, we cannot fully infer causality. While this study provides important information related to this sudden event, the cross-sectional nature of the study design cautions against interpretations that insinuate a causal mechanism behind perceived risk and e-cigarette use. Lastly, common with surveys, subjects self-reported their experiences and social desirability or recall biases may shape these reports. However, computer-assisted surveys reduce such biases in the self-report of sensitive topics.<sup>57</sup>

### Conclusions

Perceptions of risk related to the pandemic have had a direct and indirect effect on vaping behaviors among e-cigarette users. E-cigarette users who have high risk perceptions related to the pandemic reported lower intensity of vaping within the past month. Health motivations for vaping appear to be a key mediating pathway by which motivations shape the relationship between risk perceptions and e-cigarette use. Opportunities to intervene on e-cigarette use during the pandemic may be particularly persuasive for e-cigarette users who have chosen vaping as a healthier alternative to smoking.

### Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at <https://academic.oup.com/ntr>.

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### Declaration of Interests

*The authors are not aware of any conflict of interests with any affiliations, membership, or financial holdings that may affect the objectivity of this study. This study is in no part associated with any entities engaged in the production, cultivation, and sale of tobacco and tobacco-derived products. The study is conducted in full compliance with the 1964 Declaration of Helsinki and its amendments as the criteria of ethical conduct.*



## Data Availability

The collection of the data has not been funded by tax revenue, the data are proprietary and are not available for public use.

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