

Cigarette Smoking and Risk Perceptions During the COVID-19 Pandemic Reported by Recently Hospitalized Participants in a Smoking Cessation Trial



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BACKGROUND: Cigarette smoking is a risk factor for severe COVID-19 disease. Understanding smokers' responses to the pandemic will help assess its public health impact and inform future public health and provider messages to smokers.

OBJECTIVE: To assess risk perceptions and change in tobacco use among current and former smokers during the COVID-19 pandemic.

DESIGN: Cross-sectional survey conducted in May–July 2020 (55% response rate)

PARTICIPANTS: 694 current and former daily smokers (mean age 53, 40% male, 78% white) who had been hospitalized pre-COVID-19 and enrolled into a smoking cessation clinical trial at hospitals in Massachusetts, Pennsylvania, and Tennessee.

MAIN MEASURES: Perceived risk of COVID-19 due to tobacco use; changes in tobacco consumption and interest in quitting tobacco use; self-reported quitting and relapse since January 2020.

KEY RESULTS: 68% (95% CI, 65–72%) of respondents believed that smoking increases the risk of contracting COVID-19 or having a more severe case. In adjusted analyses, perceived risk was higher in Massachusetts where COVID-19 had already surged than in Pennsylvania and Tennessee which were pre-surge during survey administration (AOR 1.56, 95% CI, 1.07–2.28). Higher perceived COVID-19 risk was associated with increased interest in quitting smoking (AOR 1.72, 95% CI 1.01–2.92). During the pandemic, 32% (95% CI, 27–37%) of smokers increased, 37% (95% CI, 33–42%) decreased, and 31% (95% CI, 26–35%) did not change their cigarette consumption. Increased smoking was associated with higher perceived stress (AOR 1.49, 95% CI 1.16–1.91). Overall, 11% (95% CI, 8–14%) of respondents who smoked in January 2020 (pre-COVID-19) had quit smoking at survey (mean, 6 months later) while 28% (95% CI, 22–34%) of

former smokers relapsed. Higher perceived COVID-19 risk was associated with higher odds of quitting and lower odds of relapse.

CONCLUSIONS: Most smokers believed that smoking increased COVID-19 risk. Smokers' responses to the pandemic varied, with increased smoking related to stress and increased quitting associated with perceived COVID-19 vulnerability.

KEY WORDS: cigarette smoking; electronic cigarettes; COVID-19; risk perceptions.

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INTRODUCTION

Cigarette smoking is a potentially modifiable risk factor associated with severe coronavirus disease (COVID-19) among individuals infected with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV2),^{1–6} underscoring the public health priority of addressing tobacco use, already the leading preventable cause of death worldwide, during the COVID-19 pandemic. Data on cigarette smoking behaviors in the USA during the pandemic are needed to assess the full public health impact of the pandemic and to inform public education and tobacco cessation efforts.

COVID-19 may have positively or negatively altered tobacco users' perceptions of the risk of smoking, interest in quitting, actions to quit, or amount of tobacco used. For example, if smokers feel vulnerable to COVID-19 due to their tobacco product use, they may be more interested in reducing or quitting.^{7,8} Restrictions on social gatherings might discourage tobacco use by offering fewer cues or opportunities to smoke. Alternatively, sheltering at home might facilitate tobacco use in homes where smoking is allowed or other smokers are present. Finally, stress due to the pandemic might increase cigarette smoking.^{8,9} Historically, stress-provoking

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events with national or global impact, such as the 9/11 attacks, have been linked to greater tobacco use.^{10,11}

The current study investigated whether cigarette smokers' self-reported health risk perceptions, motivation to quit, and amount of tobacco use changed during the early months of the US COVID-19 pandemic. We conducted a survey of previously hospitalized cigarette smokers who had sought to quit and received a cessation intervention after discharge as part of a clinical trial. As individuals who had undergone a recent major health event that prompted an effort to stop smoking, study participants were a vulnerable group in whom tobacco use might be in flux and for whom smoking cessation would be especially impactful.

METHODS

Design

We conducted a cross-sectional survey of individuals enrolled in the Helping HAND 4 (HH4) study (NCT03603496), a geographically diverse three-site randomized clinical trial comparing the effectiveness of two smoking cessation interventions for hospitalized smokers who were being discharged and planned to quit smoking. The interventions lasted for 3 months and follow-up continued for 6 months after hospital discharge (study protocol previously described).¹² Both the parent HH4 study and the COVID-19 supplemental survey were approved by the Institutional Review Boards of each participating institution. The supplemental survey was administered from May 18–July 16, 2020, which was between 2 and 20 months after parent study enrollment.

Participants

Participants in the HH4 trial were recruited from inpatient units of three hospitals in Boston, MA; Pittsburgh, PA; and Nashville, TN. Participants were ≥ 18 -year-old, English-speaking daily cigarette smokers who planned to quit smoking and agreed to accept a prescription for nicotine replacement therapy at discharge. Patients were excluded if they were unable to provide informed consent due to psychiatric or cognitive impairment, medically unstable, or lacked reliable telephone access.

Enrollment

The parent study completed enrollment of 1409 participants before the current study began. We attempted to contact all parent study participants, excluding those who had died ($n=40$), withdrawn from further study participation ($n=45$), or lacked valid contact information ($n=67$). Of 1257 remaining parent study participants, 1021 had given consent to receive unencrypted text messages and were sent up to 5 messages linked to an online survey using Research Electronic Data Capture (REDCap),¹³ followed by 2 phone calls to administer the survey. The 236 remaining parent study participants

received up to 3 phone calls for survey administration. Participants received \$20 for survey completion.

Measures

COVID-19-Related Measures.

COVID-19 Testing, Infection, or Exposure. Respondents were asked whether they had been tested for COVID-19, had a positive test, had a health care provider tell them they had COVID-19, believed that they had ever had COVID-19, and had a household member or close contact infected with COVID-19. For analysis, we created a composite measure (COVID-19 exposure/illness) that included respondents who reported any of these events.

Perceived Tobacco-Related COVID-19 Risk.

Respondents were asked 2 questions about their perception of a smoker's risk of COVID-19: (1) "To what extent, if any, do you believe that continued smoking affects the risk of getting infected with coronavirus or having a more severe case?" (5-point Likert scale, from "definitely increases the risk" to "definitely reduces the risk"); (2) "In your opinion, does reducing or stopping smoking lower the risk of getting coronavirus or a more serious case?" (yes/no).

Tobacco Product Use.

Questions about changes in smoking behavior and interest in quitting due to COVID-19 were asked only of respondents who reported that they were smoking cigarettes in January 2020, before the US COVID-19 pandemic: (1) "Has your interest in reducing or stopping smoking changed since the COVID-19 pandemic started?" (no change, increased, decreased) and (2) "Has the amount you smoke changed since the COVID-19 pandemic started?" (no change, increased, decreased but still smoking, stopped smoking entirely). We also assessed the proportion of current smokers who reported that they quit between January 2020 and the survey administration (5–7 months later) and the proportion of nonsmokers who reported relapsing during the same period.

Respondents who reported a change in the amount smoked were asked if any of 8 factors led to the change: change in cravings/urge, change in ability to buy cigarettes, change in daily routine facilitating or hindering smoking, worry or stress related to stay-at-home restrictions, worry or stress related to other aspects of the COVID-19 pandemic, wanting to stay healthy, fear of getting or spreading the coronavirus, and desire or need to save money.

Covariates. Demographics (age, sex, education level, race/ethnicity), study site, date of enrollment in the parent study, years smoked, and cigarettes per day prior to the index hospital admission were obtained from the baseline

survey completed at the parent study enrollment. All other covariates were assessed at the time of supplemental COVID-19 survey.

Current Tobacco Use. Respondents were asked about past 7-day use of cigarettes and nicotine-containing e-cigarettes.

Stress. Respondents were asked to rate their overall level of stress on a 5-point Likert scale where 1 = little or none and 5 = the most stress I've ever had.

Financial Status. Worry about financial problems was assessed using a 5-point Likert scale (1 = no worry to 5 = the most worry I've ever had). One question asked whether the pandemic had affected income. Three questions from Veenstra¹⁴ asked about specific financial burdens.

Statistical Analysis

Response options for COVID-19 Likert scale smoking questions were dichotomized or trichotomized based on frequency distributions. The outcome measures for cigarette smokers were as follows: (1) perceived COVID-19 risk due to smoking; (2) change in interest in reducing or quitting smoking from January 2020 (pre-COVID-19) to survey completion; (3) change in amount smoked during that interval; and (4) quitting or relapsing during that interval.

Univariate analyses examined associations between each of the COVID-19-related outcome measures and all covariates, including demographics, study site, current tobacco use, composite measure of COVID-19 exposure/illness, financial worry, and overall stress. Multiple logistic regression models for each outcome were constructed; terms included age, gender, race, education, history of COVID-19 exposure/illness, study arm, time since study enrollment, and any other variables with a univariate association of $p \leq .10$ with the outcome measure. Significance was set at a two-sided $p \leq .05$. All analyses were conducted in SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Participant Characteristics

Of 1257 participants available for this study, 694 (55% response rate) completed the supplemental survey. Respondents and non-respondents differed slightly in age and gender but not in race or cigarettes per day. At enrollment into the parent study a mean of 12 ± 5 (SD) months earlier, respondents (vs. non-respondents) had an average age of 52 ± 12 years (vs. 50 ± 13 , $p = .004$), were 60% female (vs. 51%, $p = .002$), were 78% non-Hispanic white and 14% non-Hispanic black (vs. 78% and 16%,

Table 1 Characteristics of the Survey Respondents (n=694)

	n	%
Collected at enrollment in the Helping HAND 4 study ^a		
Age (mean years, SD) ^b	52 (± 12)	
Sex (n, %) ^b		
Male	280	40
Female	414	60
Race/ethnicity (n, %) ^b		
White non-Hispanic	543	78
Black non-Hispanic	98	14
Hispanic	42	6
Other	11	2
Education (n, %) ^b		
\leq High school graduation or GED	368	53
Some college	225	32
College graduate	101	15
Study site (n, %) ^b		
MA	270	39
PA	183	26
TN	241	35
Current (past 7-day) cigarette smoker	694	100
Years smoked ^c (mean, SD)	35 (± 13)	
Cigarettes/day ^c (mean, SD)	16 (± 11)	
Current (past 7-day) electronic cigarette user	46	7
Collected at time of COVID-19 survey administration		
Tobacco use status (in January 2020, pre-COVID-19) ^d		
Current (past 7-day) cigarette smoker	427	62
Current (past 7-day) e-cigarette user	48	7
Neither cigarettes nor e-cigarettes	238	34
Declined	12	2
Tobacco use status (at time of survey during COVID-19) ^e		
Current (past 7-day) cigarette smoker	457	66
Current (past 7-day) e-cigarette user	46	6
Neither cigarettes nor e-cigarettes	214	31
Declined	7	1
Collected at enrollment in the Helping HAND 4 study ^a		
COVID-19 history		
Tested positive	5	<1
Told by health provider that I had COVID-19	13	2
Believe I had COVID infection	63	9
Household/close contact had COVID-19 infection	35	5
COVID-19 exposure/illness (any of the four above)	95	14
Stress — overall level of stress (mean, SD) ^f	3.6 (± 1.2)	
Financial concerns		
Worry about financial problems (mean, SD) ^f	3.4 (± 1.4)	
Effect of COVID-19 pandemic on income		
Decreased	305	44
Increased	48	7
No change	317	46
Decline to answer	24	3
Financial hardship due to COVID-19 pandemic		
Had to use savings	194	28
Had to borrow money or take out loan	172	25
Could not make credit card or bill payments	165	24

^aEnrollment into the parent Helping HAND 4 survey occurred a mean (\pm SD) of 12 ± 5 months before administration of the COVID-19 supplemental survey

^bDemographic factors and study site were assessed at enrollment into the parent Helping HAND 4 survey. For multivariate modeling, age was corrected to age at administration of supplemental COVID-19 survey

^cYears smoked and cigarettes/day were assessed at HH4 study enrollment. They were not included as a variable in multivariate modeling because of potential change before administration of the supplemental survey

^dRetrospectively reported

^eSurvey administered between May 18 and July 16, 2020

^fScale range 0–5, where 1 = none, 5 = the most I ever had

respectively, $p = .84$), and smoked an average of 16 ± 11 cigarettes daily (vs. 17 ± 11 , $p = .14$). At the time of the survey administration (May 18–July 16, 2020), 457 of respondents (66%) reported past 7-day cigarette smoking, 46 (6%) reported past 7-day e-cigarette use,

and 214 (31%) reported neither (Table 1). At that time, 427 respondents (62%) reported retrospectively that they had been smoking cigarettes and 48 (7%) reported having used e-cigarettes in January 2020 (i.e., pre-COVID-19 in the USA). Fourteen percent of respondents reported a past history of COVID-19 exposure or illness. Respondents reported substantial levels of overall stress and financial concerns.

Perceived Risk of COVID-19 due to Tobacco Use

Sixty-eight percent (95% CI, 65–72%) of respondents believed that continued smoking definitely might increase the risk of a coronavirus infection or of having a more serious case. Nearly as many (63%, 95% CI, 59–66%) felt that reducing or stopping smoking would decrease that excess risk (Fig. 1). In multivariable analyses, the belief that smoking increased COVID-19 risk was more common among respondents at the MA site vs. the PA or TN sites (adjusted odds ratio [AOR] 1.56, 95% confidence interval [CI] 1.07–2.28) (Table 2). A respondent’s own experience of COVID-19 illness or exposure was not associated with perceived risk of COVID-19 due to smoking. Former smokers were more likely than current smokers to believe that smoking increases COVID-19 risk (AOR 2.35, 95% CI 1.60–3.47) and that reducing or quitting smoking reduces COVID-19 risk (AOR 2.15, 95% CI 1.50–3.09).

Interest in Reducing or Stopping Smoking

Among the 427 respondents who were smoking in January 2020 (i.e., pre-COVID-19 in the USA), 41% (95% CI, 37–46%) reported an increased interest in reducing or stopping smoking since the pandemic, while 46% (95% CI, 41–51%)

reported no change, and 13% (95% CI, 10–16%) reported less interest (Fig. 2). Heightened interest in reducing or quitting was associated with the belief that smoking increases the risk of COVID-19 infection or complications (AOR 1.72, 95% CI 1.01–2.92) and that stopping smoking decreases that risk (AOR 1.83, 95% CI 1.10–3.02) (Supplemental Table 1).

Change in Amount Smoked

Among respondents smoking pre-pandemic, 32% (95% CI, 27–37%) reported that their smoking had increased since the pandemic began, 31% (95% CI, 26–35%) reported no change, and 37% (95% CI, 33–42%) reported decreased smoking (including 8% who quit smoking) (Fig. 2). Adjusted odds of increased smoking since COVID-19 were associated with higher overall stress (AOR 1.49, 95% CI 1.16–1.91, per point on a 5-point scale), female sex (AOR 2.09, 95% CI 1.26–3.45), and Hispanic ethnicity (AOR 2.98, 95% CI 1.21–7.37) (Table 3).

Among those who increased their smoking, reasons cited most often were stress due to stay-at-home restrictions (76%), stress for other reasons (66%), a change in daily routine making it easier to smoke (62%), greater craving to smoke (46%), and fear of getting or spreading the virus (45%) (Supplemental Figure 1). In contrast, smokers who decreased their smoking most often cited a general desire to stay healthy (69%), change in daily routine making it easier to quit (47%), lower craving to smoke (36%), a need to save money (34%), and fear of getting or spreading the virus (25%). Fewer than one-quarter cited stress or difficulties obtaining cigarettes.

Smoking Cessation and Relapse

Of the 427 respondents who were smoking pre-pandemic, 45 (11%, 95% CI, 8–14%) reported not smoking when surveyed in May–July 2020 (i.e., 5–7 months later); 43 (10%) neither

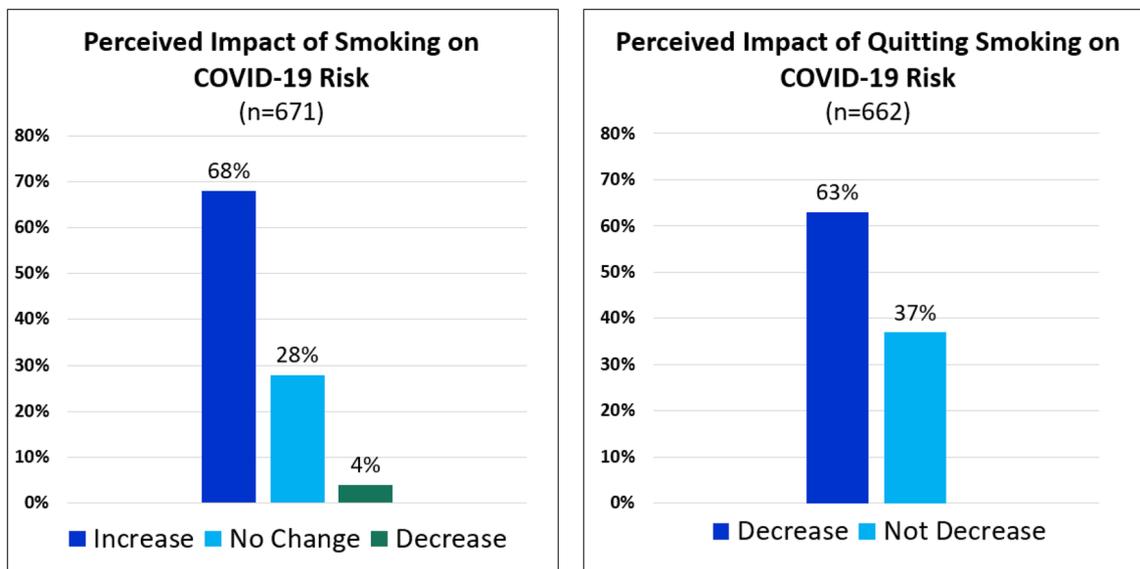


Figure 1 Respondents' perceived risk of COVID-19 illness due to smoking and perceived benefit of quitting smoking on COVID-19 risk.

Table 2 Factors Associated with Perceived Risk of Smoking and COVID-19 Infection or Severity. Multiple Logistic Regression Analysis

	Smoking increases risk of COVID-19 infection or severity ^a (n=671)			Stopping smoking reduces risk of COVID-19 infection or severity ^a (n=662)		
		AOR (95% CI) ^b	P value		AOR (95% CI) ^b	P value
Smoking status (past 7 days)						
Former smoker	80%	2.35 (1.60–3.47)	<0.001	74%	2.15 (1.50–3.09)	<0.001
Current smoker	62%	REF		57%	REF	
Age (mean years ± SD)						
Agree ^a	53±12	0.89 (0.77–1.03) ^c	0.13	53±12	0.94 (0.82–1.08) ^c	0.39
Do not agree ^a	54±12	REF		54±12	REF	
Gender						
Female	71%	1.44 (1.02–2.04)	0.04	63%	1.05 (0.75–1.47)	0.77
Male	65%	REF		62%	REF	
Race/ethnicity						
Black non-Hispanic	60%	0.67 (0.42–1.09)	0.11	64%	1.15 (0.72–1.85)	0.57
Hispanic	68%	0.85 (0.40–1.79)	0.66	63%	0.86 (0.42–1.77)	0.69
White non-Hispanic	70%	REF		63%	REF	
Education						
> High School	70%	1.05 (0.75–1.49)	0.77	65%	1.15 (0.83–1.61)	0.40
≤ High School/GED	67%	REF		61%	REF	
COVID-19 exposure/infection ^d						
Yes	67%	0.86 (0.52–1.40)	0.53	67%	1.17 (0.72–1.91)	0.52
No	69%	REF		62%	REF	
Study site						
MGH (MA) ^e	74%	1.56 (1.07–2.28)	0.02	68%	1.36 (0.95–1.95)	0.09
UPMC (PA)/VUMC (TN) ^e	65%	REF		59%	REF	

^aModel is comparing agreement vs. disagreement with statement in column heading. Analysis is also adjusted for study arm and time since index admission

^bAOR, adjusted odds ratio; CI, confidence interval. Results that are statistically significant ($p < .05$) are presented in bold face.

^c10-year increment

^dComposite variable coded as yes if respondent reported having had a positive COVID-19 test, having been given a COVID-19 diagnosis by a health professional, believing that they had had COVID-19, or having had a household member or close contact with a COVID-19 diagnosis

^eMGH, Massachusetts General Hospital; UPMC, University of Pittsburgh Medical Center; VUMC, Vanderbilt University Medical Center

smoked nor vaped; and 2 (0.5%) vaped only. Adjusting for age, sex, and COVID-19 exposure, the odds of quitting smoking during the pandemic was associated with the belief that smoking increases COVID-19 risk (AOR 2.27, 95% CI, 1.05–4.91).

Of 258 respondents who were not smoking in January 2020, 71 (28%, 95% CI, 22–34%) resumed smoking. Relapse to smoking was associated with a higher overall stress level (AOR 1.40, 95% CI, 1.01–1.94) and inversely associated with the belief that smoking increases COVID-19 risk (AOR 0.30, 95% CI 0.16–0.56) in adjusted analyses.

DISCUSSION

This cross-sectional survey assessed tobacco use and risk perceptions in the early months of the US COVID-19 pandemic among a large group of current and former smokers who had participated in a clinical trial to stop smoking after hospitalization. Tobacco users' response to the pandemic varied. While 41% of smokers reported greater interest in reducing or quitting, almost one-third of respondents increased their cigarette consumption, consistent with reports of increased

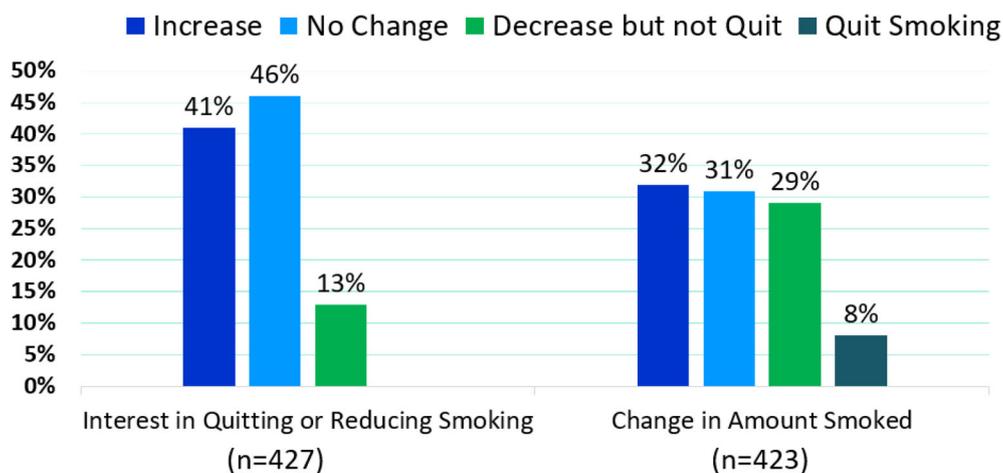


Figure 2 Change in cigarette smoking since the onset of COVID-19.

Table 3 Factors Associated with Smokers Who Increased Smoking After Onset of COVID-19. Multiple Logistic Regression Analysis

	Increased amount of smoking since COVID-19 ^a (n=423) ^b		P value
		AOR (95% CI) ^c	
Age (mean years ± SD)			
Increased smoking	52±11	0.91 (0.75–1.11) ^d	0.35
Decreased/no change	54±12	REF	
Gender			
Female	38%	2.09 (1.26–3.45)	0.004
Male	22%	REF	
Race/ethnicity			
Black non-Hispanic	33%	1.05 (0.55–2.01)	0.89
Hispanic	54%	2.98 (1.21–7.37)	0.02
White non-Hispanic	30%	REF	
Education			
> High school	34%	0.94 (0.59–1.48)	0.78
≤ High school/GED	30%	REF	
Overall stress scale (range, 1–5; mean ± SD)			
Increased smoking	4.1±0.9	1.49 (1.16–1.91)^e	.002
Decreased/no change	3.6±1.2	REF	
Financial worry scale (range 1.5; mean ± SD)			
Increased smoking	3.6±1.3	0.96 (0.79–1.16) ^e	0.67
Decreased/no change	3.3±1.4	REF	
History of COVID-19 exposure or infection			
Yes	41%	1.36 (0.74–2.49)	0.33
No	30%	REF	
Belief that smoking increases COVID-19 risk			
Yes	32%	0.91 (0.56–1.47)	0.70
No	30%	REF	
Study site			
MGH (MA) ^f	36%	1.46 (0.90–2.37)	0.13
UPMC (PA)/VUMC (TN) ^f	29%	REF	

^aAnalysis compares smokers who increased the amount of smoking vs. smokers who decreased or did not change the amount of smoking after start of COVID-19. Analysis is also adjusted for respondent's interest in reducing or quitting smoking since onset of COVID-19, study arm, and time since index admission

^b427 were smokers before the US COVID-19 pandemic but 4 did not answer the amount change question

^cAOR, adjusted odds ratio; CI, confidence interval. Results that are statistically significant ($p < .05$) are presented in bold face.

^d10-year increment

^eChange per point on 5-point Likert scale, where 1 = none, 5 = the most I've ever had

^fMGH, Massachusetts General Hospital; UPMC, University of Pittsburgh Medical Center; VUMC, Vanderbilt University Medical Center

cigarette sales during the pandemic.^{15, 16} Increased smoking was strongly related to higher levels of perceived stress. On the other hand, two-thirds of respondents believed that smoking increased the risk of a COVID-19 infection or complication. Perceived vulnerability to COVID-19 was associated with a higher odds of interest in reducing or quitting smoking, more self-reported quitting by those respondents who were smokers when the pandemic began in the USA, and less relapse to smoking among former smokers. Overall, 11% of respondents who were smokers in January 2020 had quit smoking when surveyed an average of 6 months later, but 28% of respondents not smoking before the pandemic resumed smoking during this period.

Smokers often cite stress as a reason for smoking more or returning to smoking after a quit attempt.⁹ As we hypothesized, a higher level of stress was associated with increased smoking and with relapse by former smokers. Further evidence for the role of stress comes from smokers' attributions of why their smoking behavior increased. The most frequently endorsed responses were worry or stress due to either stay-at-home restrictions (76%) or to other aspects of the coronavirus pandemic (66%). Financial worry was not independently

associated with changes in smoking behavior after adjustment for overall stress. A change in routine making it easier to smoke was the only other item endorsed by at least half of smokers. Curiously, neither perceived vulnerability to COVID-19 nor change in smoking behavior was associated with respondents' personal experiences with COVID-19. However, the survey was conducted prior to widespread availability of testing for SARS-Co-V2, and few respondents (<15%) reported COVID-19 exposure or infection, limiting our statistical power to detect an association.

An unexpected observation was that respondents' belief in smokers' vulnerability to COVID-19 varied by study site, being more common in MA than in PA or TN even after adjustment for demographic factors and respondents' COVID-19 history or exposure. A possible explanation is geographic differences in COVID-19 infection rates at the time of the survey. COVID-19 may have been a more salient threat to respondents in MA, who had experienced a COVID-19 surge just before the survey administration, than in PA or TN where COVID-19 rates were much lower (Fig. 3). Pre-existing geographic differences in smoking prevalence and tobacco control policies may have also contributed to the difference. MA has a low smoking prevalence

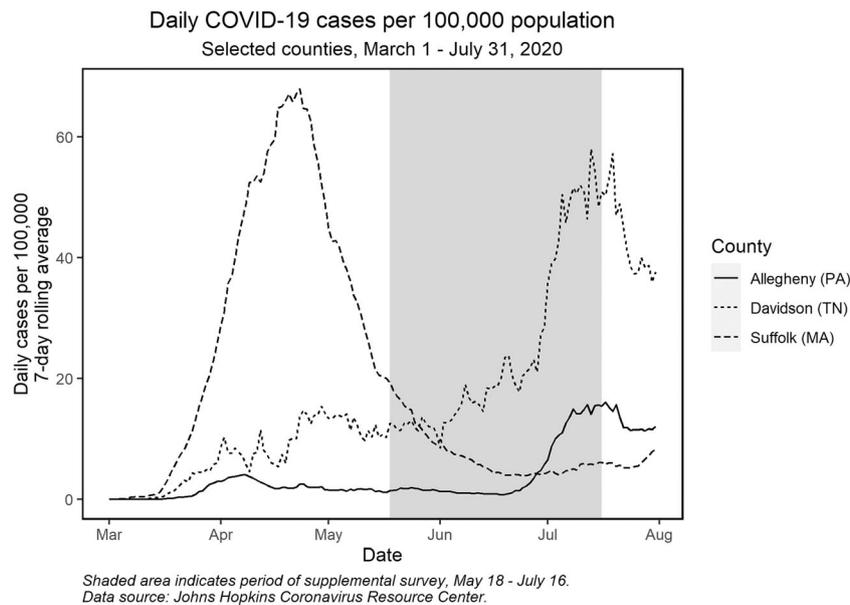


Figure 3 Daily COVID-19 cases per 100,000 population, March 1–July 31, 2020, in counties in which the 3 study sites are located. (Allegheny County = Pittsburgh, PA. Davidson County = Nashville, TN. Suffolk County = Boston, MA). Although surveys were administered between March 18 and July 16, the large majority were conducted during May 2020.

and strong state tobacco control policies, while TN has the reverse, and PA is in between.^{17, 18} Lower perceived risk of tobacco-related harms has been observed in states with higher smoking prevalence.¹⁹

This study's findings corroborate and expand on the limited prior work on this topic.^{20–25} A web-based US survey in April 2020 limited to dual cigarette and e-cigarette users also observed an association between perceived COVID-19 risk and motivation to quit and found a variable effect of COVID-19 on tobacco product use.²⁶ Our survey includes all cigarette smokers and e-cigarette users and a broader array of covariates. Two smaller US surveys also found similar associations between perceived vulnerability to COVID-19 and interest in reducing tobacco use.^{20, 21} Our finding of stress as an important factor influencing smoking behavior during the pandemic is corroborated by Dutch and Australian surveys.^{22, 23}

Eleven percent of respondents who were smokers immediately before the pandemic reported no longer smoking when surveyed 4–6 months later. We have no data on the pre-pandemic quit rate in the sample. However, English population-based surveys of adults found an increase in the number and success of quit attempts in April 2020 compared to previous months, consistent with our findings.²⁴ The 2018 population-based U.S. National Health Interview Survey found that 8% of adults who were smokers 12 months before the survey had quit 1 year later.²⁵ However, our sample is not directly comparable because it was selected for an interest in quitting and all participants received smoking cessation treatment as part of study protocol. Additionally, respondents who had quit for 4–6 months in our study might not have sustained abstinence for 12 months.

This study had several limitations. First, the cross-sectional observational study design limits the ability to infer causal relationships from observed associations. Second, we measured perceived COVID-19 risk with a single question asking both about disease susceptibility and severity. Whether respondents who endorsed this question agreed with both components of risk cannot be determined. Third, the response rate was 55%. However, in a sensitivity analysis using the propensity score approach to match each non-responder to a responder with similar characteristics, we observed very similar findings in our key results when responses from non-responders were imputed using the responses from their matched responders. Fourth, self-efficacy and barriers to quit smoking such as nicotine dependence were not collected during the pandemic, although participants' attributions for their reported change in smoking behavior reflect these barriers. Finally, the survey sample was not population-based, limiting generalizability. However, the sample consists of geographically diverse middle-aged and older smokers who have had a recent major health event and sought to quit smoking. This reflects a large group of US smokers, since more than half of smokers make a quit attempt each year and 16 million of the 34 million US smokers have a chronic tobacco-related disease.^{27, 28} The sample also resembles many smokers seen by general internists.

In summary, this study found that during the early months of the US COVID-19 pandemic, most smokers believed that smoking increased their vulnerability to COVID-19 but their subsequent tobacco use varied. While 40% reported reducing or quitting smoking, many motivated by perceived vulnerability to COVID-19, another third increased their smoking, which they attributed to pandemic-related stress. Our findings could help public health and health care systems identify

strategies to reduce tobacco use. Aggressive public education about smoking as a risk factor for poor outcomes of COVID-19 could provide a cue to action, increasing interest in quitting and discouraging stress-induced increases in tobacco use.²⁹ These messages will be more impactful if combined with information on how to access tobacco cessation treatment remotely and at no cost, which telephone quitlines and text message programs can do.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11606-021-06913-3>.

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REFERENCES

- Centers for Disease Control and Prevention (CDC). Coronavirus Disease 2019 (COVID-19). Centers for Disease Control and Prevention. <https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html>. Updated December 28, 2020. Accessed December 28, 2020.
- Simons D, Shahab L, Brown J, Perski O. The association of smoking status with SARS-CoV-2 infection, hospitalization and mortality from COVID-19: a living rapid evidence review with Bayesian meta-analyses (version 7). *Addiction*. 2020.
- Gülsen A, Yigitbas BA, Uslu B, Drömann D, Kilinc O. The Effect of Smoking on COVID-19 Symptom Severity: Systematic Review and Meta-Analysis. *Pulm Med*. 2020;2020:7590207.
- Patanavanich R, Glantz SA. Smoking Is Associated With COVID-19 Progression: A Meta-analysis. *Nicotine Tob Res*. 2020;22(9):1653-1656.
- Karanasos A, Aznaouridis K, Latsios G, et al. Impact of Smoking Status on Disease Severity and Mortality of Hospitalized Patients With COVID-19 Infection: A Systematic Review and Meta-analysis. *Nicotine Tob Res*. 2020;22(9):1657-1659.
- Reddy RK, Charles WN, Sklavounos A, Dutt A, Seed PT, Khajuria A. The effect of smoking on COVID-19 severity: A systematic review and meta-analysis. *J Med Virol*. 2020.
- McBride CM, Emmons KM, Lipkus IM. Understanding the potential of teachable moments: the case of smoking cessation. *Health Educ Res*. 2003;18(2):156-170.
- Rosenstock IM. Historical origins of the health belief model. *Health Educ Monogr*. 1974;2(4):328-335.
- McKee SA, Maciejewski PK, Falba T, Mazure CM. Sex differences in the effects of stressful life events on changes in smoking status. *Addiction*. 2003;98(6):847-855.
- Lawless MH, Harrison KA, Grandits GA, Eberly LE, Allen SS. Perceived stress and smoking-related behaviors and symptomatology in male and female smokers. *Addictive behaviors*. 2015;51:80-83.
- Pesko MF. Stress and smoking: associations with terrorism and causal impact. *Contemp Econ Policy*. 2014;32(2):351-371.
- Rigotti NA, Schnitzer K, Davis EM, et al. Comparative effectiveness of post-discharge strategies for hospitalized smokers: Study protocol for the Helping HAND 4 randomized controlled trial. *Trials*. 2020;21(336).
- Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377-381.
- Veenstra CM, Regenbogen SE, Hawley ST, et al. A composite measure of personal financial burden among patients with stage III colorectal cancer. *Med Care*. 2014;52(11):957-962.
- Rothman J, Feinberg S. Smoking through COVID? You're not alone. *The New York Times*. October 8, 2020: <https://www.nytimes.com/interactive/2020/2010/2008/business/covid-smoking-cigarette-sales.html>.
- Maloney J. Cigarette smoking makes comeback during coronavirus pandemic. *The Wall Street Journal*. July 28, 2020: <https://www.wsj.com/articles/altrias-net-revenue-falls-11595938465>.
- Odani S, Armour BS, Graffunder CM, Willis G, Hartman AM, Agaku IT. State-Specific Prevalence of Tobacco Product Use Among Adults - United States, 2014-2015. *MMWR Morb Mortal Wkly Rep*. 2018;67(3):97-102.
- American Lung Association. State of Tobacco Control. State Grades. <https://www.lung.org/research/sotc/state-grades>. Accessed December 28, 2020.
- Finney Rutten LJ, Augustson EM, Moser RP, Beckjord EB, Hesse BW. Smoking knowledge and behavior in the United States: sociodemographic, smoking status, and geographic patterns. *Nicotine Tob Res*. 2008;10(10):1559-1570.
- Streck JM, Kalkhoran S, Bearnot B, et al. Perceived risk, attitudes, and behavior of cigarette smokers and nicotine vapers receiving buprenorphine treatment for opioid use disorder during the COVID-19 pandemic. *Drug Alcohol Depend*. 2021;218:108438.
- Chertok IRA. Perceived risk of infection and smoking behavior change during COVID-19 in Ohio. *Public Health Nurs*. 2020.
- Bommelé J, Hopman P, Walters BH, et al. The double-edged relationship between COVID-19 stress and smoking: implications for smoking cessation. *Tob Induc Dis*. 2020;18.
- Stanton R, To QG, Khalesi S, et al. Depression, Anxiety and Stress during COVID-19: Associations with Changes in Physical Activity, Sleep, Tobacco and Alcohol Use in Australian Adults. *Int J Environ Res Public Health*. 2020;17(11):4065.
- Jackson SE, Garnett C, Shahab L, Oldham M, Brown J. Association of the COVID-19 lockdown with smoking, drinking and attempts to quit in England: an analysis of 2019-20 data. *Addiction*. 2020.
- Creamer MR, Wang TW, Babb S, et al. Tobacco Product Use and Cessation Indicators Among Adults — United States, 2018. *MMWR Morb Mortal Wkly Rep* 2019;68:1013-1019.
- Klempere EM, West JC, Peasley-Miklus C, Villanti AC. Change in Tobacco and Electronic Cigarette Use and Motivation to Quit in Response to COVID-19. *Nicotine Tob Res*. 2020;22(9):1662-1663.
- Babb S, Malarcher A, Schauer G, Asman K, Jamal A. Quitting Smoking Among Adults — United States, 2000–2015. *MMWR Morb Mortal Wkly Rep*. 2017;65(52):1457-1464.
- U.S. Department of Health and Human Services. *The Health Consequences of Smoking: 50 Years of Progress: A Report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office of Smoking and Health; 2014.
- Grummon AH, Hall MG, Mitchell CG, et al. Reactions to messages about smoking, vaping and COVID-19: two national experiments. *Tob Control*. 2020: doi: <https://doi.org/10.1136/tobaccocontrol-2020-055956>.

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