

THE IMPACT OF THE COVID-19 PANDEMIC ON SMOKING AMONG VULNERABLE POPULATIONS

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ABSTRACT

Aim

While accumulating evidence suggests that people modified their smoking during the ongoing COVID-19 pandemic, it remains unclear whether those most at risk for tobacco-related health disparities did so. The current study examined changes in smoking among several vulnerable smoker populations during the COVID-19 pandemic.

Methods

A web-based survey was distributed in 2020 to 709 adults with socioeconomic disadvantage, affective disorders, or opioid use disorder who participated in a previous study investigating the effects of very low nicotine content (VLNC) cigarettes on smoking. Current smoking status and rate, and adoption of protective health behaviors in response to the pandemic (e.g., social distancing, mask wearing) were examined.

Results

Among 332 survey respondents (46.8% response rate), 84.6% were current smokers. Repeated measures ANOVA showed that current cigarettes/day (CPD) was higher during COVID than pre-COVID (12.9 ± 1.0 vs 11.6 ± 1.0 ; $p < .001$). Most respondents had adopted protective health behaviors to prevent infection (>79% for all behaviors). More than half indicated that they were still leaving their homes specifically to buy cigarettes (64.6%) and were buying more packs per visit to the store (54.5%) than pre-COVID. Individuals unemployed at the time of the survey experienced greater increases in CPD (from 11.4 ± 1.4 to 13.3 ± 1.4 , $p = .024$) as did those with higher levels of anxiety (from 11.5 ± 1.1 to 13.6 ± 1.1 , $p < .001$).

Conclusions

Smoking increased during the COVID-19 pandemic in this sample of adults from vulnerable populations, even while most adopted protective health measures to prevent infection.

Unemployment and anxiety might identify those at greatest risk for increases in tobacco use.

Implications

Individuals from populations especially vulnerable to smoking might be at risk for greater harm from cigarette smoking during times of pandemic-related stress. Public health interventions are warranted to ameliorate increases in smoking among these populations. Special attention should be paid to those experiencing unemployment and high anxiety.

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INTRODUCTION

As of May 2022, COVID-19 had infected over 500 million people and killed over 6 million people worldwide.¹ Cigarette smoking has been identified as an independent risk factor for mortality among COVID-19 patients.² Despite the potential risks smoking poses for individuals diagnosed with COVID-19,³ the impact of the COVID-19 pandemic on cigarette smoking is unclear. Tobacco industry data demonstrate an increase in sales since the beginning of COVID-19 pandemic.⁴ Federal Trade Commission data support that annual cigarette sales increased for the first time in 20 years in 2020.⁵ The extent to which increased sales reflect a change in smoking prevalence or smoking intensity remains unclear.

Studies from a diverse array of populations around the world suggest that roughly a third of smokers surveyed increased their cigarette consumption during the pandemic, whereas roughly a fifth decreased consumption,⁶⁻¹¹ though other studies suggest greater proportions of individuals decreased or did not change their cigarette consumption.^{12,13} Across studies, roughly 40% of individuals surveyed experienced increases in motivation or intentions to quit smoking during the pandemic.^{6,7,11,12} Few demographic and other characteristics associated with increasing vs. decreasing smoking during the pandemic have been described, nor has the adoption of protective health behaviors among tobacco users to mitigate the potential health risks posed by the pandemic (e.g., social distancing, mask wearing), which could contextualize changes in smoking.

Few studies on the impacts of the COVID-19 pandemic on smoking have explicitly focused on populations most vulnerable to smoking and associated health disparities. Some populations of vulnerable smokers, such as women with low socioeconomic status (SES), individuals with opioid use disorder (OUD), and those with affective disorders, already experience disproportionately high rates of smoking and adverse health outcomes related to smoking compared to the general population,¹⁴⁻²¹ which might also put them at greater risk of COVID-related harm. Further, individuals with mood or substance use disorders are also more at risk of serious illness and death from COVID-19.^{22,23} Information on how people vulnerable to

tobacco use have responded to the COVID-19 pandemic may inform targeted efforts to prevent greater health disparities in these groups.

The purpose of the current study was to examine how smoking and related behaviors of vulnerable populations have changed since the start of the COVID-19 pandemic. Specifically, we were interested in examining possible changes in smoking status or rate prior to versus during the pandemic, and in identifying psychosocial risk factors (i.e., age, sex, race/ethnicity, employment status, education level, anxiety and depression symptoms) associated with different changes in smoking. Lastly, we examined whether these individuals were attempting to modify their behavior in other ways to protect themselves from COVID-related harm.

METHOD

Participants

Participants were drawn from a completed multi-site study involving three randomized clinical trials using parallel research designs to examine the effects of very low nicotine content (VLNC) cigarettes on smoking rate and dependence severity among people with psychiatric conditions or socioeconomic disadvantage. Details of the parent study have been reported previously;¹⁴ parent study inclusion and exclusion criteria are included in the eSupplement. Briefly, the study encompassed three populations of vulnerable smokers: socioeconomically disadvantaged women of childbearing age whose highest academic degree was a high school diploma, individuals receiving maintenance treatment for OUD, and individuals with affective disorders. The three study sites were located at the University of Vermont, Burlington, Vermont; Brown University, Providence, Rhode Island; and Johns Hopkins University School of Medicine, Baltimore, Maryland. Data collection for the parent study was completed in September of 2019. In total, 709 of the of 775 participants randomized in the parent study were invited to participate in the present study. Sixty-six individuals who did not provide consent for future research contact at the time of the parent study were not invited to participate in the survey.

Procedure

Parent Study

Briefly, participants were randomized to one of three study conditions that varied in terms of the nicotine content of the research cigarettes provided (i.e., 0.4, 2.4, & 15.8 mg nicotine/g tobacco). Participants reported their daily cigarette consumption over a 12-week period and attended weekly clinic assessment sessions. During these weekly sessions, participants returned unused study cigarettes, engaged in behavioral assessments as well as physiological data collection, and received additional study product for the following week. Thirty days following study completion, participants were asked if they were still smoking and, if applicable, how many cigarettes they consumed per day (CPD).

Survey participation

Participants from the parent study who expressed interest in participating in additional research were contacted via email and phone between 6/22/2020 and 11/13/2020 and invited to complete the survey, which was distributed through the REDCap (Research Electronic Data Capture) platform.^{24,25} Up to five attempts over the course of three weeks were made to reach invited participants. Respondents could choose to complete the survey online or a trained research assistant could administer it to them over the phone. Respondents were required to be at least 21 years of age at the time they completed the survey and had to endorse being aware of the ongoing COVID-19 pandemic. Respondents received a \$20 Amazon gift card upon completion of the survey. All study procedures were approved by an institutional review board at each of the three study sites.

Measures

The survey inquired about current age, residence, employment status, and experiences related to job loss, change, or essential worker status due to the pandemic (eTable 1 in Supplement). Other respondent demographics were collected during the parent study and not

included in the survey. Current symptoms of anxiety and depression were assessed by the Generalized Anxiety Disorder 2-item (GAD-2) and Patient Health Questionnaire-2 (PHQ-2), respectively.^{26,27} A score ≥ 3 is considered the clinical cut-off score for both these measures.

Respondents who endorsed the survey item “I currently smoke cigarettes on at least some days” were considered current smokers and asked to provide their current CPD; those who endorsed the alternative item “I have quit smoking cigarettes” were considered former smokers. Respondents were also asked to retrospectively report the average number of cigarettes they smoked per day in February of 2020. This timeframe was chosen as an indicator of their smoking intensity prior to the first shut-down orders in the United States in March of 2020.²⁸ In addition, we asked respondents to indicate whether their cigarette consumption increased, decreased, or stayed the same; four of seven respondents with missing information were classified using supplemental free-text responses (See eTable 2 in Supplement).

The survey also inquired about respondents’ current cigarette purchasing habits, perceptions of risk of harm from COVID-19, perceived COVID-19 risk due to smoking, and health behavior changes in response to COVID-19. Questions related to COVID-19 risk perceptions and health behavior changes were adapted from a survey tool recently developed by the World Health Organization.²⁹ Sample items from this survey include: “What is your probability of getting infected with the novel coronavirus?,” “How severe would contracting the novel coronavirus be for you?,” and “How susceptible do you consider yourself to an infection with the novel coronavirus?” Responses to these questions were measured on a 7-point Likert scale.

Data analysis

A response bias analysis was conducted to compare survey responders to non-responders on demographic characteristics, population, nicotine dose condition, and CPD at the baseline and follow-up visits of the parent study. Chi-square tests were used for categorical variables and Wilcoxon rank sum tests for continuous variables. Survey item responses were summarized using means and standard deviations or frequencies and percentages as

appropriate. Questions asked on 7-point Likert scales were collapsed into categories of low (1-2), medium (3-5), and high (6-7) for reporting.

To examine whether CPD changed between pre-COVID to the time of the survey, we conducted a repeated-measures analysis of variance (ANOVA), with time as the within-subjects variable. Also included were psychosocial covariates identified from prior literature³⁰⁻³² to be risk factors related to smoking: age, sex, race/ethnicity (non-Hispanic White or other), employment (employed full/part-time, student/homemaker/retired/unable to work, or unemployed), education (some high school, high school graduate/equivalent, some college, or associate's degree or higher), anxiety symptoms (GAD-2 score of ≤ 2 or ≥ 3) and depression symptoms (PHQ-2 score of ≤ 2 or ≥ 3). In addition to these sociodemographic covariates, we included menthol status, parent study condition, population, and site as covariates.

Respondents who reported that they were no longer smoking cigarettes at the time of the survey had their "during-COVID CPD" set to 0. Those who indicated that they had quit smoking prior to the pandemic had their "pre-COVID CPD" set to 0. Two individuals who reported current CPD of >130 were considered outliers and removed from all subsequent models as it was determined that these smoking rates were improbable. A parent study population by condition by time interaction, along with all lower-level interactions were explored; in the event of non-significant interactions, the analysis was repeated, eliminating non-significant effects. We chose to limit analyses to self-reported CPD in the current survey due to inconsistency in collection methods between the survey and the parent study, and to avoid capturing changes in CPD due to the parent study manipulations. Models including parent study follow-up CPD, however, were conducted as sensitivity analyses.

To investigate which demographic or psychosocial risk factors might impact changes in CPD, interaction terms for time by menthol status, sex, age, race/ethnicity, depression symptoms, anxiety symptoms, employment status, and education were included in the same repeated measures ANOVA model. In the event of non-significant interactions, the analysis was

repeated, eliminating non-significant effects. All analyses were conducted using SAS version 9.4. Post-hoc *p*-values were Bonferroni-corrected to account for multiple comparisons.

RESULTS

Respondents

Of the 709 individuals from the parent study who consented to further research contact, 332 completed the first required question of the survey, resulting in a response rate of 46.8%. Survey respondents did not differ from non-responders on CPD at parent study baseline ($p=.092$) or follow-up ($p=.411$; full response bias analyses presented in Supplementary eTable 3). Consistent with the parent study,¹⁴ survey respondents were predominantly female, of non-Hispanic White race/ethnicity, and most had been recruited from the Vermont site (68.4%). At the time of the survey, respondents were on average 38.0 years old ($SD=10.8$); 16.6% of respondents had attained an associate's degree or higher level of education, and 51.2% were employed. Nearly half of respondents (44.6%) endorsed experiencing a change in their employment status because of the pandemic; of the 178 participants reporting an employment status change, 47.3% indicated that they were no longer working and 46.0% were working fewer hours (Table 1). At the time of the survey, the majority of participants scored in the clinical range on the PHQ-2 (75.0%) and GAD-2 (81.9%), indicating the likely presence of major depressive disorder or generalized anxiety disorder, respectively.

Smoking

Most respondents (84.6%) indicated that they were still smoking at the time of the survey (Table 2). Of the 51 respondents who indicated they were no longer smoking at the time of the survey, 40 (78.4%) indicated that they had quit smoking prior to becoming aware of the COVID-19 pandemic. In response to the question, "How has your cigarette use changed since you learned about the coronavirus pandemic?" 45.6% of respondents who were still smoking at

the time of the survey indicated that their cigarette consumption had increased, 40.9% reported no change, and 12.5% reported that their cigarette consumption had decreased.

Cigarettes Smoked Per Day

There was a significant effect of time on CPD ($F[1,314]=21.60, p<.001$), indicating that, on average, individuals were smoking 1.3 more CPD during COVID ($M=12.9, SE=1.0$) compared to pre-COVID ($M=11.6, SE=1.0$). Age ($F[1,310]=8.20, p=.005$), education ($F[3,310]=3.45, p=.017$), and population ($F[2,310]=9.97, p<.001$) were also significantly associated with CPD. Older participants reported greater CPD across both time-points compared to younger participants ($p=.005$) and those with a high school diploma or equivalent reported smoking more than those with some college ($p=.027$). Individuals with affective disorder reported smoking fewer CPD across both time-points compared with those with OUD ($p<.001$) or women of childbearing age ($p=.026$). We did not observe significant associations of menthol status, sex, depression or anxiety symptomology, employment, race/ethnicity, study site, or nicotine dose condition with CPD. There were also no significant interactions between time and parent trial (i.e., vulnerable) population or nicotine dose condition within the trials, suggesting these aspects of the prior study did not result in systematic changes in pre-COVID to during-COVID CPD (Table 3). Sensitivity analyses including CPD collected at the parent trial follow-up visit showed the same pattern of significance as the primary model (see eTable 4 in Supplement for more details).

Exploration of risk factors associated with change in CPD showed a significant time-by-employment status interaction ($F[2,311]=3.61, p=.028$; Table 3 and Figure 1). Those who were unemployed reported a statistically significant increase in smoking during COVID compared to before COVID (pre-COVID CPD=11.4, SE=1.4, during COVID CPD=13.3, SE=1.4, $p=.024$), while those who were employed or were students, homemakers, retired, or unable to work reported no significant changes. In addition, there was a significant interaction of time and anxiety status ($F[1,311]=8.01, p=.005$; Table 3 and Figure 1), with those with higher GAD-2 scores reporting an increase in CPD (pre-COVID CPD=11.5, SE=1.1, during COVID CPD=13.6, SE=1.1; $p<0.001$) while

those with lower scores reported no change in CPD (pre-COVID CPD= 12.0, SE=1.5, during COVID CPD=12.0, SE=1.5; $p=.999$).

Cigarette Purchasing

More than half of respondents indicated that they were still leaving their homes specifically to buy cigarettes (64.6%) and were buying more packs per visit to the store (54.5%). A fifth of these respondents (22.1%) said they were leaving their house specifically to buy cigarettes more frequently than prior to the pandemic, a third (33.2%) reported leaving their house less frequently, and 44.8% reported no change (Table 2).

COVID-Related Thoughts and Behavior Change

Regarding COVID-19 risk perceptions, the majority of respondents perceived a medium (59.3%) or low (34.9%) probability of becoming infected with COVID and a medium (62.2%) or low level (26.0%) of personal susceptibility to infection. However, most respondents indicated that, if infected with COVID, they expected that the disease would be moderate (50.3%) or severe (35.8%). Roughly half of all respondents (55.2%) indicated that they believed smoking increased their risk of harm from COVID-19. A fifth of respondents (21.7%) indicated that their motivation to quit smoking cigarettes had increased since becoming aware of the pandemic, compared to 48.0% who said that their motivation to quit had stayed the same and 27.8% who said that their motivation to quit had decreased. Regarding COVID-related protective health behaviors, most participants indicated that they were engaging in handwashing (97.3%), avoiding touching their eyes and face with unwashed hands (86.1%), using hand sanitizer when soap and water were unavailable (93.6%), maintaining a 6-foot distance from others (90.3%), wearing a facemask (90.9%), and staying home except for essential reasons (79.0%; Table 2).

DISCUSSION

The purpose of this study was to examine how smoking and related health behaviors had changed during the COVID-19 pandemic among three populations highly vulnerable to smoking. Overall, respondents reported increases in cigarette smoking despite recognizing smoking as potentially harmful in the face of the pandemic. Unemployment was associated with an increase in CPD during COVID. It is possible that, in accordance with findings that people smoke to deal with pandemic-related stress,³³ individuals who were unemployed faced greater stress as a result of the pandemic that then caused them to smoke more. It is also possible that individuals who were unemployed during the pandemic might have had more time each day to smoke and were not subject to workplace restrictions on smoking. We also observed an independent positive association between anxiety symptoms and increased CPD in the present study. This is in line with prior survey and qualitative research that has highlighted emotional distress caused by the pandemic as a driver of increased tobacco consumption.^{9,33-35}

Individuals from these three vulnerable populations recognized the COVID-19 pandemic as a serious issue and reported modifying their behavior to reduce infection risk (e.g., social distancing, wearing masks). However, more than half of respondents indicated that they were still leaving their homes specifically to buy cigarettes. The changes they reported in their cigarette purchasing habits could reflect a multitude of factors. Giovenco, Spillane, Maggi, Lee and Philbin³⁴ observed that adult cigarette smokers changed their cigarette purchasing patterns (e.g., by rationing cigarettes, visiting stores during non-peak hours, buying cartons instead of packs) during the pandemic because of changes in personal finances due to the pandemic, or to reduce exposure to COVID-19 through trips to the store. It is possible that the changes in purchasing habits reported in the present study reflect similar concerns.

Respondents in the present study may have faced a dilemma between perceived competing needs to protect themselves from the pandemic and continue purchasing and smoking cigarettes. Importantly, the uniformly high levels of adoption of protective health behaviors

observed in the present sample suggests that a general apathy towards one's personal health is unlikely to account for the continued cigarette consumption and purchasing behaviors of vulnerable smokers observed in this study.

Prior research suggests that the relationships between exposure to stressful events and subsequent substance use rates is likely complex and moderated by several risk and protective factors including mental health symptoms, social support, and degree of exposure to the stressful event.³⁶⁻⁴⁰ Much of this research has been conducted in the context of discrete events of extreme stress such as natural disasters or terror attacks; it is unclear whether this generalizes to more pervasive and chronic experiences of extreme stress such as the COVID-19 pandemic. Although we measured mental health symptoms in this survey, we did not measure the degree of exposure to the COVID-19 pandemic or presence of social support. Further work is needed to develop theoretically relevant and reliable measures of exposure to the COVID-19 pandemic.

Multiple studies have observed that a third of smokers surveyed indicated increasing their cigarette consumption during the pandemic.⁶⁻¹¹ These proportions are similar to those observed in the context of other crises.³⁹ Additionally, between a fifth and a third of respondents in the above studies indicated decreasing their cigarette consumption. By contrast, greater proportions of our sample of vulnerable smokers indicated increases in their smoking rate. Further, compared to the two fifths of individuals who endorsed an increase in motivation to quit smoking during the pandemic in prior studies,^{6,7,11,12} only one fifth of the present sample experienced increases in motivation to quit. This suggests differential response patterns in smoking among vulnerable populations compared to general population samples. It is possible that vulnerable smokers experienced greater stress as a result of the pandemic, which prevented them from reducing or quitting smoking. Vulnerable smokers may view cigarettes as an essential coping strategy used especially in times of crisis. Given our observations that vulnerable smokers experiencing unemployment and greater anxiety experienced the greatest increases in smoking, interventions to reduce smoking disparities during public health crises might benefit from the inclusion of employment assistance and emotion regulation strategies.

Future national-level cohort surveys might also benefit from inclusion of psychosocial risk factors, including employment and anxiety symptoms, in their design and analytic strategy.

Strengths and Limitations

One of the major contributions of the current study is that we examined the cigarette consumption patterns of vulnerable smokers. We also assessed quantitative changes in smoking patterns in terms of CPD before and during COVID and explored potential risk factors associated with this change. Lastly, we examined changes in behaviors related to smoking, perceptions of COVID-19 risk and severity, and adoption of protective health behaviors to lend context to observed changes in cigarette consumption.

This study is not without limitations. Slightly under half of individuals responded to the survey, indicating that nonresponse bias may have impacted the findings. Further, self-selection bias might have impacted findings. It is possible that those who were less impacted by the pandemic were more likely to respond to our recruitment efforts and more able to participate in the survey. Conversely, respondents who were more financially impacted by the pandemic might have been more motivated by the provided compensation to participate in the present survey. Importantly, survey non-responders did not differ from responders on CPD at parent study baseline or follow-up visit, suggesting that nonresponse bias would not have systematically impacted the outcome of our primary analyses. Pre-COVID CPD was assessed via retrospective recall in the survey, which is subject to recall bias. Although we were unable to compare prospectively collected CPD measures from pre-pandemic trial participation, we conducted sensitivity analyses including these data which demonstrated similar outcomes. Parent study inclusion criteria limited the initial participation to individuals who were of three specific vulnerable smoker populations: women of childbearing age with socioeconomic disadvantage, individuals seeking treatment for OUD, and individuals with affective disorders. It is therefore unclear whether the present findings generalize to other identified vulnerable populations (e.g., LGBTQ+ and military populations).

Finally, the survey potentially captured holdover effects of prior experimental manipulation on respondents' smoking patterns. However, the parent trial ended more than nine months prior to survey distribution, suggesting that any holdover effects from the parent trial would likely have dissipated by the time of the survey. Furthermore, we controlled for the potential impact of variables associated with study participation and manipulation in our models and did not observe significant effects, suggesting that manipulations from parent study involvement did not contribute to systematic error in our findings.

Conclusion

Many individuals from vulnerable smoking populations increased their cigarette consumption during the COVID-19 pandemic, and those who were unemployed experienced the greatest increase in smoking. Most participants had adopted protective health behaviors to prevent COVID-19 infection, though the majority continued to go to stores to purchase cigarettes and endorsed buying more packs of cigarettes per visit to the store. Consistent with data documenting increases in cigarette sales in 2020, findings from the current study highlight that increases in cigarette use may be disproportionately borne by populations at greater risk of tobacco-related health disparities and potentially, greater risk of COVID-related harms. Our results highlight the urgency of expanding tobacco control efforts in at-risk populations to mitigate the long-term effects of increases in COVID-related tobacco consumption.

Data Availability Statement

The data underlying this article will be shared on reasonable request to the corresponding author.

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Declaration of Interests

Authors have no conflicts of interest to declare.

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REFERENCES

1. Johns Hopkins. COVID-19 Dashboard by the Center for Science and Engineering. Accessed May 15, 2022. <https://coronavirus.jhu.edu/map.html>
2. Hou H, Li Y, Zhang P, et al. Smoking Is Independently Associated With an Increased Risk for COVID-19 Mortality: A Systematic Review and Meta-analysis Based on Adjusted Effect Estimates. *Nicotine Tob Res.* 2021;doi:10.1093/ntr/ntab112
3. Centers for Disease Control and Prevention. COVID-19 (coronavirus disease): people with certain medical conditions. Accessed September 29, 2021. <https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html>
4. Maloney J. Cigarette Smoking Makes Comeback During Coronavirus Pandemic. *The Wall Street Journal.* July 28th. <https://www.wsj.com/articles/altrias-net-revenue-falls-11595938465>
5. FTC Report Finds Annual Cigarette Sales Increased for the First Time in 20 Years. October 26, 2021, 2021. Accessed October 31st, 2021. <https://www.ftc.gov/news-events/press-releases/2021/10/ftc-report-finds-annual-cigarette-sales-increased-first-time-20>
6. Klemperer 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.* Aug 24 2020;22(9):1662-1663. doi:10.1093/ntr/ntaa072
7. Bar-Zeev Y, Shauly M, Lee H, Neumark Y. Changes in Smoking Behaviour and Home-Smoking Rules during the Initial COVID-19 Lockdown Period in Israel. *Int J Environ Res Public Health.* Feb 17 2021;18(4)doi:10.3390/ijerph18041931
8. Guignard R, Andler R, Quatremère G, et al. Changes in smoking and alcohol consumption during COVID-19-related lockdown: a cross-sectional study in France. *Eur J Public Health.* 2021;31(5):1076-1083. doi:10.1093/eurpub/ckab054
9. Schafer AA, Santos LP, Quadra MR, Dumith SC, Meller FO. Alcohol Consumption and Smoking During Covid-19 Pandemic: Association with Sociodemographic, Behavioral, and Mental Health Characteristics. *J Community Health.* Mar 25 2022;doi:10.1007/s10900-022-01085-5
10. Ferrante G, Camussi E, Piccinelli C, et al. Did social isolation during the SARS-CoV-2 epidemic have an impact on the lifestyles of citizens? *Epidemiol Prev.* Sep-Dec 2020;44(5-6 Suppl 2):353-362. L'isolamento sociale durante l'epidemia da SARS-CoV-2 ha avuto un impatto sugli stili di vita dei cittadini? doi:10.19191/EP20.5-6.S2.137
11. Al-Tammemi AB, Barakat M, Al Tamimi D, et al. Beliefs Toward Smoking and COVID-19, and the Pandemic Impact on Smoking Behavior and Quit Intention: Findings from a Community-Based Cross-Sectional Study in Jordan. *Tob Use Insights.* 2021;14:1179173X211053022. doi:10.1177/1179173X211053022
12. Siddiqi K, Siddiqi F, Khan A, et al. The Impact of COVID-19 on Smoking Patterns in Pakistan: Findings From a Longitudinal Survey of Smokers. *Nicotine Tob Res.* 2021;23(4):765-769. doi:10.1093/ntr/ntaa207
13. Busse H, Buck C, Stock C, et al. Engagement in Health Risk Behaviours before and during the COVID-19 Pandemic in German University Students: Results of a Cross-Sectional Study. *Int J Environ Res Public Health.* Feb 3 2021;18(4)doi:10.3390/ijerph18041410
14. Higgins ST, Tidey JW, Sigmon SC, et al. Changes in Cigarette Consumption With Reduced Nicotine Content Cigarettes Among Smokers With Psychiatric Conditions or Socioeconomic Disadvantage: 3 Randomized Clinical Trials. *JAMA Netw Open.* 2020;3(10):e2019311. doi:10.1001/jamanetworkopen.2020.19311
15. National Center for Chronic Disease P, Health Promotion Office on S, Health. Reports of the Surgeon General. *The Health Consequences of Smoking-50 Years of Progress: A Report of the Surgeon General.* Centers for Disease Control and Prevention (US); 2014.
16. Schroeder SA. American health improvement depends upon addressing class disparities. *Prev Med.* Nov 2016;92:6-15. doi:10.1016/j.ypmed.2016.02.024

17. Tidey JW, Miller ME. Smoking cessation and reduction in people with chronic mental illness. *BMJ*. 2015;351:h4065. doi:10.1136/bmj.h4065
18. Lasser K, Boyd JW, Woolhandler S, Himmelstein DU, McCormick D, Bor DH. Smoking and Mental Illness. *JAMA*. 2000;284(20):2606. doi:10.1001/jama.284.20.2606
19. Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci*. 2012;1248(1):107-123. doi:10.1111/j.1749-6632.2011.06202.x
20. Hser YI, McCarthy WJ, Anglin MD. Tobacco use as a distal predictor of mortality among long-term narcotics addicts. *Prev Med*. 1994;23(1):61-69. doi:10.1006/pmed.1994.1009
21. Hser Y-I, Hoffman V, Grella CE, Anglin MD. A 33-Year Follow-up of Narcotics Addicts. *Arch Gen Psychiatry*. 2001;58(5):503. doi:10.1001/archpsyc.58.5.503
22. Fond G, Nemani K, Etchecopar-Etchart D, et al. Association Between Mental Health Disorders and Mortality Among Patients With COVID-19 in 7 Countries: A Systematic Review and Meta-analysis. *JAMA Psychiatry*. Jul 27 2021;doi:10.1001/jamapsychiatry.2021.2274
23. Ceban F, Nogo D, Carvalho IP, et al. Association Between Mood Disorders and Risk of COVID-19 Infection, Hospitalization, and Death: A Systematic Review and Meta-analysis. *JAMA Psychiatry*. Jul 28 2021;doi:10.1001/jamapsychiatry.2021.1818
24. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208. doi:10.1016/j.jbi.2019.103208
25. 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. doi:10.1016/j.jbi.2008.08.010
26. Kroenke K, Spitzer RL, Williams J, Monahan PO, Lowe B. Anxiety Disorders in Primary Care: Prevalence, Impairment, Comorbidity, and Detection. *Ann Intern Med*. 2007;146(5):317-325.
27. Löwe B, Kroenke K, Gräfe K. Detecting and monitoring depression with a two-item questionnaire (PHQ-2). *J Psychosom Res*. 2005/02/01/ 2005;58(2):163-171. doi:https://doi.org/10.1016/j.jpsychores.2004.09.006
28. American Journal of Managed Care. A Timeline of COVID-19 Developments in 2020. Updated 1/1/2021. Accessed September 29, 2021. <https://www.ajmc.com/view/a-timeline-of-covid19-developments-in-2020>
29. World Health Organization. Survey Tool and Guidance: Rapid, simple, flexible behavioural insights on COVID-19. Monitoring knowledge, risk perceptions, preventive behaviours and trust to inform pandemic outbreak response. Copenhagen, Denmark: WHO Regional Office for Europe; 2020.
30. Leventhal AM, Bello MS, Galstyan E, Higgins ST, Barrington-Trimis JL. Association of cumulative socioeconomic and health-related disadvantage with disparities in smoking prevalence in the United States, 2008 to 2017. *JAMA Intern Med*. Jun 1 2019;179(6):777-785. doi:10.1001/jamainternmed.2019.0192
31. Gaalema DE, Leventhal AM, Priest JS, Higgins ST. Understanding individual differences in vulnerability to cigarette smoking is enhanced by attention to the intersection of common risk factors. *Prev Med*. Dec 2018;117:38-42. doi:10.1016/j.yppmed.2018.09.006
32. Higgins ST, Kurti AN, Redner R, et al. Co-occurring risk factors for current cigarette smoking in a U.S. nationally representative sample. *Prev Med*. Nov 2016;92:110-117. doi:10.1016/j.yppmed.2016.02.025
33. Yach D. Tobacco Use Patterns in Five Countries During the COVID-19 Lockdown. *Nicotine Tob Res*. Aug 24 2020;22(9):1671-1672. doi:10.1093/ntr/ntaa097
34. Giovenco DP, Spillane TE, Maggi RM, Lee EY, Philbin MM. Multi-level drivers of tobacco use and purchasing behaviors during COVID-19 "lockdown": A qualitative study in the United States. *Int J Drug Policy*. Aug 2021;94:103175. doi:10.1016/j.drugpo.2021.103175

35. Tran DD, Fitzke RE, Wang J, Davis JP, Pedersen ER. Substance Use, Financial Stress, Employment Disruptions, and Anxiety among Veterans during the COVID-19 Pandemic. *Psychol Rep.* Mar 24 2022;332941221080413. doi:10.1177/00332941221080413
36. Alexander AC, Ward KD, Forde DR, Stockton M. Are posttraumatic stress and depressive symptoms pathways to smoking relapse after a natural disaster? *Drug Alcohol Depend.* Feb 1 2019;195:178-185. doi:10.1016/j.drugalcdep.2018.09.025
37. Beaudoin CE. Hurricane Katrina: Addictive Behavior Trends and Predictors. *Public Health Rep.* 2011;126:400-409.
38. DiMaggio C, Galea S, Li G. Substance use and misuse in the aftermath of terrorism. A Bayesian meta-analysis. *Addiction.* Jun 2009;104(6):894-904. doi:10.1111/j.1360-0443.2009.02526.x
39. Erskine N, Daley V, Stevenson S, Rhodes B, Beckert L. Smoking prevalence increases following Canterbury earthquakes. *Sci World J.* 2013;2013:596957. doi:10.1155/2013/596957
40. Flory K, Hankin BL, Kloos B, Cheely C, Turecki G. Alcohol and Cigarette Use and Misuse among Hurricane Katrina Survivors: Psychosocial Risk and Protective Factors. *Subst Use Misuse.* 2009;44(12):1711-1724.

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Table 1. Demographic and Parent Trial Characteristics of Survey Respondents

Variable	<i>n</i>	%
Sex*		
<i>Male</i>	69	20.9
<i>Female</i>	262	79.2
Race/Ethnicity*		
<i>White/Non-Hispanic</i>	286	86.1
<i>Black/Non-Hispanic</i>	23	6.9
<i>Hispanic</i>	5	1.5
<i>More than one race</i>	13	3.9
<i>Other/unknown</i>	5	1.5
Education		
<i>Less than high school</i>	26	7.9
<i>High school graduate/GED</i>	126	38.1
<i>Some college</i>	124	37.5
<i>2-Year associate's degree or higher</i>	55	16.6
Present Employment Status		
<i>Employed full- or part-time</i>	170	51.2
<i>Student, homemaker, retired, or unable to work</i>	102	30.7
<i>Unemployed</i>	60	18.1
Change in employment status due to COVID		
<i>No</i>	184	55.4
<i>Yes</i>	148	44.6
Specifics of those with change in employment status		
<i>No longer working</i>	70	47.3
<i>Working but for fewer hours each week</i>	68	46.0
<i>Working but for more hours each week</i>	10	6.8
Menthol Status*		
<i>Menthol</i>	147	44.3

<i>Non-menthol</i>	185	55.7
Patient Health Questionnaire-2 Score		
<i>2 or less</i>	83	25.0
<i>3 or more</i>	249	75.0
Generalized Anxiety Disorder 2-item Score		
<i>2 or less</i>	60	18.1
<i>3 or more</i>	272	81.9
Population*		
<i>Women of child-bearing age</i>	127	38.3
<i>Individuals with opioid use disorder</i>	77	23.2
<i>Individuals with affective disorders</i>	128	38.6
Study Site*		
<i>Brown University</i>	48	14.5
<i>Johns Hopkins University</i>	57	17.2
<i>University of Vermont</i>	227	68.4
Parent Trial Nicotine Dose Condition*		
<i>0.4 mg/g</i>	112	33.7
<i>2.4 mg/g</i>	87	26.2
<i>15.8 mg/g</i>	133	40.1

* Denotes data collected during parent study baseline

Table 2. Responses to smoking and COVID-19 related behavior survey questions

	<i>n</i>	%		<i>n</i>	%		<i>n</i>	%
Current smoking status			Buy online			Perceived severity of COVID if infected		
<i>I currently smoke</i>	281	84.6	<i>No</i>	280	99.6	<i>Mild</i>	46	13.9
<i>I have quit smoking</i>	51	15.4	<i>Yes</i>	1	0.4	<i>Medium</i>	167	50.3
Do you think cigarette use increases risk of harm			Buy reservation			<i>Severe</i>	119	35.8
<i>No</i>	75	26.7	<i>No</i>	236	84	Perceived susceptibility to infection		
<i>Maybe</i>	51	18.2	<i>Yes</i>	45	16	<i>Low</i>	86	26
<i>Yes</i>	155	55.2	Buy fewer cigarettes than normal			<i>Medium</i>	206	62.2
Cigarette use changed			<i>No</i>	247	87.9	<i>High</i>	39	11.8
<i>Increased</i>	128	45.6	<i>Yes</i>	34	12.1	Hand washing		
<i>Same</i>	115	40.9	Buy other tobacco products (filtered cigars, cigarillos, smokeless)			<i>No</i>	8	2.4
<i>Decreased</i>	35	12.5	<i>No</i>	254	90.4	<i>Yes</i>	323	97.3
Change in motivation to quit cigarettes			<i>Yes</i>	27	9.6	Avoid touching eyes and face with unwashed hands		
<i>Increased</i>	61	21.7	Change way smoke to avoid touching face			<i>No</i>	45	13.6
<i>Same</i>	135	48	<i>No</i>	202	83.1	<i>Yes</i>	286	86.1
<i>Decreased</i>	78	27.8	<i>Yes</i>	41	16.9	Use hand sanitizer when soap water not available		

Leave house specifically to buy cigarettes			Avoid wearing mask in order to smoke			<i>No</i>	19	5.8
<i>No</i>	100	35.6	<i>No</i>	136	54	<i>Yes</i>	306	93.6
<i>Yes</i>	181	64.4	<i>Yes</i>	116	46	Stay 6 feet from others		
Buy more packs/visit			Leave house to buy cigarettes			<i>No</i>	29	8.8
<i>No</i>	128	45.6	<i>More frequently</i>	40	22.1	<i>Yes</i>	299	90.3
<i>Yes</i>	153	54.5	<i>Less frequently</i>	60	33.2	Wear facemask		
Buy cartons instead of packs			<i>About the same</i>	81	44.8	<i>No</i>	28	8.5
<i>No</i>	201	71.5	Perceived probability of infection			<i>Yes</i>	300	90.9
<i>Yes</i>	80	28.5	<i>Low</i>	116	34.9	Stay home except for essential reasons		
Buy cheaper brands			<i>Medium</i>	197	59.3	<i>No</i>	64	19.5
<i>No</i>	211	75.1	<i>High</i>	19	5.7	<i>Yes</i>	260	79
<i>Yes</i>	70	24.9						

Table 3. Sociodemographic risk factors and parent trial variables associated with CPD at pre-COVID and during COVID timepoints (n=330)

Primary Model					Risk Factors for Differences Over Time				
Variable	Num DF	Den DF	F	p	Variable	Num DF	Den DF	F	p
Site	2	310	1.45	0.236	Site	2	310	1.41	0.245
Population ¹	2	310	9.97	<.0001	Population ³	2	310	9.96	<.0001
Condition	2	310	2.15	0.111	Condition	2	310	2.16	0.117
Sex	1	310	0.18	0.676	Sex	1	310	0.17	0.682
Age	1	310	8.20	0.005	Age	1	310	8.15	0.005
Race	1	310	0.01	0.906	Race	1	310	0.02	0.895
Education ²	3	310	3.45	0.017	Education ⁴	3	310	3.51	0.016
Menthol	1	310	0.72	0.395	Menthol	1	310	0.74	0.392
PHQ-2	1	310	0.71	0.399	PHQ-2	1	310	0.69	0.408
GAD-2	1	310	0.16	0.690	GAD-2	1	310	0.14	0.712
Employment	2	310	0.04	0.958	Employment	2	310	0.03	0.966
Time	1	314	21.60	<.0001	Time	1	311	6.00	0.0149
					Time-by-Employment	2	311	3.61	0.028
					Time-by-GAD-2	1	311	8.01	0.005

Note: PHQ-2: Patient Health Questionnaire-2; GAD-2: Generalized Anxiety Disorder 2-Item

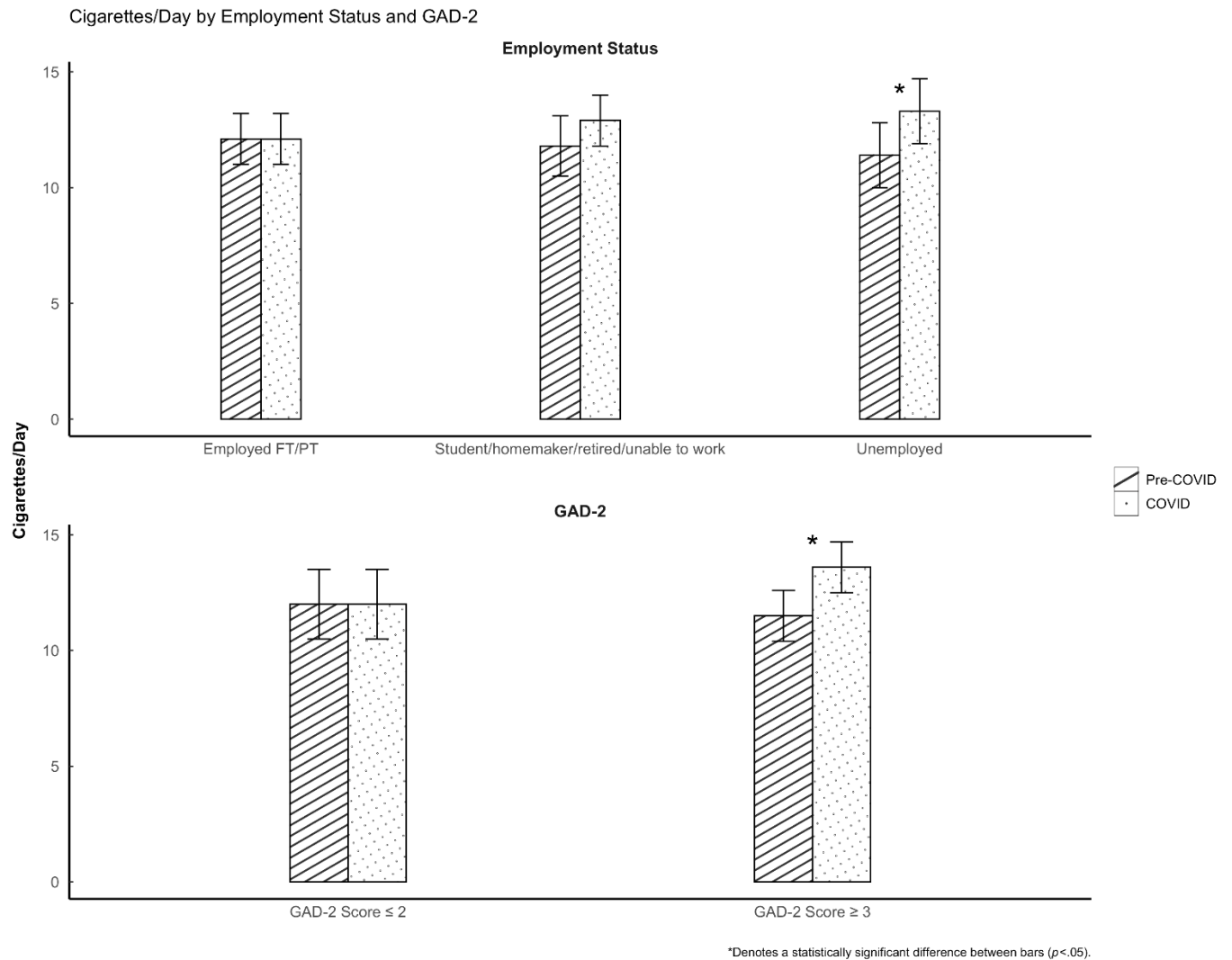
¹Bonferroni corrected post-hoc comparisons indicate a difference between smokers with affective disorders and those with opioid use disorder (OUD) and ($p < 0.001$) and between women of childbearing age and those with affective disorders ($p = 0.026$).

²Bonferroni corrected post-hoc comparisons indicate a difference between those with a high school degree/equivalent and those with some college ($p=0.027$), but no other differences among the other education categories.

³Bonferroni corrected post-hoc comparisons indicate a difference between smokers with affective disorders and those with OUD and ($p < 0.001$) and between women of childbearing age and those with affective disorder ($p = 0.027$).

⁴Bonferroni corrected post-hoc comparisons indicate a difference between those with a high school degree/equivalent and those with some college ($p=0.025$), but no other differences among the other education categories.

Figure 1.



Note: All p -values for post-hoc comparisons are Bonferroni corrected.

No difference in CPD over time for those who are employed full- or part-time ($p=0.999$) or for those who are students/homemakers/retired ($p=0.208$). There was a statistically significant increase in CPD for those who are unemployed ($p=0.024$).

No difference in CPD over time for those with GAD-2 scores ≤ 2 ($p=0.999$). There was a statistically significant increase in CPD for those with GAD-2 scores ≥ 3 ($p < 0.001$).