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# How the COVID-19 pandemic impacts tobacco addiction: Changes in smoking behavior and associations with well-being

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## ABSTRACT

This research investigated (1) how the coronavirus pandemic impacted tobacco addiction, (2) which smoker segments were more vulnerable, and (3) how the changes in tobacco consumption were associated with smokers' satisfaction with physical health and psychological well-being. Data from a large-scale cross-sectional study of adults in China were analyzed. Outcome measures were the quantity of cigarettes consumed per day prior to the COVID-19 pandemic, the quantity after the nationwide outbreak had been contained, satisfaction with physical health, and emotional well-being. Analyses revealed that, after the nationwide outbreak, more individuals quit (vs. started) smoking. Compared to their pre-COVID-19 consumption levels, smokers significantly reduced the quantity of cigarettes they consumed after the nationwide outbreak had been contained. However, there were substantial disparities across individuals: male (vs. female) smokers were less able to curb their smoking; smokers residing in urban (vs. rural) areas or with a longer smoking history were also less able to reduce their smoking. Importantly, a greater reduction in smoking was associated with higher satisfaction with physical health and better emotional well-being. Furthermore, a follow-up investigation revealed that concerns about increased COVID-19 health risks due to smoking were a primary factor driving smokers' behavior change. Overall, these results suggest that, to help smokers fight tobacco addiction and improve well-being, pandemic health policies need to take account of the differences in vulnerability across individuals and leverage the psychological factors that can facilitate behavior change.

## 1. Introduction

COVID-19 is the infectious disease caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). Soon after the first cases of COVID-19 were publically reported in Wuhan, China in late December 2019, the disease became one of the most severe pandemics in the twenty-first century. In about a year, there were over 100 million confirmed COVID-19 infection cases and 2 million deaths globally (Dong, Du, & Gardner, 2020). Despite the wide impact of COVID-19 on many aspects of people's lives, the current understanding of how this respiratory disease pandemic impacts addiction related behaviors is relatively limited (McKay & Asmundson, 2020). For example, it is unclear whether the addiction to tobacco products might increase or decrease after people endured a nationwide coronavirus outbreak. It is also unknown which population segments might be more vulnerable to the addiction. Given that infectious disease outbreaks are anticipated to occur at an increasing frequency (Jones et al., 2008; Wolfe, 2011),

seeking answers to these questions can inform health policies and interventions aimed at helping people fight tobacco addiction in future health crises. More importantly, with over 8 million deaths attributed to smoking annually (Stanaway et al., 2018), tobacco addiction itself can be seen as a form of pandemic – a potentially more deadly one than COVID-19. It is thus important to explore these research questions, informing how we can more effectively fight the pandemic of tobacco addiction.

Prior research suggests that different factors associated with the COVID-19 pandemic may have opposing impacts on tobacco addiction. On one hand, COVID-19 related lockdowns and movement restrictions as well as financial constraints may reduce access to tobacco products, which can facilitate smoking reduction (Chaiton, McCreedy, & Cohen, 2018). Also, COVID-19 is a respiratory disease, and smoking is known to be harmful to the respiratory system. Hence, smokers (vs. non-smokers) may worry more about becoming seriously ill from a coronavirus infection; such increased health concern might motivate some smokers

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to reduce or even quit smoking (Jackson et al., 2020; McCaul et al., 2006). On the other hand, experiencing the COVID-19 pandemic can evoke negative emotions (Yang & Ma, 2020) and increase stress (Rodriguez, Litt, & Stewart, 2020). Social distancing practices can lead to boredom (Hawryluck et al., 2004). Such emotional states are not only barriers to smoking reduction but may lead to increased tobacco consumption (Twyman et al., 2014). Thus, at the macro level, the overall impact of the coronavirus pandemic on tobacco addiction in the general population is unclear. At the individual level, who might be more vulnerable to the addiction due to the pandemic is also unclear. We seek answers to these important questions by examining smokers in China. The country currently has the world’s largest smoker population – over 307 million (WHO, 2018), and is where COVID-19 was first discovered (Dong, Du, & Gardner 2020). We investigate how tobacco consumption prior to the COVID-19 pandemic differs from that after the nationwide outbreak had been contained. We also examine the well-being implications associated with the behavior change, and explore the potential factors driving the change.

**2. Methods**

*2.1. Study design*

This research received IRB clearance at a major university in the Mid-Atlantic region in the US as well as the approval by a major university in northern China. The research data were collected in October 2020, by which the nationwide COVID-19 outbreak in China had been contained (although some isolated infection cases were sporadically reported). A large-scale, random sample of adults in China (n = 13,484) were invited to respond to the research questionnaire. All participants consented before responding to the questionnaire, were able to terminate their participation at any point, provided their responses anonymously, and were compensated.

*2.2. Measures*

*2.2.1. Smoking*

Participants indicated, just before the onset of the COVID-19 pandemic, how long they had been smoking (years) and the quantity of cigarettes they smoked per day. Next, they indicated the quantity of cigarettes they currently smoked per day.

*2.2.2. Subjective well-being*

Participants indicated the extent to which they were satisfied with their current physical health (1 = not at all satisfied, 5 = completely satisfied). They also completed an established measure of emotional well-being (Kahneman & Deaton, 2010) – they indicated whether they smiled or laughed a lot yesterday, and whether they experienced a lot of enjoyment/happiness/anger/sadness/stress/worry yesterday (1 = yes, 0 = no).

*2.2.3. Socio-demographic information*

Participants responded to socio-demographic measures including age (18 or higher), gender (1 = female, 0 = male), marital status (1 = married, 0 = not married), education level (1 = below elementary school, 2 = elementary school, 3 = middle school, 4 = high school, 5 = college degree, 6 = master degree, 7 = doctorate degree), and monthly household income (in ¥). They also indicated their resident province/region as well as the type of locale where they resided (1 = urban, 0 = rural).

*2.3. Statistical analyses*

Statistical analyses were performed using SAS 9.4. Four measures were created or transformed based on participants’ responses. First, as a measure of the change in smoking, we subtracted the number of

consumed cigarettes per day (CPD) prior to the onset of the COVID-19 pandemic from the CPD after the nationwide outbreak had been contained. Thus, a positive value on this measure indicates an increase in smoking. A negative value indicates a decrease. Zero indicates no change. Further, following prior research (Yang & Ma, 2020), we normalized the monthly household income by linearly transforming the value and then dividing it by 10,000 (so that the income is in units of ¥10,000). We coded whether participants were residing in Hubei (1 = yes, 0 = no), the province where COVID-19 was first discovered in the country (Dong, Du, & Gardner, 2020). Finally, to create an overall index of emotional well-being, we subtracted the average of participants’ responses to the negative emotion measures from the average of their responses to the positive emotion measures. This index thus has a value range of –1 to 1: a value closer to 1 indicates a more favorable emotional well-being, whereas a value closer to –1 indicates a more unfavorable state.

We first tested whether there was an overall change in cigarette consumption in the general population before the nationwide COVID-19 outbreak versus after the outbreak had been contained. We then conducted regression analyses to identify which smoker segments were more impacted. We also analyzed the associations between the change in smoking and satisfaction with one’s physical health as well as emotional well-being.

**3. Results**

Of the 13,484 adults recruited to respond to the research questionnaire, 85.3% agreed and completed the study, yielding a cross-sectional sample of 11,500 adults (from 32 provincial regions; 49% women; average age of 36.8; 63% married). The observable demographic variables (e.g., age, gender, location) of those who did not complete the study were similar to those who did.

Among those who completed the study, 6,659 (57.9%) were non-smokers (i.e., did not smoke before the COVID-19 pandemic nor currently). Compared to non-smokers, smokers were older ( $t = 11.09, p < 0.0001$ ), more likely to be male ( $\chi^2 = 927.32, p < 0.0001$ ), married ( $\chi^2 = 135.78, p < 0.0001$ ), and less educated ( $\chi^2 = 23.78, p < 0.0001$ ). On average, smokers had been smoking for 8.47 years, consuming 11.02 cigarettes per day. (See Table 1 for detailed socio-demographic characteristics of smokers, non-smokers, versus the whole sample.)

*3.1. Change in smoking*

Overall, more individuals quit (n = 219) versus started (n = 121)

**Table 1**  
Sample characteristics

	Whole sample	Smokers	Non-smokers
n	11,500	4841	6659
Age	36.79	38.45	35.58
Female	49%	32%	61%
Married	63%	69%	59%
With college degree	81%	79%	83%
Monthly household income (in ¥10,000)	2.09	2.06	2.11
Urban (vs. rural) resident	96%	95%	96%
Hubei province	5%	5%	5%
Smoking history prior to COVID-19 (years)	3.64	8.47	N/A
Smoking level prior to COVID-19 (CPD)	4.64	11.02	N/A

Note: “Non-smokers” refers to individuals who indicated consuming zero cigarette per day (CPD) prior to the COVID-19 pandemic as well as currently. “Smokers” refers to individuals who indicated consuming one or more cigarettes per day on either measure. For dichotomous measures, percentages are shown. For continuous measures, means are shown.

smoking, yielding a net positive change in smoking cessation ( $\chi^2 = 28.25, p < 0.0001$ ). Analyses on the change in smoking measure (cigarettes per day) revealed that, compared to their consumption levels prior to the onset of the COVID-19 pandemic, smokers on average significantly reduced the quantity of cigarettes they consumed daily after the nationwide outbreak had been contained ( $M = -0.38, SD = 8.39; t = 3.19, p < 0.001$ ). We ran a regression with the change in smoking as the dependent variable, individual characteristics as the predictors, and smoking history and prior smoking level as the control variables (see Table 2). This analysis showed that smokers' age, education, income, and whether they resided in the province of Hubei (where COVID-19 was first discovered in the country) were not significant predictors of the change in smoking. However, smokers' gender and whether they resided in urban (vs. rural) areas were significant predictors. Specifically, male smokers were less able to reduce their smoking than female smokers ( $\beta = -0.841, SE = 0.257, t = -3.27, p = 0.001$ ). Smokers residing in urban areas were less able to reduce their smoking than those residing in rural areas ( $\beta = 1.353, SE = 0.576, t = 2.35, p = 0.019$ ). Finally, the coefficient estimates related to smokers' prior tobacco consumption were also significant — those with a longer history of smoking reduced their smoking less ( $\beta = 0.066, SE = 0.015, t = 4.4, p < 0.0001$ ). Those with a higher prior consumption level, however, reduced their smoking more ( $\beta = -0.307, SE = 0.013, t = -23.83, p < 0.0001$ ). (See Table 3 for the characteristics of smokers who reduced their smoking by 5 or more cigarettes per day [CPD], decreased by <5 CPD, did not change, increased by <5 CPD, versus increased by 5 or more CPD.)

### 3.2. Satisfaction with physical health

We ran a regression using smokers' satisfaction with their current physical health as the dependent variable, the change in smoking as the predictor, and individual characteristics, smoking history and prior smoking level as the control variables (see Table 4). This analysis showed that the change in smoking was a significant predictor of satisfaction with physical health ( $\beta = -0.01, SE = 0.002, t = -5.84, p < 0.0001$ ) — smokers who reduced smoking more, experienced higher satisfaction with their physical health. Further, smokers who were married ( $\beta = 0.068, SE = 0.034, t = 2.01, p = 0.045$ ), more educated ( $\beta = 0.047, SE = 0.019, t = 2.49, p = 0.013$ ), with a higher income ( $\beta = 0.043, SE = 0.007, t = 5.88, p < 0.0001$ ), shorter smoking history ( $\beta = -0.005, SE = 0.002, t = -2.87, p = 0.004$ ), or lower level of prior smoking ( $\beta = -0.01, SE = 0.001, t = -5.66, p < 0.0001$ ) were more satisfied with their physical health.

### 3.3. Emotional well-being

We also ran a regression with emotional well-being as the dependent variable, the change in smoking as the predictor, and individual

**Table 2**  
Relationships between change in smoking and individual characteristics

	$\beta$	SE	t	p
Age	-0.016	0.012	-1.35	0.176
Female	-0.841	0.257	-3.27	0.001
Married	0.061	0.317	0.19	0.847
Education	-0.132	0.177	-0.74	0.458
Monthly household income (in ¥10,000)	0.058	0.069	0.84	0.400
Urban (vs. rural) resident	1.353	0.576	2.35	0.019
Hubei province	0.195	0.518	0.38	0.707
Smoking history prior to COVID-19 (years)	0.066	0.015	4.4	<0.0001
Smoking level prior to COVID-19 (CPD)	-0.307	0.013	-23.83	<0.0001
Intercept	2.459	1.050	2.34	0.019

Note: "Change in smoking" in Tables 2, 4 and 5 is calculated by subtracting the number of consumed cigarettes per day (CPD) prior to COVID-19 from the current CPD. A positive value on this measure indicates an increase in smoking. A negative value indicates a decrease. Zero indicates no change.

**Table 3**  
Characteristics of individuals who reduced vs. maintained vs. increased their smoking after the nationwide COVID-19 outbreak

	Decreased by 5 or more CPD	Decreased by <5 CPD	No change	Increased by <5 CPD	Increased by 5 or more CPD
n	981	1146	1000	1047	667
Age	39.28	38.73	37.8	38.17	38.13
Female	32%	37%	28%	33%	31%
Married	76%	71%	63%	66%	71%
With college degree	83%	79%	78%	76%	79%
Monthly household income (in ¥10,000)	2.05	2.07	2.18	1.9	2.13
Urban (vs. rural) resident	96%	93%	95%	96%	97%
Hubei province	4%	5%	5%	5%	6%
Smoking history prior to COVID-19 (years)	10.04	7.88	8.41	7.08	9.42
Smoking level prior to COVID-19 (CPD)	19.39	7.92	8.79	7.93	12.26
Satisfaction with physical health	3.83	3.78	3.69	3.66	3.61
Emotional well-being	0.54	0.47	0.55	0.43	0.31

Note: For dichotomous measures, percentages are shown. For continuous measures, means are shown.

**Table 4**  
Relationships between satisfaction with physical health and change in smoking as well as individual characteristics

	$\beta$	SE	t	p
Change in smoking	-0.009	0.002	-5.84	<0.0001
Age	-0.001	0.001	-0.04	0.970
Female	-0.028	0.027	-1	0.315
Married	0.068	0.034	2.01	0.045
Education	0.047	0.019	2.49	0.013
Monthly household income (in ¥10,000)	0.043	0.007	5.88	<0.0001
Urban (vs. rural) resident	0.024	0.061	0.38	0.701
Hubei province	-0.013	0.055	-0.24	0.811
Smoking history prior to COVID-19 (years)	-0.005	0.002	-2.87	0.004
Smoking level prior to COVID-19 (CPD)	-0.008	0.001	-5.66	<0.0001
Intercept	3.477	0.112	31.1	<0.0001

characteristics, smoking history, and prior smoking level as the control variables (see Table 5). This analysis showed that the change in smoking was a significant predictor of emotional well-being ( $\beta = -0.009, SE = 0.001, t = -8.88, p < 0.0001$ ) — smokers who reduced their smoking more, experienced better emotional well-being. Further, smokers who were male ( $\beta = -0.038, SE = 0.017, t = -2.18, p = 0.029$ ), with a higher income ( $\beta = 0.037, SE = 0.005, t = 8.04, p < 0.0001$ ), residing in urban areas ( $\beta = 0.086, SE = 0.039, t = 2.2, p = 0.028$ ), or with a lower level of prior smoking ( $\beta = -0.006, SE = 0.001, t = -6.12, p < 0.0001$ ) had a higher level of emotional well-being.

## 4. Follow-up investigation

The study reported above revealed an overall reduction of smoking after the nationwide coronavirus outbreak had been contained. To probe

**Table 5**  
Relationships between emotional well-being and change in smoking as well as individual characteristics

	$\beta$	SE	t	p
Change in smoking	-0.009	0.001	-8.88	<0.0001
Age	0.001	0.001	1.21	0.228
Female	-0.038	0.0171	-2.18	0.029
Married	0.039	0.021	1.81	0.070
Education	0.005	0.012	0.43	0.664
Monthly household income (in ¥10,000)	0.037	0.005	8.04	<0.0001
Urban (vs. rural) resident	0.086	0.039	2.2	0.028
Hubei province	-0.029	0.035	-0.81	0.415
Smoking history prior to COVID-19 (years)	0.002	0.001	1.84	0.066
Smoking level prior to COVID-19 (CPD)	-0.006	0.001	-6.12	<0.0001
Intercept	0.283	0.071	3.99	<0.0001

why and how smokers quit or reduced tobacco consumption, we conducted a brief follow-up study in late January 2021. Using a similar sampling method as in the main study, we recruited 533 individuals who quit or reduced smoking during the COVID-19 pandemic to participate in the study (43.34% women; average age of 30.77; 71.86% married; 17.64% ceased smoking / 82.36% reduced smoking). As shown in Table 6, participants were shown a list of potential reasons for quitting or reducing smoking, and asked to select the one(s) that drove their behavior change. Next, they were shown a list of potential approaches for quitting or reducing smoking, and asked to select the one(s) they took.

The great majority of participants (93.25%) indicated that they quit/reduced smoking due to COVID-19 related health concerns (46.9% indicated that smoking might increase the likelihood of COVID-19 contraction; 35.08% indicated that smoking might worsen their condition if they contract the virus; 50.84% indicated that they needed to be in a better health condition during the COVID-19 pandemic). Furthermore, 26.08% indicated that reduced ability to consume tobacco products played a role in their behavior change (12.57% indicated that they had fewer opportunities to smoke because of the pandemic; 18.95% indicated that the pandemic made it more difficult for them to purchase tobacco products). These patterns thus suggest that concerns about increased COVID-19 health risks due to smoking were a primary factor driving smokers' behavior change.

With regard to the approaches smokers took to facilitate their behavior change, 20.64% of participants indicated that they used medical treatment (12.38% took prescription medicine; 12.2% received counselling from health professionals). Furthermore, 33.21% used over-the-counter NRT (nicotine replacement treatment) products. 54.41% indicated that they quit/reduced smoking on their own without

**Table 6**  
Why and how smokers quit or reduced tobacco consumption

Why smokers quit or reduced tobacco consumption	
Reason	%
Smoking might increase the likelihood that I contract COVID-19	46.90
Smoking might worsen my condition if I contract COVID-19	35.08
I needed to be in a better health condition during the COVID-19 pandemic	50.84
I had fewer opportunities to smoke during the pandemic	12.57
The pandemic made it more difficult for me to purchase tobacco products	18.95
Other reason	1.31
How smokers quit or reduced tobacco consumption	
Method	%
I took prescription medicine	12.38
I received counselling from health professionals	12.20
I used over-the-counter NRT products	33.21
I quit or reduced smoking on my own without assistance	54.41
I quit or reduced smoking by switching to other (non-tobacco) products	24.20
Other method	0.38

Note: Participants could select multiple reasons / methods.

assistance. 24.20% indicated that they quit/reduced tobacco consumption by switching to other (non-tobacco) products. These patterns thus suggest that there were large variations in the means through which smokers changed their behavior.

### 5. Discussion

This research investigated how a respiratory disease pandemic – COVID-19 – impacted tobacco addiction in China, a nation with the world's largest smoker population. We found that, after the nationwide COVID-19 outbreak, more individuals quit (vs. started) smoking. Compared to their pre-COVID-19 levels, smokers on average reduced the quantity of cigarettes they consumed daily after the nationwide outbreak had been contained. Given the 307 million smokers in this country (WHO, 2018), the estimated average reduction of 0.38 cigarettes per smoker per day suggests a nationwide reduction of 116.66 million cigarettes every day. Thus, this overall reduction in smoking may have important health implications not only for those who reduced or quit smoking but also for individuals who are exposed to secondhand smoking.

Our research also found important disparities across individuals: male smokers were less able to reduce their smoking than female smokers; those with a longer smoking history or residing in urban (vs. rural) areas were also less able to reduce their smoking. Hence, health policies and programs for smoking cessation/reduction need to take into account these differences in vulnerabilities across individuals. Furthermore, the changes in smoking were associated with smokers' well-being. Those who reduced their smoking more, reported a higher level of satisfaction with their current physical health, and better emotional well-being. These findings thus highlight the physical and psychological benefits associated with overcoming tobacco addiction.

This research has limitations and suggests several directions for future investigations. First, the data used in the current research were collected after the nationwide COVID-19 outbreak had been contained in China. However, there were still sporadic infection cases. Thus, the longer-term impact of the pandemic on smoking may require further investigation (e.g., after an effective COVID-19 vaccine has been widely adopted). Second, the behavioral measures utilized in this cross-sectional study were self-reported. Further research using direct observation and longitudinal approaches may yield additional evidence of the impact of the COVID-19 pandemic on tobacco addiction. Relatedly, while the follow-up investigation we conducted identified important factors driving smokers' behavior change and the cessation approaches smokers took, future research can utilize experimental approaches to more fully examine the causal mechanisms and develop effective interventions.

Our research focused on the smoker population in China. Although this group is the world's largest at the time of our research, given that countries may differ in aspects such as culture, economic development stage, and pandemic related health policies, the extent to which the findings are generalizable to smoker populations of other regions requires further exploration. Moreover, we focused on cigarette consumption in this research because cigarettes account for the overwhelming majority (94%) of tobacco products sold in China (Euromonitor, 2020). Future research can assess the extent to which the pattern observed in the current research occurs with other types of tobacco products, as well as the extent to which smokers switched from cigarettes to other tobacco products during the pandemic. Further, the data we obtained did not contain information on whether smokers contracted COVID-19. Future research can investigate how personally experiencing the viral infection may impact smokers' subsequent behavior.

Finally, the current mainstream scientific understanding is that smoking accentuates COVID-19 related risks. For example, the Centers for Disease Control and Prevention notes that "being a current or former cigarette smoker increases your risk of severe illness from COVID-19"



and that “if you currently smoke, quit. If you used to smoke, don’t start again. If you’ve never smoked, don’t start” (CDC, 2021). Similarly, in a summary of scientific findings pertaining to the relationship between tobacco consumption and COVID-19, the World Health Organization recommends that “tobacco users stop using tobacco” (WHO, 2020). However, a few emerging studies (e.g., de Lusignan et al., 2020; Paleiron et al., 2021) suggest that smoking might potentially be associated with a decreased likelihood of COVID-19 contraction. Because the great majority of participants in our follow-up investigation (93.25%) believed that smoking would accentuate COVID-19 related health risks, becoming aware of such contrary information may lead to feelings of uncertainty (Yang, Carmon, Ariely, & Norton, 2019). Future research should thus investigate how exposures to conflicting research findings regarding the relationship between smoking and COVID-19 may impact smokers’ behavior.

## 6. Conclusions

Analyses using a large-scale cross-sectional dataset showed that, compared to their pre-COVID-19 levels, smokers in China on average reduced their tobacco consumption after the nationwide viral outbreak had been contained. There were substantial disparities across individuals: male smokers were less able to curb their smoking than female smokers; those residing in urban (vs. rural) areas or with a longer smoking history were also less able to reduce their smoking. Importantly, a greater reduction in smoking was associated with higher satisfaction with one’s physical health as well as better emotional well-being. Thus, to more effectively help smokers fight tobacco addiction and attain better well-being, pandemic health policies and programs need to take account of the differences in vulnerability across individuals. Finally, the results of our follow-up study suggest that the respiratory disease pandemic increased smokers’ concern about health risks associated with tobacco consumption. This may present an enhanced opportunity for policy makers and health organizations to take on the pandemic of tobacco addiction, assisting more smokers to change their behavior. Our findings also suggest that because different smokers may require different health assistance (e.g., prescription medicine vs. over-the-counter NTR product), health policies and programs should facilitate access to smoking cessation resources that match individual preferences.

## CRedit authorship contribution statement

**Haiyang Yang:** Conceptualization, Investigation, Methodology, Formal analysis, Project administration, Writing - original draft, Writing - review & editing. **Jingjing Ma:** Conceptualization, Investigation, Data curation, Methodology, Formal analysis, Project administration, Writing - original draft, Writing - review & editing.

## Ethics approval

This research received IRB clearance from the Johns Hopkins University as well as the approval by the National School of Development at Peking University where the data collection took place.

## Data Availability

The dataset used in this research can be available upon request.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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