An Empirical Analysis of Demographic Characteristics, Acquired Knowledge, and Personal Beliefs as Indicators of Behavioral Compliance during the COVID-19 Pandemic: A National Cross-Sectional Study

Nikita Radha Chin, Ashley Reshma Chin, Robert Brookshire, Amita Goyal Chin, Seonjun Kang

Submitted to: JMIR Public Health and Surveillance
on: June 15, 2021

Table of Contents

An Empirical Analysis of Demographic Characteristics, Acquired Knowledge, and Personal Beliefs as Indicators of Behavioral Compliance during the COVID-19 Pandemic: A National Cross-Sectional Study

Nikita Radha Chin[1] BSc; Ashley Reshma Chin[1]; Robert Brookshire[2] PhD; Amita Goyal Chin[3] PhD; Seonjun Kang[3] MSc

[1]Virginia Commonwealth University Richmond US
[2]Integrated Information Technology University of South Carolina Columbia US
[3]Department of Information Systems Virginia Commonwealth University Richmond US

Corresponding Author:
Amita Goyal Chin PhD
Department of Information Systems
Virginia Commonwealth University
Snead Hall
Richmond
US

Abstract

Background: During the COVID-19 pandemic, it is of vital importance to identify factors that promote behavioral compliance of consumers to the recommendations of government agencies.

Objective: This study analyzed demographic characteristics, acquired knowledge, and personal beliefs, in combination with anxiety and stress, as indicators of compliance in the general population to recommended behavioral changes during COVID-19.

Methods: Data from a survey that was administered on Facebook, Instagram, Twitter, and WhatsApp was analyzed. Participation was voluntary and no compensation of any kind was provided. T tests and analysis of variance were used to compare average scores of the different demographic groups, with degrees of freedom adjusted if the equal variance assumption appeared to be violated. Logistic regression was used to determine the odds ratios for adoption of the various preventive behaviors. Data were analyzed using SPSS (version 27, IBM Corp). Structural equation modelling was performed using SmartPLS. The impact of personal characteristics – age, gender, education, race, and political affiliation, combined with acquired knowledge about COVID-19, personal beliefs during the crisis, and the resulting anxiety and stress were evaluated for their effect on the adoption of recommended behavioral changes during COVID-19.

Results: 5,677 social media users participated in the online survey, however, only 4,998 completed the entire survey and were used in our analyses. Only respondents who were 18 years of age or older and U.S. residents were included in the final data set. Females had a higher average knowledge about COVID-19 ($t=3.09$, $df=4960$, $p<0.01$), but the genders were similar in their knowledge of protective factors ($t=0.26$, $df=4960$, $p=0.79$). Republicans had a lower average COVID-19 knowledge score ($t=-3.93$, $df=4996$, $p<0.001$) and a lower average knowledge of protective factors ($t=-2.82$, $df=4996$, $p<0.01$). Those with higher levels of education had higher mean COVID-19 knowledge scores ($F=79.10$, $df=4,4993$, $p<0.001$). Among the different age groups, younger respondents had higher levels of COVID-19 knowledge ($F=11.46$, $df=2,4995$, $p<0.001$), but the age groups were similar in their knowledge of protective factors ($F=0.28$, $df=2,4995$, $p=0.645$). About two-thirds of the sample (67%) disagreed or strongly disagreed that COVID-19 was an act of bioterrorism. About 82% agreed or strongly agreed that COVID-19 is more deadly than the seasonal flu. About 84% agreed or strongly agreed that the amount of media attention paid to COVID-19 was adequate, and most (80%) disagreed or strongly disagreed that COVID-19 is not as big a problem as the media suggests. Republicans on average had higher agreement that the virus was released as an act of bioterrorism ($t=16.00$, $df=2030.3$, $p<0.001$), that the virus is not as big a problem as the media suggests ($t=20.61$, $df=1908.3$, $p<0.001$), and that warm weather will reduce the spread of the virus ($t=16.52$, $df=2286$, $p<0.001$). Among the preventive behaviors that respondents reported adopting, the most frequent were keeping away from crowded places (N=4863, 96.5%), using hand sanitizer or washing hands more often (N=4826, 95.8%), starting to clean or disinfect things they might touch (N=4482, 89.0%) and avoiding public transportation (N=4393, 87.2%).

Conclusions: Individual beliefs in the severity of the pandemic, the level of stress/anxiety, and protective knowledge for COVID-19 were significant indicators in the adoption of protective behaviors while the level of COVID-19 knowledge was weakly and negatively associated with these indicators. Demographic factors including age, gender, political affiliation, education level, and race were also significant indicators of behavioral compliance. Study findings can provide valuable insights that can be used to further increase behavioral compliance among the population during COVID-19.

(JMIR Preprints 15/06/2021:31238)
DOI: https://doi.org/10.2196/preprints.31238

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

An Empirical Analysis of Demographic Characteristics, Acquired Knowledge, and Personal Beliefs as Indicators of Behavioral Compliance during the COVID-19 Pandemic: A National Cross-Sectional Study

Abstract

Background: During the COVID-19 pandemic, it is of vital importance to identify factors that promote behavioral compliance of consumers to the recommendations of government agencies.
Objective: This study analyzed demographic characteristics, acquired knowledge, and personal beliefs, in combination with anxiety and stress, as indicators of compliance in the population to recommended behavioral changes during COVID-19.
Methods: Data from a survey that was administered on Facebook, Instagram, Twitter, and WhatsApp was analyzed. Participation was voluntary and no compensation of any kind was provided. T tests and analysis of variance were used to compare average scores of the different demographic groups, with degrees of freedom adjusted if the equal variance assumption appeared to be violated. Logistic regression was used to determine the odds ratios for adoption of the various preventive behaviors. Data were analyzed using SPSS (version 27, IBM Corp). Structural equation modelling was performed using SmartPLS. The impact of personal characteristics – age, gender, education, race, and political affiliation, combined with acquired knowledge about COVID-19, personal beliefs during the crisis, and the resulting anxiety and stress were evaluated for their effect on the adoption of recommended behavioral changes during COVID-19.
Results: 5,677 social media users participated in the online survey, however, only 4,998 completed the entire survey and were used in our analyses. Only respondents who were 18 years of age or older and U.S. residents were included in the final data set. Females had a higher average knowledge about COVID-19 ($t=3.09$, $df=4960$, $p<0.01$), but the genders were similar in their knowledge of protective factors ($t=0.26$, $df=4960$, $p=0.79$). Republicans had a lower average COVID-19 knowledge score ($t=-3.93$, $df=4996$, $p<0.001$) and a lower average knowledge of protective factors ($t=-2.82$, $df=4996$, $p<0.01$). Those with higher levels of education had higher mean COVID-19 knowledge scores ($F=79.10$, $df=4,4993$, $p<0.001$). Among the different age groups, younger respondents had higher levels of COVID-19 knowledge ($F=11.46$, $df=2,4995$, $p<0.001$), but the age groups were similar in their knowledge of protective factors ($F=0.28$, $df=2,4995$, $p=0.645$). About two-thirds of the sample (67%) disagreed or strongly disagreed that COVID-19 was an act of bioterrorism. About 82% agreed or strongly agreed that COVID-19 is more deadly than the seasonal flu. About 84% agreed or strongly agreed that the amount of media attention paid to COVID-19 was adequate, and most (80%) disagreed or strongly disagreed that COVID-19 is not as big a problem as the media suggests. Republicans on average had higher agreement that the virus was released as an act of bioterrorism ($t=16.00$, $df=2030.3$, $p<0.001$), that the virus is not as big a problem as the media suggests ($t=20.61$, $df=1908.3$, $p<0.001$), and that warm weather will reduce the spread of the virus ($t=16.52$, $df=2286$, $p<0.001$). Among the preventive behaviors that respondents reported adopting, the most frequent were keeping away from crowded places (N=4863, 96.5%), using hand sanitizer or washing hands more often (N=4826, 95.8%), starting to clean or disinfect things they might touch (N=4482, 89.0%) and avoiding public transportation (N=4393, 87.2%).

Conclusions: Individual beliefs in the severity of the pandemic, the level of stress/anxiety, and protective knowledge for COVID-19 were significant indicators in the adoption of protective behaviors while the level of COVID-19 knowledge was weakly and negatively associated with these

indicators. Demographic factors including age, gender, political affiliation, education level, and race were also significant indicators of behavioral compliance. Study findings can provide valuable insights that can be used to further increase behavioral compliance among the population during COVID-19.

KEYWORDS:
COVID-19; knowledge; behavior modification; protective practices; personal beliefs; pandemic

Introduction

Since the initial cases of a mysterious illness first began emerging in December 2019, society has come under siege from the novel coronavirus SARS-CoV-2 in what has colloquially become known as the COVID-19 pandemic. The COVID-19 virus is thought to have originated in Wuhan, China and is characterized by a high transmission and fatality rate. COVID-19 spread rapidly, passing from one host to another through small droplets in the air, establishing itself as a global presence in just a few months. COVID-19 was declared a worldwide pandemic by the World Health Organization (WHO) on March 11, 2020.

COVID-19 has proven to be one of the deadliest pandemics in history. Prior diseases that wreaked havoc on human life included the Plague of Justinian in 541-542 A.D. which claimed 30-50 million lives; Smallpox was responsible for 25-55 million deaths; the Russian flu and yellow fever accounted for just over a million lives lost in the later 1800s [1]. The 1900s were marred by the Spanish flu in 1918-1920 (20 million deaths), the Asian flu of 1957-1958 (1 million deaths), and the Hong Kong flu of 1968-1970 (1 million deaths) [1]. In the current century, we battled SARS in 2002-2003 and MERS in 2015 (each with less than 1,000 deaths), the Swine flu that began in 2009 (200,000 deaths), and Ebola in 2014-2016 (11,000 deaths) [1]. HIV/AIDS, an ongoing battle since 1981, has claimed approximately 35 million lives [1]. As of April 20, 2021, 219 countries across the world have reported over 142 million infections of COVID-19 which have resulted in 3 million deaths [2]. In the United States alone, 32 million cases have been documented and over 581,000 have died from the virus [3].

COVID-19 has drastically affected everyday life, where people are strongly urged to wear masks in public, eliminate group gatherings in favor of social distancing practices, vacate offices and public buildings to work from home, opt for online meetings to replace face-to-face conversations and social interactions that were once the norm in offices, and transition to (asynchronous) online learning instead of experiential and interactive in-person learning in schools. Efforts for contact tracing for those that become symptomatic have become commonplace and drastic measures of sheltering in quarantine at home and even citywide lockdowns have become all too familiar.

In addition to the major restrictions on day-to-day activities and overall social disruptions, COVID-19 has caused economic upheaval and devastated the livelihoods of millions of individuals and businesses. Over 3.3 billion workers have lost their jobs or are at risk of losing them, causing many to fall into poverty [4]. Travel restrictions have been imposed and international borders have been closed, nearly paralyzing the airline and shipping industries, and debilitating the transportation of goods. At a global level, supply chains for food harvesting, selling, and delivery have been severely compromised or completely shut down, pushing numerous families into lives ridden with food insecurity. Health systems are bursting at the seams and healthcare providers have reached exhaustion. Makeshift medical facilities have proven inadequate as the struggles to accommodate the very large numbers of afflicted people in the face of dwindling or thoroughly depleted medical supplies have become overwhelming.

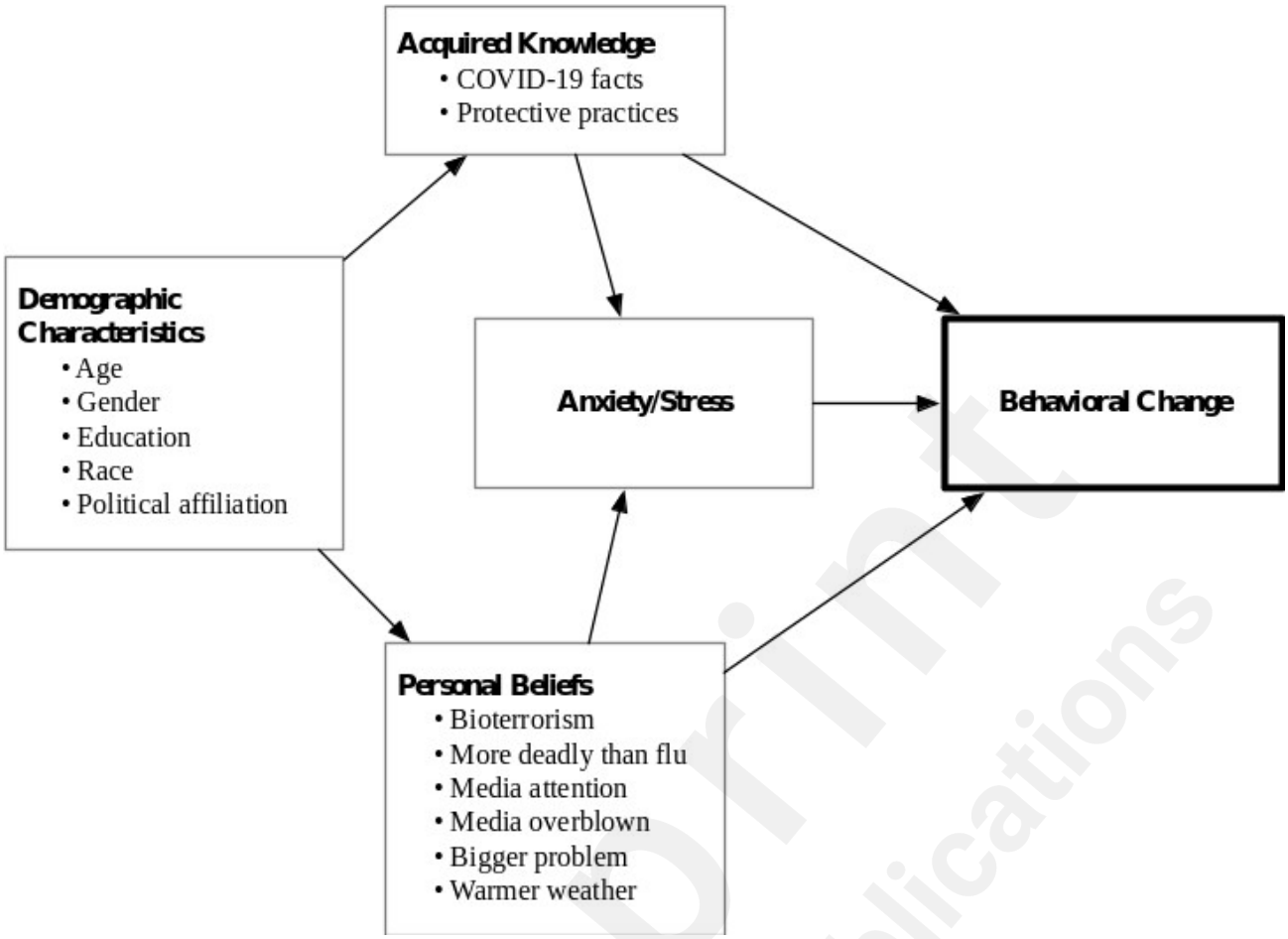
Over a year has passed since COVID-19 first emerged; however, the world continues to grapple with the virus, including its multiple variants, and the paralysis that it continues to warrant in our everyday life. For example, on April 19, 2021, New Delhi imposed yet another weeklong citywide

lockdown in an attempt to combat the rapidly rising rate of infections and deaths, which continue to break daily records [5]. To date, there is no known cure for COVID-19.

In the midst of this worldwide struggle, it has become extremely important to effectively disseminate news and instructions to the masses as quickly and efficiently as possible, as public awareness, reasonable understanding, trust, and the maintenance of calm contributes to a compliance to recommended procedures in an effort to control the spread of the disease. News outlets, including television, radio, print media, and websites and other social media as well as public health agencies including the WHO and the Center for Disease Control (CDC) have been actively disseminating information about COVID-19 to the public at large. Information has included scientific facts about the virus as well as precautionary measures that should be taken and behavioral modifications that should occur in order to avoid both becoming infected and, if infected, spreading the disease to others. Amassing information from a variety of sources, people have attempted to identify errors and sift through biases to formulate their own conclusions and beliefs [6,7]. However, the deluge of information, some of which has been based on scientific discovery and some of which amounts to being fake news [8–11], has caused confusion, anxiety, and stress amongst the population all over the world [12–14]. This has resulted in a lower than desired level of consumer compliance to the changes in behaviors that have been recommended by the WHO and the CDC [15].

The purpose of the current study is to identify factors that contribute to the compliance of the general population to recommended behavioral changes during the COVID-19 pandemic. As shown in Figure 1, we analyze the impact of demographic characteristics on acquired knowledge as well as on personal beliefs. The knowledge and understanding of what is happening around us [16–19] and our belief in the veracity of the news and information [20–23] that we pull or that is being pushed upon us affects the level of anxiety and stress that we feel. For example, during COVID-19, being bombarded with abysmal daily news reports of record hospitalizations and deaths worldwide, especially during the long period of time before any vaccines were developed, while living in round-the-clock quarantine at home, contributed to a high level of personal anxiety and stress, which in turn led to depression and in behavioral change in the form of an elevation in suicide rates [24]. Adopting changes in personal behaviors, in particular drastic changes that may be recommended during a health crisis, are an outcome of the knowledge and understanding of the dire situation [17,19,25–27], belief in the legitimacy of both the situation and the negative effects of the situation, and a reaction to the level of anxiety and stress felt from the situation [12,28–30]. Therefore, it is imperative to study how knowledge about COVID-19 and the recommended countermeasures, combined with people's personal beliefs, impacts people's mental state and the preventive behaviors taken during this health crisis. Our findings may help us understand the indicators for behavioral compliance during the early stages of this pandemic and help us in formulating and establishing policies that further promote the adoption of the recommended protective behaviors.

Figure 1. Research model.



Methods

Study Design and Population

A survey instrument was designed to gain insights into the protective behavioral practices embraced by the population during the COVID-19 pandemic. As shown in Figure 1, survey questions assessed predictive factors – demographic characteristics, acquired knowledge, personal beliefs, and anxiety and stress levels – that contribute to the modification of routine behaviors in order to adhere to the new behaviors that comply with the recommendations of the WHO and the CDC. New behaviors include, for example, wearing a mask in public, social distancing, and using hand sanitizer or washing hands more frequently.

A detailed description of the methods of data collection has been published elsewhere [17]. Briefly speaking, the study participants responded to an advertisement campaign conducted on Facebook and its associated platforms – Instagram, Twitter, and WhatsApp -- from March 20-30, 2020. Facebook and its platforms were chosen because they represent a wide swath of the population, including difficult-to-reach populations such as the young, LGBT, and the homeless [31–33]. Facebook is used by more than 2.7 billion active users around the world, including 69% of American adults [34,35]. Prior studies have shown that Facebook is a successful platform for the recruitment of survey participants, particularly for health research [33,36,37]. Using Facebook offers several benefits over the traditional participant recruitment methods (e.g., flyers, radio, email), including a better representation of the population, shorter survey periods, and cost savings [37].

The survey advertisements on Facebook and the three additional social media platforms used for data collection in this study were linked to a Qualtrics web-based survey. The New York University Institutional Review Board reviewed the procedures for the initial study [17], waiving explicit oral and written consent from survey respondents. Survey respondents were volunteers and were not compensated in any way.

Survey data was collected by Ali et al. [17] and made available upon request to the authors of the current study. 5,677 social media users participated in the survey, however, only 4,998 completed the entire survey and were used in our analysis. Only respondents who were 18 years of age or older and U.S. residents were included in the final data set. T tests and analysis of variance were used to compare average scores of the different demographic groups, with degrees of freedom adjusted if the equal variance assumption appeared to be violated. Logistic regression was used to determine the odds ratios for adoption of the various preventive behaviors. Data were analyzed using SPSS (version 27, IBM Corp). Structural equation modelling was performed using SmartPLS [38].

Results

Characteristics of the Sample

Table 1 shows the demographic characteristics of those who responded to the online survey (N=4,998). Compared to the U.S. population [39], respondents in this sample are more likely to be female (50.8% vs. 58.3%), to have a bachelor's degree or above (33.1% vs. 49.7%), and to identify as white, non-Hispanic (72% vs. 91.6%). Persons in this sample are slightly less likely to identify as Republican than the U.S. population (29% vs. 25.4%) [40].

In the online questionnaire, participants reported their age, gender, education level, race, and political affiliation. In this analysis, age is coded 1 for 18 to 39 years, 2 for 40 to 59 years, and 3 for 60 years and over; gender is coded 1 for female, 0 for other; education is coded as 0 for less than high school, 1 for high school, 2 for some college, 3 for Bachelor's degree, and 4 for Masters or Professional degree; race is coded as 1 for White, Non-Hispanic and 0 for other; and political affiliation is coded as 1 for Republican and 0 for other.

Table 1. Demographic characteristics of survey respondents (N=4998).

Variable	Value
Age group, n (%)	
18 to 39	1231 (24.4)
40 to 59	2314 (45.9)
60 and up	1493 (29.6)
Gender, n (%)	
Female	2937 (58.3)
Male	2014 (40.0)
Other	11 (0.2)
Prefer not to disclose	36 (0.7)
Education Level, n (%)	
Less than High School	59 (0.9)
High School	726 (11.0)
Some College	1711 (34.0)
Bachelor's Degree	1376 (27.3)
Master's or Professional Degree	1126 (22.4)
Race/Ethnicity, n (%)	
Asian/Pacific Islander	51 (1.0)
Black, Non-Hispanic	37 (0.7)
Hispanic/Latinx	145 (2.9)
Interracial, Mixed race, or Other	102 (2.0)
Native American or American Indian	50 (1.0)
White, Non-Hispanic	4613 (91.6)
Political Affiliation, n (%)	
Democrat	1684 (33.4)
Republican	1282 (25.4)
Other	940 (18.7)
Prefer Not to Say	1092 (21.7)

Knowledge Indicators (about COVID-19 and protective practices)

A set of 23 true-false questions was used to ascertain participants' level of knowledge about COVID-19 [17]. Thirteen questions assessed knowledge of facts about the virus, while 10 questions measured knowledge of effective protective practices for preventing COVID-19 transmission (Table 2). Example virus knowledge questions included, "Coronavirus is a contagious disease," "Older people with other health conditions are more likely to die from Coronavirus," and "People with Coronavirus can have not symptoms at all." The protective practice questions asked, "How can you protect yourself from being INFECTED with Coronavirus," and included practices such as "Washing your hands frequently with soap and water," "Wearing a face mask," and "Staying away from people who sneeze and cough." Correct responses to these sets of questions were summed to create a COVID-19 knowledge score (0-13) and a protective knowledge score (0-10).

Table 2. Survey Questions – Knowledge of Facts, Knowledge of Effective Protective Practices.

	Knowledge of Facts About COVID-19 (T/F)	Knowledge of Effective Protective Practices (T/F)
(1)	Coronavirus is a contagious disease.	Washing your hands frequently with soap and water.
(2)	A person infected with Coronavirus is not	Getting a flu shot.

	contagious until after symptoms appear.	
(3)	Coronavirus cannot be spread through sneezing and coughing.	Wearing a face mask.
(4)	Currently, there is an FDA approved drug for treating individuals with Coronavirus.	Stop going to school/work.
(5)	Coronavirus can live on surfaces outside of the body for a few hours or several days.	Wiping potentially contaminated surfaces with a disinfectant.
(6)	There is no vaccine currently available to prevent infection with Coronavirus.	Staying away from Asian people.
(7)	Children are at high risk for complications from Coronavirus.	Staying away from people who sneeze and cough.
(8)	Older people with other health conditions are more likely to die from Coronavirus.	Avoiding touching your eyes, nose and mouth.
(9)	People with Coronavirus can have no symptoms at all.	Taking antibiotics.
(10)	Most people with Coronavirus will have severe or critical symptoms.	Stop eating Chinese food.
(11)	Alcohol-based hand sanitizers cannot protect you from Coronavirus.	
(12)	Coronavirus may be transmitted by mosquito bites.	
(13)	Coronavirus originated from animals	

Table 3 compares the different demographic groups on their knowledge of COVID-19 and protective practices. Females had a higher average knowledge about COVID-19 (t=3.09, df=4960, p<0.01), but the genders were similar in their knowledge of protective factors (t=0.26, df=4960, p=0.79). Republicans had a lower average COVID-19 knowledge score (t=-3.93, df=4996, p<0.001) and a lower average knowledge of protective factors (t=-2.82, df=4996, p<0.01). Those with higher levels of education had higher mean COVID-19 knowledge scores (F=79.10, df=4,4993, p<0.001).

With regard to knowledge of protective practices, in general, mean knowledge increased with education; however, those with less than a high school education also had higher knowledge of protective practices in this sample (F=6.92, df=4,4993, p<0.001). White non-Hispanics had a slightly higher average knowledge of COVID-19 (t=3.77, df=430.02, p0.001), but were not different from non-whites in their knowledge of protective practices (t=0.05, df=4996, p=0.096. Among the different age groups, younger respondents had higher levels of COVID-19 knowledge (F=11.46, df=2,4995, p<0.001), but the age groups were similar in their knowledge of protective factors (F=0.28, df=2,4995, p=0.645).

Table 3. Knowledge and Demographics.

	COVID-19 Knowledge	Knowledge of Protective Practices
Gender, mean (std dev)		
Female	12.13 (1.07)	9.17 (0.73)
Other	12.03 (1.14)	9.16 (0.87)
	t=3.09, df=4960, p<0.01	t=0.26, df=4960, p=0.79
Political Party, mean (std dev)		
Republican	11.98 (1.15)	9.11 (0.83)
Other	12.13 (1.08)	9.19 (0.76)

	t=-3.93, df=4996, p<.001	t=-2.82, df=4996, p<.01
Education Level, mean (std dev)		
Less than HS	10.97 (1.74)	9.22 (0.87)
High School	11.70 (1.29)	9.04 (0.92)
Some College	11.99 (1.15)	9.16 (0.78)
Bachelors	12.22 (0.96)	9.19 (0.77)
Masters or Prof	12.39 (0.84)	9.23 (0.72)
	F=79.10, df=4,4993, p<0.001	F=6.92, df=4,4993, p<0.001
Race/Ethnicity, mean (std dev)		
White, Non-Hispanic	12.11 (1.08)	9.17 (0.78)
Other	11.85 (1.29)	9.17 (0.86)
	t=3.77, df=430.02, p<0.001	t=0.05, df=4996, p=0.96
Age Group, mean (std dev)		
18 to 39	12.16 (1.13)	9.17 (0.81)
40 to 59	12.12 (1.05)	9.18 (0.78)
60 +	11.97 (1.15)	9.15 (0.79)
	F=11.46, df=2,4995, p<0.001	F=0.28, df=2,4995, p=0.645

Beliefs (about COVID-19) Indicators

As shown in Table 4, about two-thirds of the sample (67%) disagreed or strongly disagreed that COVID-19 was an act of bioterrorism. About 82% agreed or strongly agreed that COVID-19 is more deadly than the seasonal flu. About 84% agreed or strongly agreed that the amount of media attention paid to COVID-19 was adequate, and most (80%) disagreed or strongly disagreed that COVID-19 is not as big a problem as the media suggests. More than two-thirds (69%) agreed or strongly agreed that COVID-19 is a bigger problem than the government suggests. The sample was about evenly split on whether warmer weather would reduce the spread of COVID-19, with 50.8 % disagreeing or strongly disagreeing with this statement.

Table 4. Beliefs about COVID-19.

Belief, n (%)	Strongly Disagree	Disagree	Agree	Strongly Agree
I think that Coronavirus was released as an act of bioterrorism.	2130 (42.3)	1748 (34.7)	770 (15.3)	350 (6.9)
Coronavirus is more deadly than the seasonal flu.	158 (3.1)	700 (13.9)	1536 (30.5)	2604 (51.7)
The amount of media attention devoted to Coronavirus has been adequate.	284 (5.6)	510 (10.1)	2680 (53.2)	1524 (30.3)
Coronavirus is not as big a problem as the media suggests.	2236 (44.4)	1792 (35.6)	718 (14.3)	252 (5.0)
Coronavirus is a bigger problem than the government suggests.	301 (6.0)	1210 (24.0)	1532 (30.4)	1955 (38.8)
I think warmer weather will reduce the spread of Coronavirus.	486 (9.6)	2077 (41.2)	2163 (42.9)	272 (5.4)

Table 5 compares the mean belief scores for the different demographic groups. Agreement was measured from 1 indicating strongly disagree to 4 indicating strongly agree, so higher mean scores indicate more agreement. Females had lower average agreement that “Coronavirus was released as

an act of bioterrorism" (t=-3.08, df=4087, p<0.01), "Coronavirus is not as big a problem as the media suggests" (t=-13.92, df=3746.2, p<0.001) and that warmer weather will reduce the spread of the virus (t=-7.25, df=4960, p<0.001), but higher average agreement that the virus is more deadly than the seasonal flu (t=7.37, df=4010.5, p<0.001), the amount of media attention to the virus is adequate (t=6.32, df=4960, p<0.001), and the virus is a bigger problem than the government suggests (t=5.29, df=4215.6, p<0.001).

Republicans on average had higher agreement that the virus was released as an act of bioterrorism (t=16.00, df=2030.3, p<0.001), that the virus is not as big a problem as the media suggests (t=20.61, df=1908.3, p<0.001), and that warm weather will reduce the spread of the virus (t=16.52, df=2286, p<0.001). Republicans had lower average agreement that the virus is more deadly than the season flu (t=-118,7, df=2035.3, p<0.001), the amount of media attention to the virus is adequate (t=-4.70, df=1971.0, p<0.001), and that the virus is a bigger problem than the government suggests (t=-24.04, df=2199.9, p<0.001).

Respondents with lower levels of education had higher average agreement that the virus was released as an act of bioterrorism (F=68.8, df=4,4993, p<0.001), that the virus is not as big a problem as the media suggests (F=19.5, df=4,4993, p<0.001), and that warmer weather will reduce the spread of the virus (F=4.39, df=4,4993, p<0.01). Those with higher levels of education had higher average agreement that the virus is more deadly than the seasonal flu (F=8.17, df=4,4993, p<0.001) and that the virus is a bigger problem than the government suggests (F=6.5, df=4,4993, p<0.001). There was no significant difference between the groups in their agreement that the amount of media attention to the virus has been adequate (F=1.30, df=4,4993, p=0.52).

White non-Hispanics had lower average agreement that the virus was released as an act of bioterrorism (t=-4.55, df=434.7, p<0.001) and that the virus is a bigger problem than the government suggests (t=-2.73, df=4996, p<0.01). There were no significant differences between white non-Hispanics and others in their agreement with the other COVID-19 belief questions.

The oldest respondents had slightly less average agreement that the virus was released as an act of bioterrorism (F=4.97, df=2,4995, p<0.01), that the virus is not as big a problem as the media suggests (F=3.45, df=2,4995, p<0.05), and that the virus is a bigger problem than the government suggests (F=6.02, df=4,4995, p<0.01), but higher average agreement that media attention to the virus has been adequate (F=12.01, df=2,4995, p<0.001). Middle-aged respondents had lower average agreement that the virus is more deadly than the seasonal flu (F=6.11, df=2,4995, p<0.01). There was no significant difference among the age groups in their agreement that warmer weather will reduce the spread of the virus (F=1.12, df=2,4995, p=0.33).

Beliefs	I think that Coronavirus was released as an act of bioterrorism.	Coronavirus is more deadly than the seasonal flu.	The amount of media attention devoted to Coronavirus has been adequate.	Coronavirus is not as big a problem as the media suggests.	Coronavirus is a bigger problem than the government suggests.	I think warmer weather will reduce the spread of Coronavirus.
Gender, mean (std dev)						
Female	1.84 (0.88)	3.39 (0.78)	3.15 (0.75)	1.65 (0.77)	3.09 (0.91)	2.38 (0.73)
Other	1.92 (0.97)	3.21 (0.88)	3.01 (0.84)	2.01 (0.95)	2.94 ((0.96)	2.54 (0.75)
	t=-3.08, df=4087,1, p<0.01	t=7.35, df=4010.5, p<0.001	t=6.32, df=4960, p<0.001	t=-13.92, df=3746.2, p<0.001	t=5.39, df=4215.6, p<0.001	t=-7.25, df=4960, p<0.001
Political Party, mean (std dev)						
Republican	2.25 (0.96)	3.07 (0.88)	2.99 (0.88)	2.25 (0.95)	2.51 (0.89)	2.72 (0.71)
Other	1.74 (0.86)	3.40 (0.79)	3.12 (0.76)	1.64 (0.78)	3.20 ((0.88)	2.35 (0.73)
	t=16.00, df=2030.3, p<0.001	t=-11.87, df=2035.3, p<0.001	t=-4.70, df=1971.0, p<0.001	t=20.61, df=1908.3, p<0.001	t=-24.04, df=2199.9, p<0.001	t=16.52, df=2286.1, p<0.001
Education Level, mean (std dev)						
Less than HS	2.37 (1.02)	3.36 (0.83)	3.19 (0.78)	1.95 (0.94)	3.00 (0.87)	2.41 (0.93)
High School	2.21 (0.98)	3.20 (0.87)	3.08 (0.81)	1.92 (0.88)	2.95 (0.93)	2.51 (0.81)
Some College	1.98 (0.94)	3.26 (0.85)	3.07 (0.81)	1.89 (0.90)	2.96 (0.95)	2.48 (0.73)
Bachelors	1.72 ((0.83)	3.35 (0.80)	3.08 (0.77)	1.75 (0.83)	3.09 (0.92)	2.43 (0.72)
Masters or Prof	1.62 (0.82)	3.43 (0.78)	3.12 (0.78)	1.64 (0.81)	3.12 (0.93)	2.38 (0.72)
	F=68.8, df=4,4993, p<0.001	F=8.17, df=4,4993, p<0.001	F=1.30, df=4,4993, p=0.27	F=19.5, df=4,4993, p<0.001	F=6.5, df=4,4993, p<0.001	F=4.39, df=4,4993, p<0.01
Race/Ethnicity, mean (std dev)						
White, Non-Hispanic	1.85 (0.91)	3.32 (0.83)	3.09 (0.79)	1.80 (0.87)	3.02 (0.93)	2.45 (0.73)
Other	2.10 (1.03)	3.32 (0.87)	3.11 (0.79)	1.75 (0.99)	3.15 (0.95))	2.40 (0.73)
	t=-4.55, df=434.7, p<0.001	t=-0.11, df=4996, p=0.92	t=-0.65, df=4996, p=0.52	t=1.03, df=4996, p=0.30	t=-2.73, df=4996, p<0.01	t=1.29, df=436.1, p=0.24
Age Group, mean (std dev)						
18 to 39	1.90 (0.91)	3.35 (0.80)	3.02 (0.79)	1.83 (0.84)	3.11 (0.89)	2.44 (0.74)
40 to 59	1.90 (0.93)	3.27 (0.85)	3.07 (0.79)	1.81 (0.78)	3.01(0.93)	2.46 (0.74)
60 +	1.80 (0.90)	3.36 (0.82)	3.17 (0.78)	1.75 (0.87)	2.98 (0.03)	2.42 (0.75)
	F=4.97, df=2,4995, p<0.01	F=6.11, df=2,4995, p<0.01	F=12.01, df=2,4995, p<0.001	F=3.45, df=2,4995, p<0.05	F=6.02, df=2,4995, p<0.01	F=1.12, df=2,4995, p=0.33

Table 5. Beliefs and Demographics.

Anxiety, Depression and Stress Indicators

The levels of anxiety and stress were measured using an adapted version of the 4-item Patient Health Questionnaire (PHQ-4) [41,42], which consists of a two-item Generalized Anxiety Disorder 2 (GAD-2) subscale and a two-item PHQ-2 scale assessing depression [43]. Stress was measured using an adapted version of the Impact of Event Scale (IES-6) [44]. Examples of question items include, “I thought about Coronavirus when I didn’t mean to,” and “Other things kept making me think about Coronavirus.” Both scales are highly reliable (PHQ-4: Cronbach’s alpha=.891; IES-6: Cronbach’s alpha=.863). They are also highly correlated (r=0.798, p<0.001).
Table 6 shows the correlations between the knowledge indicators, the belief indicators, and the stress and anxiety indicators. Stress and anxiety are not strongly correlated with the knowledge of COVID-19 or protective practices. There are significant relationships between the knowledge indicators and whether respondents believe COVID-19 is more deadly than the seasonal flu. Respondents with higher stress and anxiety scores tend to agree with this statement (r=0.24, p<0.001). Likewise, those with higher stress and anxiety tend to agree that COVID-19 is a bigger problem than the government suggests (with PHQ-4, r=0.24; with IES-6, r=0.22, p<0.001)). On the other hand, those with stress and anxiety scores tend to disagree that COVID-19 is not as big a problem as the media suggests (with PHQ-4, r=-0.25; with IES-6. R=-0.24; p<0.001).

Table 6. Correlations Between Anxiety, Stress, Knowledge and Belief Indicators.

	PHQ-4	IES-6
COVID-19 Knowledge Score	0.01	0.03*
Knowledge of Protective Factors Score	0.02	0.02
I think that Coronavirus was released as an act of bioterrorism.	0.04**	0.03*
Coronavirus is more deadly than the seasonal flu.	0.24**	0.24**
The amount of media attention devoted to Coronavirus has been adequate.	0.07**	0.06**
Coronavirus is not as big a problem as the media suggests.	-0.25**	-0.24**
Coronavirus is a bigger problem than the government suggests.	0.24**	0.22**
I think warmer weather will reduce the spread of Coronavirus.	-0.12**	-0.09**

***** p<0.05; ** p<0.001

Behavioral Compliance Indicators

Study participants were asked a set of 12 questions designed to elicit COVID-19 prevention behaviors they may have undertaken (Table 7). Examples of these behaviors included getting a flu shot, purchasing a face mask, taking antiviral medications or antibiotics, taking dietary supplements, cleaning or disinfecting surfaces, wearing rubber gloves in public, and taking more hot baths. Participants responded if these activities were true or false for them. An additive scale was constructed to count how many of the 8 behaviors thought to be protective against COVID-19 in March 2020 each respondent reported adopting. These were purchasing a face mask, starting to work from home, hand washing or using hand-sanitizer more often, drinking more fluids and/or getting more rest, avoiding public transportation, keeping away from crowded

places, cleaning or disinfecting surfaces, and wearing rubber gloves in public.

Among the preventive behaviors that respondents reported adopting, the most frequent were keeping away from crowded places (N=4863, 96.5%), using hand sanitizer or washing hands more often (N=4826, 95.8%), starting to clean or disinfect things they might touch (N=4482, 89.0%) and avoiding public transportation (N=4393, 87.2%). Slightly fewer reported drinking more fluids or getting more rest (N=3818, 75.8%) or working from home (N=3187, 63.3%). Only minorities of respondents reported starting to wear rubber gloves in public (N=1224, 24.3%) or purchasing a face mask (N=921, 18.3%). The median number of the 8 behaviors thought to be protective against COVID-19 in March 2020 that were adopted was 6 (mean=5.56, std dev=1.37). About 60% of the sample adopted 5 or 6 new behaviors.

Table 7. Behavior Compliance Indicators.

	COVID-19 Prevention Behaviors (T/F)	Included in additive scale
(1)	Got a flu shot (or had my children get a flu shot) after hearing about Coronavirus.	
(2)	Purchased a face mask.	√
(3)	Started working from home.	√
(4)	Started using hand-sanitizer and/or washing my hands more often.	√
(5)	Started drinking more fluids and/or getting more rest.	√
(6)	Started taking antiviral and/or antibiotics.	
(7)	Started taking dietary supplements (e.g., vitamins, probiotics).	
(8)	Avoided using public transportation.	√
(9)	Kept away from crowded places.	√
(10)	Started cleaning and/or disinfecting things that I might touch (e.g., doorknobs, phone).	√
(11)	Started wearing rubber gloves in public.	
(12)	Started taking more hot baths.	√

Participant Characteristics and Preventive Behaviors

Table 8 shows the distribution of the behaviors adopted across the different demographic groups. Table 9 shows the associations between participant demographic characteristics and the eight preventive behaviors. Females were slightly less like to purchase face masks than others, but were more likely to work from home, use hand sanitizer or wash their hands more frequently, drink more fluids or get more rest, avoid public transportation, stay away from crowded places, and start cleaning or disinfecting surfaces. There was no significant difference between females and others in wearing rubber gloves in public.

Republicans were less likely than others to work from home, and to use hand sanitizer or wash their hands more frequently. There was no significant difference between Republicans and others on the other behavioral measures.

There was only one significant difference among the various levels of education on the

behavioral indicators: Those with masters or professional degrees were more likely to work from home.

White, non-Hispanic survey respondents were less likely to purchase face masks, work from home, drink more fluids or get more rest, and wear rubber gloves in public than other respondents. Older respondents were more likely to purchase face masks or wear rubber gloves in public compared to the youngest age group. Those aged 60 and over were more likely to drink more fluids or got more rest. Middle-aged respondents were slightly less likely to avoid public transportation.

Table 8. Behaviors and Demographics – Distribution

Behaviors	Total (%)	Purchased Face Mask	Worked From Home	Used Hand Sanitizer / Washed Hands	Drank More Fluids / Got More Rest	Avoided Public Transport	Avoided Crowds	Started Cleaning or Disinfecting	Started Wearing Gloves in Public
Gender (%)									
Female	2937 (59.2)	507 (55.3)	1970 (62.3)	2855 (59.6)	2287 (60.4)	2629 (60.3)	2872 (59.5)	2696 (60.6)	734 (60.4
Other	2025 (40.8)	409 (44.7)	1193 (37.7)	1935 (40.4)	1502 (39.6)	1732 (39.7)	1955 (40.5)	1752 (39.4)	481 (39.6
Political Party (%)									
Republican	1282 (25.7)	251 (27.3)	739 (23.2)	1219 (25.3)	977 (25.6)	1118 (25.4)	1238 (25.5)	1140 (25.4)	298 (24.3
Other	3716 (74.3)	670 (72.7)	2448 (76.8)	3607 (74.7)	2841 (74.4)	3275 (74.6)	3625 (74.5)	3342 (74.6)	926 (75.7
Education Level (%)									
Less than HS	59 (1.2)	13 (1.4)	37 (1.2)	58 (1.2)	43 (1.1)	51 (1.2)	58 (1.2)	55 (1.2)	17 (1.4
High School	726 (14.5)	157 (17.0)	358 (11.2)	698 (14.5)	546 (14.3)	645 (14.7)	699 (14.4)	658 (14.7)	218 (17.8
Some College	1711 (34.2)	335 (36.4)	957 (30.0)	1644 (34.1)	1340 (35.1)	1514 (34.5)	1657 (34.1)	1546 (34.5)	418 (34.2
Bachelors	1376 (27.5)	223 (24.2)	927 (29.1)	1326 (27.5)	1037 (27.2)	1196 (27.2)	1344 (27.6)	1209 (27.0)	309 (25.2
Masters or Prof	1126 (22.5)	193 (21.0)	908 (28.5)	1100 (22.8)	852 (22.3)	987 (22.5)	1105 (22.7)	1014 (22.6)	262 (21.4
Race/Ethnicity (%)									
White, Non-Hispanic	4613 (92.3)	810 (87.9)	2922 (91.7)	4457 (92.4)	3498 (91.6)	4053 (92.3)	4485 (92.2)	4133 (92.2)	109 (89.5
Other	385 (7.7)	111 (12.2)	265 (8.3)	369 (7.6)	320 (8.4)	340 (7.7)	378 (7.8)	349 (7.8)	128 (10.5
Age (%)									
18 to 39	1231 (24.6)	194 (21.1)	794 (24.9)	1194 (24.7)	909 (23.8)	1113 (25.3)	1200 (24.7)	1094 (24.4)	257 (21.0
40 to 59	2314 (46.3)	435 (47.2)	1469 (46.1)	2228 (46.2)	1734 (45.4)	2000 (45.5)	2240 (46.1)	2101 (46.9)	558 (45.6
60 +	1453 (29.1)	292 (31.7)	924 (29.0)	1404 (29.1)	1175 (30.8)	1280 (29.1)	1423 (29.3)	1287 (28.7)	409 (33.4

Table 9. Behaviors and Demographics – Odds Ratios.

Behaviors	Purchased Face Mask	Worked From Home	Used Hand Sanitizer / Washed Hands	Drank More Fluids / Got More Rest	Avoided Public Transport	Avoided Crowds	Started Cleaning or Disinfecting	Start Wear Glove Publ
Gender								
Female	Ref	Ref	Ref	Ref	Ref	Ref	Ref	
Other	1.21 (1.05-1.40) *	0.70 (0.63-0.79) *	0.62 (0.46-0.84)*	0.82 (0.72-0.93) *	0.69 (0.58-0.82)*	0.63 (0.45-0.89)	0.57 (0.48-0.69)*	(0.82-
Political Party								
Republican	Ref	Ref	Ref	Ref	Ref	Ref	Ref	
Other	0.90 (0.77-1.06)	1.42 (1.25-1.62)*	1.71 (1.25-2.35)*	1.01 (0.87-1.18)	1.09 (0.90-1.32)	1.42 (0.98-2.04)	1.11 (0.91-1.37)	(0.94-
Education Level								
Less than HS	Ref	Ref	Ref	Ref	Ref	Ref	Ref	
High School	0.98 (0.51-1.85)	0.58 (0.33-1.00)	0.43 (0.06-3.22)	1.13 (0.62-2.05)	1.25 (0.57-2.72)	0.45 (0.06-3.34)	0.70 (0.25-2.00)	(0.59-
Some College	0.86 (0.46-1.61)	0.76 (0.44-1.29)	0.42 (0.06-3.10)	1.34 (0.75-2.42)	1.21 (0.56-2.58)	0.53 (0.07-3.93)	0.68 (0.24-1.90)	(0.45-
Bachelors	0.68 (0.36-1.29)	1.23 (0.72-2.10)	0.46 (0.06-3.37)	1.14 (0.63-2.04)	1.04 (0.49-2.23)	0.72 (0.10-5.39)	0.53 (0.19-1.47)	(0.40-
Masters or Prof	0.73 (0.39-1.38)	2.48 (1.43-4.29) *	0.73 (0.10-5.47)	1.16 (0.64-2.09)	1.11 (0.52-2.40)	0.91 (0.12-6.86)	0.66 (0.19-1.47)	(0.42-
Race/Ethnicity (%)								
White, Non-Hispanic	Ref	Ref	Ref	Ref	Ref	Ref	Ref	
Other	1.90 (1.51-2.40)*	1.28 (1.02-1.60)*	0.81 (0.48-1.37)	1.57 (1.19-2.07)*	1.04 (0.76-1.44)	1.54 (0.72-3.32)	1.13 (0.79-1.61)	(1.28-2
Age (%)								
18 to 39	Ref	Ref	Ref	Ref	Ref	Ref	Ref	
40 to 59	1.24 (1.03-1.49)*	0.96 (0.83-1.11)	0.80 (0.54-1.19)	1.06 (0.90-1.24)	0.68 (0.54-0.84)*	.78 (0.51-1.20)	1.24 (0.98-1.55)	(1.02-1
60 +	1.34 (1.10-1.64)*	0.96 (0.82-1.13)	0.89 (0.58-1.37)	1.50 (1.25-1.80)*	0.78 (0.61-1.00)	1.23 (0.74-2.04)	0.97 (0.76-1.24)	(1.24-1

Structural Equation Model Results

A partial least squares structural equation model (PLS-SEM) method was used to estimate the relationships shown in Figure 1. This method is appropriate when several measures are formative and the analysis uses large secondary data sets [45].

For the purpose of the SEM, three of the belief indicators were used to create a belief construct. These were the responses to the questions "Coronavirus is a bigger problem than the government suggests," "Coronavirus is more deadly than the seasonal flu," and "Coronavirus is not as big a problem as the media suggests" (reverse coded). The combination of these responses resulted in a reliable construct (Cronbach's alpha=0.74, composite reliability=0.74, AVE=0.49, HTMT=0.04). These belief questions are the ones that were more highly related to the stress and anxiety measures, as shown in Table 6, and were strongly related to the demographic measures, as shown in Table 5. These indicators show respondents' beliefs about the severity and importance of the disease. The stress and anxiety indicators are highly correlated, as previously noted, and were likewise combined, resulting in a reliable measure (Cronbach's alpha=0.89, composite reliability=0.89, AVE=0.80, HTMT=0.26). All other constructs in the model were measured formatively with single indicators. The largest variance inflation factor was 2.75, indicating little collinearity among the indicators.

Figure 2 and Table 10 show the results of the structural equation estimation of the model shown in Figure 1. R^2 values for the equations predicting the knowledge indicators are low, 0.06 for COVID-19 knowledge and 0.005 for protective knowledge, indicating that factors other than demographic characteristics are important in explaining the respondents' levels of knowledge. The R^2 for the equation predicting the beliefs construct is more robust at 0.18, indicating slightly less than a fifth of the variation in beliefs can be accounted for by demographic factors. The R^2 measure for the equation predicting the stress/anxiety construct is 0.14. The R^2 for the equation predicting the number of behaviors adopted is 0.126, showing that a small but significant portion of the variation in behavior can be accounted for by the predictors.

Age is positively related to COVID-19 knowledge and negatively related to beliefs about COVID-19, but not significantly related to knowledge of protective practices. Level of education is positively related to COVID-19 knowledge, knowledge of protective practices, and beliefs about COVID-19. Female gender is positively related to beliefs about COVID-19, but not to the knowledge measures. White non-Hispanic race/ethnicity is negatively related to beliefs about COVID-19 and negatively related to knowledge about COVID-19. It is not related to knowledge of protective practices. Republican political identity is negatively related to COVID-19 beliefs, indicating that Republicans were less likely to believe in the severity and importance of the disease. It is also negatively related to knowledge of protective practices; however, it is not related to general COVID-19 knowledge.

Knowledge about COVID-19 is not related to stress/anxiety, while knowledge of protective practices is negatively related, meaning those with more knowledge of protective practices reported less stress and anxiety. Beliefs about COVID-19 were positively related to stress and anxiety, showing that those who believed COVID-19 is more dangerous than the flu, that the disease was a bigger problem than the government suggests, and disagreed that it was not as big a problem as the media suggests, reported more stress and anxiety.

Knowledge of protective practices, beliefs about the severity and importance of the disease, and stress/anxiety are all positive predictors of the adoption of more preventive behaviors. Those with higher levels of knowledge of protective practices were more likely to adopt more practices,

as were those with more stress/anxiety and those who believed the disease is severe and important. Knowledge of COVID-19 in general is negatively related to the adoption of more behaviors, indicating that those with more knowledge of the disease were somewhat less likely to adopt more protective behaviors. It should be noted, however, that the effects of the knowledge indicators and the stress construct on behaviors are weak.

Figure 2. SEM Model.

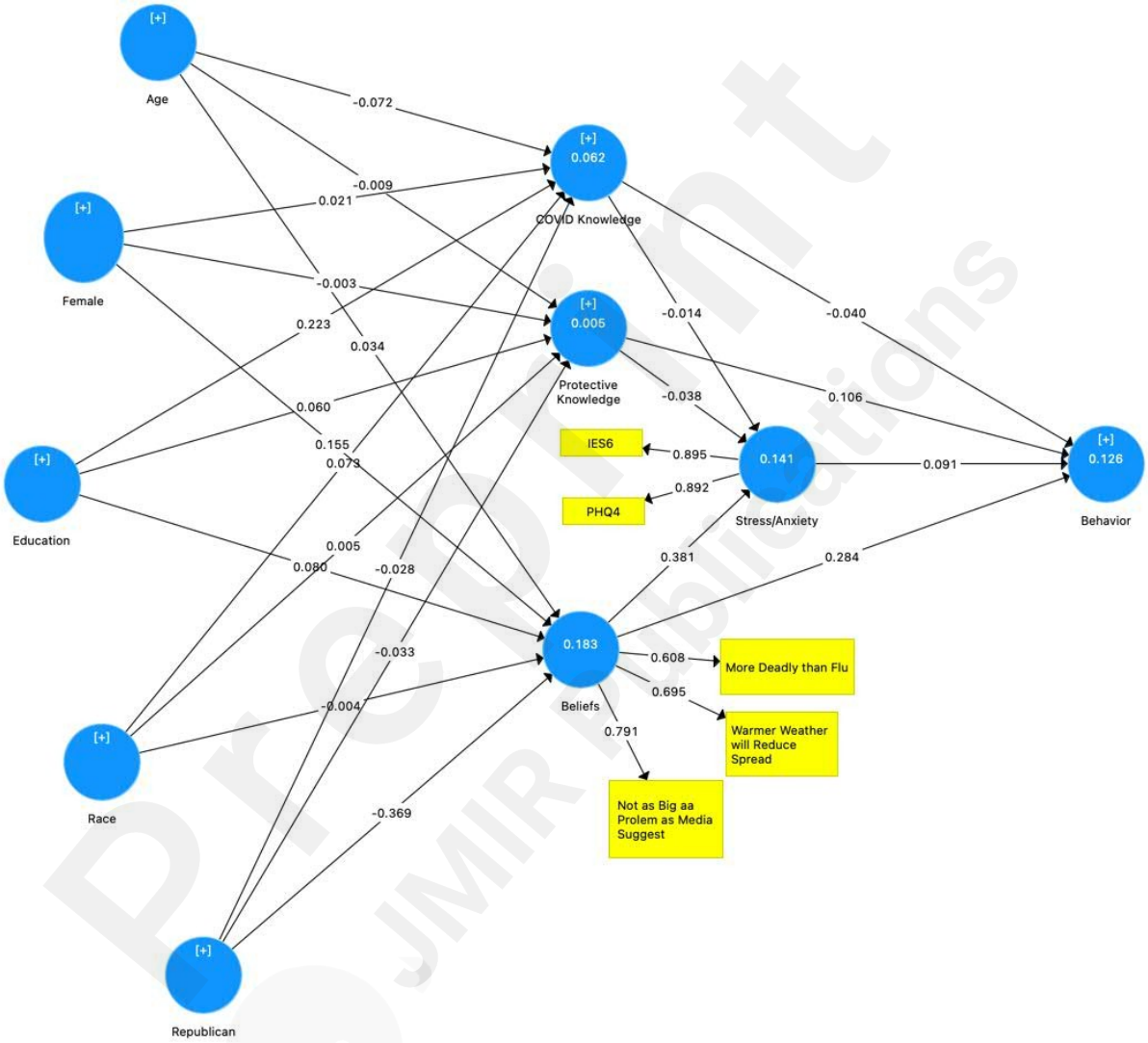


Table 10. SEM Results

	Path Coefficients	Standard Deviation	T Statistics	P Values
Age -> Beliefs	0.034*	0.015	2.289	0.023
Age -> COVID Knowledge	-0.072**	0.014	5.073	0.000
Age -> Protective Knowledge	-0.009	0.014	0.660	0.510
Beliefs -> Behavior	0.284**	0.019	14.624	0.000
Beliefs -> Stress/Anxiety	0.381**	0.017	21.870	0.000
COVID Knowledge -> Behavior	-0.040**	0.015	2.693	0.007
COVID Knowledge -> Stress/Anxiety	-0.014	0.014	0.976	0.330
Education -> Beliefs	0.080**	0.016	5.129	0.000

Education -> COVID Knowledge	0.223**	0.014	16.132	0.000
Education -> Protective Knowledge	0.060**	0.014	4.250	0.000
Female -> Beliefs	0.155**	0.015	10.084	0.000
Female -> COVID Knowledge	0.021	0.014	1.461	0.145
Female -> Protective Knowledge	-0.003	0.014	0.234	0.815
Protective Knowledge -> Behavior	0.106**	0.016	6.564	0.000
Protective Knowledge -> Stress/Anxiety	-0.038*	0.016	2.444	0.015
Race -> Beliefs	-0.004	0.017	0.250	0.803
Race -> COVID Knowledge	0.073**	0.017	4.396	0.000
Race -> Protective Knowledge	0.005	0.016	0.340	0.734
Republican -> Beliefs	-0.369**	0.016	23.263	0.000
Republican -> COVID Knowledge	-0.028	0.014	1.959	0.051
Republican -> Protective Knowledge	-0.033*	0.014	2.261	0.024
Stress/Anxiety -> Behavior	0.091**	0.016	5.724	0.000

* $p<0.05$;** $p<0.001$

Discussion

Even though an increasing number of people are being vaccinated, the CDC is still recommending that protective actions continue to be implemented in order to curtail disease propagation [46]. In this paper, we have identified and evaluated several indicators of behavioral compliance with WHO and CDC guidelines among the general population during the COVID-19 pandemic. Our data analyses using a SEM indicates that psychological factors – anxiety and stress – as well as demographic characteristics, acquired knowledge, and personal beliefs are all factors that contribute to behavioral compliance with recommended practices such as avoiding crowds and washing hands frequently.

The SEM results suggest that the level of anxiety/stress mediated the effect of knowledge of protecting against COVID-19 and the effect of belief about COVID-19 on protective behaviors. This demonstrates that the knowledge of protecting against COVID-19 and the belief about COVID-19 each have two paths to the association between protective behaviors.

While some previous research has investigated the impact of knowledge on protective behavior [26,47–49], the results have largely been inconclusive. When investigating protective behavior in our study, we classify knowledge into two types: knowledge about COVID-19 and knowledge of protecting against COVID-19. It is logical to expect that the more information people have about the pandemic and on how to respond to the crisis, the more protective they will be in their daily actions and behaviors. In our analyses, the effect of the respondents' level of knowledge about COVID-19 was significant but weak, while their knowledge of practices that were thought to be protective against COVID-19 infection did have a significant effect ($p<0.001$). Our results show that the two types of knowledge – COVID 19 and protective practices – have different effects on the level of anxiety and on the protective behaviors that are adopted. While protective knowledge against COVID-19 increases protective behavior and reduces anxiety, general knowledge of COVID-19 has a negative relationship to protective behavior and has no significant effect on anxiety. This suggests that when disseminating knowledge about the pandemic, the WHO and the CDC may want to focus on disseminating protective knowledge that can be used to navigate the pandemic.

The Health Belief Model [50] has theorized that individual beliefs predict individual protective behaviors. Previous research has found that individual beliefs promote protective behaviors in the context of pandemics [23,48,51]. In our study, we focus on the relationship between beliefs about the severity of COVID-19 as well as additional belief variables, as shown in Figure 1. In accordance with previous findings, our study also found that individual beliefs are associated with protective behaviors [23,48,51]. Furthermore, our finding that belief is associated with the level of anxiety/stress is consistent with previous studies [21,22]. Our results highlight the importance of managing population beliefs during COVID-19 and other public crisis.

Pandemics can cause a high level of stress due to the possibility of infection and economic difficulties. In turn, anxiety is caused by these stressful situations [52]. Anxiety and stress have long been regarded as significant predictors of protective behaviors such as handwashing and wearing of face masks in the context of pandemics [12,30,49,53]. Consistent with previous research, we found that respondents' levels of stress and anxiety had an effect ($p<0.001$) on the number of protective behaviors adopted. These results suggest the importance of managing the level of anxiety/stress in the population in order to promote behavioral compliance during COVID-19.

Our findings indicate that several demographic factors are related to knowledge of facts about COVID-19 and knowledge of effective protective practices. Our results show that there are differences in COVID-19 knowledge among people of different race, educational level, political affiliation, gender, and age. Whites/non-Hispanics and those with higher levels of education indicated having a higher level of knowledge of facts about COVID-19 and knowledge about protecting against COVID-19, while Republican indicated having a lower level of both types of knowledge. Age had a negative relationship with the level of knowledge of facts about COVID-19, while it had no significant relationship with the knowledge of protecting against COVID-19. Republicans had less beliefs in the severity of the pandemic, as one might expect based on the previous research that shows that Republicans practice fewer protective behaviors [48,54–56].

Conclusions

Our study reveals that individual beliefs in the severity of the pandemic, the level of stress/anxiety, and protective knowledge for COVID-19 are significant indicators for the adoption of protective behaviors while the level of COVID-19 knowledge is weakly and negatively associated with these indicators. Our findings suggest that higher levels of anxiety/stress lead to a higher adoption of protective behaviors. The level of stress/anxiety appears to significantly mediate between individual beliefs and protective knowledge and protective behaviors. Moreover, several demographic factors including age, gender, political affiliation, education level, and race emerge as significant indicators of behavioral compliance. The findings from our study provide valuable insights that may be used to help increase behavioral compliance among the population during COVID-19: (1) emphasis should be placed on the dissemination of protective knowledge over general knowledge about the pandemic; (2) behavioral compliance should be encouraged while managing anxiety and stress levels; (3) the adoption of protective behaviors is indirectly driven by different individual demographic characteristics including age, gender, and ethnicity; and (4) efforts should be made to prevent the spread of fake news about the pandemic.

Limitations and Future Research Directions

As with all research, our study has some limitations. First, the data that is used in our study is

from a self-selected population of active users of Facebook and its associated platforms. Therefore, members of the general population that do not engage in social media are not represented in the analyses. Since females have a higher propensity to engage in social media, our data includes a significantly larger number of female respondents even though the males to females ratio in the US is 98:100 [57]. Therefore, while the results of this study are very informative, they are not generalizable.

Second, the data used in our analyses was collected in March 2020, during the height of the COVID-19 pandemic. Behavioral compliance, beliefs, and levels of knowledge changed during the course of the pandemic, e.g., based on input from family, friends, neighbors, as well as changes in CDC guidelines. For example, masks were worn more uniformly as they became required in all public establishments. Data collected in late 2021 may provide additional insights and guidance on consumer attitudes and compliance.

Third, COVID-19 has affected the global population, not just the population of the US. We suggest that a future research study collect data from a larger constituency, including multiple countries across multiple continents. This is a reasonable undertaking since surveys can easily be administered over social media to cross international boundaries. Such a study could provide additional insights that may be more generalizable to the population worldwide.

Finally, a future research direction is to incorporate, categorize, and analyze the impact on behavioral compliance of news collected from different sources. Evaluating the adherence to governmental recommendations and understanding the levels of behavioral compliance of individuals whose beliefs have been formulated based on knowledge gathered from friends and family versus social media outlets versus television and radio news versus information from government entities could provide interesting insights.

Conflicts of Interest

None declared.

References

1. Rosenwald MS. History’s deadliest pandemics, from ancient Rome to modern America. The Washington Post. 2021. URL: https://www.washingtonpost.com/graphics/2020/local/retropolis/coronavirus-deadliest-pandemics/ [accessed 2021-06-11]
2. Pettersson H, Manley B, Hernandez S. Tracking Covid-19’s global spread. CNN. 2021. URL: https://edition.cnn.com/interactive/2020/health/coronavirus-maps-and-cases/ [accessed 2021-06-11]
3. COVID19 Cases in U.S.2021. Worldometers. URL: https://www.worldometers.info/coronavirus/country/us/ [accessed 2021-06-11]
4. Chriscaden K. Impact of COVID-19 on people’s livelihoods, their health and our food systems. World Health Organization. 2020. URL: https://www.who.int/news/item/13-10-2020-impact-of-covid-19-on-people’s-livelihoods-their-health-and-our-food-systems [accessed 2021-06-11]
5. Singh KD. India faces new lockdowns plus oxygen and drug shortages as cases spiral, and other news from around the world. The New York Times. 2021. https://www.nytimes.com/2021/04/19/world/india-delhi-lockdown.html. [accessed 2021-06-11]
6. Alkali YE, Amichai-Hamburger Y. Experiments in Digital Literacy. CyberPsychology Behav 2004 Aug;7(4):421–429. [doi: 10.1089/cpb.2004.7.421]

7. Ho P, Lubik TA, Matthes C. COVID-19 Over Time and Across States: Predictions From a Statistical Model. Fraser. 2020. URL: https://fraser.stlouisfed.org/title/6126/item/596462 [accessed 2021-06-11]
8. Howell B. Infodemic: The Rise of Fake News During Covid-19. Tech.co. 2020. URL: https://tech.co/news/fake-news-covid-19 [accessed 2021-06-11]
9. During this coronavirus pandemic, 'fake news' is putting lives at risk: UNESCO. 2020. UN News. https://news.un.org/en/story/2020/04/1061592 [accessed 2021-06-11]
10. Chughtai NA. Mental Health Consequences of the Coronavirus Pandemic. J Coll Physicians Surg Pakistan 2020 Oct 1;30(2):139–140. [doi: 10.29271/jcpsp.2020.Supp2.139]
11. Mian A, Khan S. Medical education during pandemics: a UK perspective. BMC Med 2020 Dec 9;18(1):100. [doi: 10.1186/s12916-020-01577-y]
12. Wong LP, Hung C-C, Alias H, Lee TS-H. Anxiety symptoms and preventive measures during the COVID-19 outbreak in Taiwan. BMC Psychiatry 2020 Dec 16;20(1):376. [doi: 10.1186/s12888-020-02786-8]
13. Zhong B, Jiang Z, Xie W, Qin X. Association of Social Media Use With Mental Health Conditions of Nonpatients During the COVID-19 Outbreak: Insights from a National Survey Study. J Med Internet Res 2020;22(12):e23696. [doi: 10.2196/23696]
14. Brewer K. Coronavirus: How to protect your mental health. BBC. 2020. URL: https://www.bbc.com/news/health-51873799. [accessed 2021-06-11]
15. Algara C, Fuller S, Hare C, Kazemian S. The Interactive Effects of Scientific Knowledge and Gender on COVID-19 Social Distancing Compliance. Soc Sci Q 2021 Jan 22;102(1):7–16. [doi: 10.1111/ssqu.12894]
16. Maarefvand M, Hosseinzadeh S, Farmani O, Safarabadi Farahani A, Khubchandani J. Coronavirus Outbreak and Stress in Iranians. Int J Environ Res Public Health 2020 Jan;17(12):4441. [doi: 10.3390/ijerph17124441]
17. Alrubaiee GG, Al-Qalah TAH, Al-Aawar MSA. Knowledge, attitudes, anxiety, and preventive behaviours towards COVID-19 among health care providers in Yemen: an online cross-sectional survey. BMC Public Health 2020 Dec;20(1):1–11. [doi: 10.1186/s12889-020-09644-y]
18. Malesza M, Kaczmarek MC. Predictors of anxiety during the COVID-19 pandemic in Poland. Pers Individ Dif 2021 Feb 15;170:110419. [doi: 10.1016/j.paid.2020.110419]
19. Faisal RA, Jobe MC, Ahmed O, Sharker T. Mental health status, anxiety, and depression levels of Bangladeshi university students during the COVID-19 pandemic. Int J Ment Health Addict 2021 Jan 4;1–16. [doi: 10.1007/s11469-020-00458-y]
20. Ahmad AR, Murad HR. The impact of social media on panic during the COVID-19 pandemic in Iraqi Kurdistan: online questionnaire study. J Med Internet Res 2020;22(5):e19556. [doi: 10.2196/19556]
21. Allington D, Duffy B, Wessely S, Dhavan N, Rubin J. Health-protective behaviour, social media usage and conspiracy belief during the COVID-19 public health emergency. Psychol Med 2020 Jun 9;1–7. [doi: 10.1017/S003329172000224X]
22. Vazquez C, Valiente C, García FE, Contreras A, Peinado V, Trucharte A, Bentall RP. Post-traumatic growth and stress-related responses during the COVID-19 pandemic in a national representative sample: The role of positive core beliefs about the world and others. J Happiness Stud 2021 Jan;1–21. [doi: 10.1007/s10902-020-00352-3]
23. Erceg N, Ružojčić M, Galić Z. Misbehaving in the corona crisis: The role of anxiety and

unfounded beliefs. Curr Psychol 2020 Sep;1–10. [doi: 10.1007/s12144-020-01040-4]
24. Emamzadeh A. COVID-19 Pandemic: Loneliness, Depression, and Suicide. Psychology Today. 2020. URL: https://www.psychologytoday.com/intl/blog/finding-new-home/202008/covid-19-pandemic-loneliness-depression-and-suicide. [accessed 2021-06-11]
25. Sailer M, Stadler M, Botes E, Fischer F, Greiff S. Science knowledge and trust in medicine affect individuals' behavior in pandemic crises. Eur J Psychol Educ 2021 Apr;1–14. [doi: 10.1007/s10212-021-00529-1]
26. Iorfa SK, Ottu IFA, Oguntayo R, Ayandele O, Kolawole SO, Gandi JC, Dangiwa AL, Olapegba PO. COVID-19 Knowledge, Risk Perception, and Precautionary Behavior Among Nigerians: A Moderated Mediation Approach. Front Psychol 2020;11. [doi: 10.3389/fpsyg.2020.566773]
27. Bish A, Michie S. Demographic and attitudinal determinants of protective behaviours during a pandemic: A review. Br J Health Psychol 2010 Nov;15(4):797–824. [doi: 10.1348/135910710X485826]
28. Prete G, Fontanesi L, Porcelli P, Tommasi L. The psychological impact of COVID-19 in Italy: Worry leads to protective behavior, but at the cost of anxiety. Front Psychol 2020;11. [doi: 10.3389/fpsyg.2020.566659]
29. Faasse K, Newby J. Public perceptions of COVID-19 in Australia: Perceived risk, knowledge, health-protective behaviors, and vaccine intentions. Front Psychol 2020;11. [doi: 10.3389/fpsyg.2020.551004]
30. Cai G, Lin Y, Lu Y, He F, Morita K, Yamamoto T, Aoyagi K, Taguri T, Hu Z, Alias H. Behavioural responses and anxiety symptoms during the coronavirus disease 2019 (COVID-19) pandemic in Japan: A large scale cross-sectional study. J Psychiatr Res 2021 Apr 1;136:296–305. [doi: 10.1016/j.jpsychires.2021.02.008]
31. Iannelli L, Giglietto F, Rossi L, Zurovac E. Facebook digital traces for survey research: Assessing the efficiency and effectiveness of a Facebook Ad–based procedure for recruiting online survey respondents in niche and difficult-to-reach populations. Soc Sci Comput Rev 2020 Aug;38(4):462–476. [doi: 10.1177/0894439318816638]
32. Guillory J, Wiant KF, Farrelly M, Fiacco L, Alam I, Hoffman L, Crankshaw E, Delahanty J, Alexander TN. Recruiting hard-to-reach populations for survey research: using Facebook and Instagram advertisements and in-person intercept in LGBT bars and nightclubs to recruit LGBT young adults. J Med Internet Res 2018;20(6):e197. [doi: 10.2196/jmir.9461]
33. Young SD, Rice E. Online social networking technologies, HIV knowledge, and sexual risk and testing behaviors among homeless youth. AIDS Behav 2011 Feb;15(2):253–260. [doi: 10.1007/s10461-010-9810-0]
34. Facebook Users by Country. World Population Review. 2021. URL: https://worldpopulationreview.com/country-rankings/facebook-users-by-country 2021. [accessed 2021-06-11]
35. Facebook by the Numbers: Stats, Demographics & Fun Facts. Omnicore. URL: https://www.omnicoreagency.com/facebook-statistics/ [accessed 2021-06-11]
36. Shaver LG, Khawer A, Yi Y, Aubrey-Bassler K, Etchegary H, Roebothan B, Asghari S, Wang PP. Using Facebook advertising to recruit representative samples: feasibility assessment of a cross-sectional survey. J Med Internet Res 2019 Aug 19;21(8):e14021. [doi: 10.2196/14021]

37. Whitaker C, Stevelink S, Fear N. The use of Facebook in recruiting participants for health research purposes: a systematic review. J Med Internet Res 2017;19(8):e290. [doi: 10.2196/jmir.7071]
38. Ringle, Christian M., Wende, Sven, & Becker J-M. SmartPLS 3. Bönningstedt: SmartPLS. URL: http://www.smartpls.com [accessed 2021-06-11]
39. U.S. population. United States Census Bureau. URL: https://data.census.gov/cedsci/ [accessed 2021-06-11]
40. Gramlich J. What the 2020 electorate looks like by party, race and ethnicity, age, education and religion. Pewresearch. 2020. https://www.pewresearch.org/fact-tank/2020/10/26/what-the-2020-electorate-looks-like-by-party-race-and-ethnicity-age-education-and-religion/ [accessed 2021-06-11]
41. Löwe B, Wahl I, Rose M, Spitzer C, Glaesmer H, Wingenfeld K, Schneider A, Brähler E. A 4-item measure of depression and anxiety: validation and standardization of the Patient Health Questionnaire-4 (PHQ-4) in the general population. J Affect Disord 2010 Apr 1;122(1–2):86–95. [doi: 10.1016/j.jad.2009.06.019]
42. Jalloh MF, Li W, Bunnell RE, Ethier KA, O'Leary A, Hageman KM, Sengeh P, Jalloh MB, Morgan O, Hersey S. Impact of Ebola experiences and risk perceptions on mental health in Sierra Leone, July 2015. BMJ Glob Heal 2018 Mar 1;3(2):e000471. [doi: 10.1136/bmjgh-2017-000471]
43. Capasso A, Jones AM, Ali SH, Foreman J, Tozan Y, DiClemente RJ. Increased alcohol use during the COVID-19 pandemic: The effect of mental health and age in a cross-sectional sample of social media users in the US. Prev Med 2021 Apr 1;145:106422. [doi: 10.1016/j.ypmed.2021.106422]
44. Thoresen S, Tambs K, Hussain A, Heir T, Johansen VA, Bisson JI. Brief measure of posttraumatic stress reactions: Impact of Event Scale-6. Soc Psychiatry Psychiatr Epidemiol 2010 Mar 1;45(3):405–412. [doi: 10.1007/s00127-009-0073-x]
45. Hair JF, Risher JJ, Sarstedt M, Ringle CM. When to use and how to report the results of PLS-SEM. Eur Bus Rev 2019 Jan 14; [doi: 10.1108/EBR-11-2018-0203]
46. Mask requirements. Centers for Disease Control and Prevention. URL: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/faq.html. [accessed 2021-06-11]
47. Zickfeld JH, Schubert TW, Herting AK, Grahe J, Faasse K. Correlates of health-protective behavior during the initial days of the COVID-19 outbreak in Norway. Front Psychol 2020;11. [doi: 10.3389/fpsyg.2020.564083]
48. Chen Y, Zhou R, Chen B, Chen H, Li Y, Chen Z, Zhu H, Wang H. Knowledge, Perceived Beliefs, and Preventive Behaviors Related to COVID-19 Among Chinese Older Adults: Cross-Sectional Web-Based Survey. J Med Internet Res 2020;22(12):e23729. [doi: 10.2196/23729]
49. Leung GM, Ho L-M, Chan SKK, Ho S-Y, Bacon-Shone J, Choy RYL, Hedley AJ, Lam T-H, Fielding R. Longitudinal assessment of community psychobehavioral responses during and after the 2003 outbreak of severe acute respiratory syndrome in Hong Kong. Clin Infect Dis 2005 Jun 15;40(12):1713–1720. [doi: 10.1086/429923]
50. Rosenstock IM. Historical origins of the health belief model. Health Educ Monogr 1974 Dec;2(4):328–335. [doi: 10.1177/109019817400200403]
51. Shahnazi H, Ahmadi-Livani M, Pahlavanzadeh B, Rajabi A, Hamrah MS, Charkazi A. Assessing preventive health behaviors from COVID-19: a cross sectional study with health belief model in Golestan Province, Northern of Iran. Infect Dis poverty 2020

Dec;9(1):1–9. [doi: 10.1186/s40249-020-00776-2]
52. Roy D, Tripathy S, Kar SK, Sharma N, Verma SK, Kaushal V. Study of knowledge, attitude, anxiety & perceived mental healthcare need in Indian population during COVID-19 pandemic. Asian J Psychiatr 2020 Jun 1;51:102083. [doi: 10.1016/j.ajp.2020.102083]
53. Lieberoth A, Lin S-Y, Stöckli S, Han H, Kowal M, Gelpi R, Chrona S, Tran TP, Jeftić A, Rasmussen J. Stress and worry in the 2020 coronavirus pandemic: relationships to trust and compliance with preventive measures across 48 countries in the COVIDiSTRESS global survey. R Soc open Sci 2021 Feb 10;8(2):200589. [doi: 10.1098/rsos.200589]
54. Allcott H, Boxell L, Conway J, Gentzkow M, Thaler M, Yang D. Polarization and public health: Partisan differences in social distancing during the coronavirus pandemic. J Public Econ 2020 Nov 1;191:104254. [doi: 10.1016/j.jpubeco.2020.104254]
55. Simonov A, Sacher SK, Dubé J-PH, Biswas S. The persuasive effect of fox news: non-compliance with social distancing during the covid-19 pandemic. National Bureau of Economic Research 2020 May 21 [doi: 10.3386/w27237]
56. Kerr J, Panagopoulos C, van der Linden S. Political polarization on COVID-19 pandemic response in the United States. Pers Individ Dif 2021 Sep 1;179:110892. [doi: 10.1016/j.paid.2021.110892]
57. Male to female ratio of the total population. Knoema. URL: https://knoema.com/atlas/United-States-of-America/topics/Demographics/Population/Male-to-female-ratio. [accessed 2021-06-11]