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Cognitive Stressors and COVID-19 Infection: A Longitudinal Survey

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Abstract

Objectives: Survey the prevalence of various stress-related factors among a sample of the US adult population over the course of 1 year to compare rates among those who reported ever receiving a positive COVID-19 test vs those who never received a positive test. Highlight the potential impact of these factors upon cognitive functioning during the COVID-19 pandemic.

Methods: A US census, age-balanced sample of adults was recruited through an online survey platform and participated in three waves of surveys. In each wave, roughly 3 months apart, participants, blinded to the survey sponsor, completed surveys with demographic information and questions regarding mental health, physical health, and environmental factors which have been linked to cognitive health. Participants were also asked whether they had ever received a positive COVID-19 test.

Results: A total of 4,905 respondents were included in the first wave, 3,940 were included in the second wave, and 3,157 respondents were included in the third wave. In the third wave of the survey the largest age group was those 30 to 39 years of age (33.7% of respondents; n=1,063/3,157). The majority of respondents reported that they had never tested positive for COVID-19 (87.2%; n=2,610/3,157). The rate of those who reported ever receiving a positive COVID-19 test result was 17.3% (n=547/3,157). Respondents who reported a positive test result were more likely to report experiencing anxious symptoms and depressive symptoms between the second and third surveys vs those who never received a positive test result (70.5% vs 47.5% and 66.5% vs 37.3%, respectively). Respondents who reported a positive test result were more likely to report receiving a formal diagnosis from a healthcare provider for a sleep-related disorder (53.7% vs 19.1%). Respondents who reported a positive test result were more likely to report experiencing "more" or "much more" concern vs those without a positive test result since the second survey in the following areas: affording housing (49.5% vs 25.3%); employment or potential job loss (33.6% vs 20.0%); and affording necessities like food and medicine (44.8% vs 27.6%).

Conclusions: Survey respondents who reported receiving a positive COVID-19 test result vs those who did not had a higher prevalence of stressors known to affect cognitive functioning, including anxiety, depression, sleep troubles, and concerns over issues recognized as social determinants of health. Routine neurocognitive assessment in clinical practice may be an important tool clinicians can use to track the long-term effects of the COVID-19 pandemic on overall cognitive health, allowing them to intervene as needed.

Keywords: Cognitive Test; Cognition; Stress; COVID-19; Social Determinants of Health

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Introduction

The novel coronavirus (COVID-19), which first appeared in December 2019 in Wuhan, China, quickly spread across the globe, upending daily life for billions of people [1]. Along with its well-documented physical effects, the uniquely global disruptive nature of the disease has taken a psychological toll as well [2,3]. Since its emergence, the COVID-19 pandemic has proven to be a multidimensional stressor, impacting social relationships, employment, the global economy, and other areas [4].

The near-global lockdowns of Spring of 2020, instituted to separate populations and slow the spread of the disease, resulted in widespread social isolation [2]. In times of stress and upheaval, strong social connections are recommended by mental health experts as key to coping with stressful situations, but the social distancing recommended by governments removed these supports when they may have been needed most [2]. However, the isolation recommended to preserve the physical health of populations has been shown to exacerbate existing or trigger new mental health conditions; it can lead to higher stress levels, increased depression and anxiety, and a rise in intimate partner violence [5-8]. Research has also shown during lockdown people engaged in more unhealthy lifestyle behaviors, such as increased smoking, alcohol consumption, and decreased physical activity, all of which resulted in increased stress [9].

In addition to lockdowns, uncertainty related to the pandemic contributed to greater psychological stress [10]. Questions about how the disease was spread and when the pandemic would end led to feelings of vulnerability and a loss of control [11]. Bombarded with a steady drumbeat of changing guidance, emerging facts, and misinformation,

people who frequently searched for information about the disease showed greater levels of fear of the coronavirus [12]. This perceived vulnerability to COVID-19 drove higher rates of social isolation, which in turn increased stress among populations [11].

The efforts to contain the COVID-19 pandemic in Spring 2020 also resulted in a dramatic increase in unemployment in the United States [13]. In April of that year, the unemployment rate increased 10.3 percentage points to reach 14.7%, the highest rate since data began to be recorded in 1948 [13]. In the month of April, the number of unemployed rose by 15.9 million to 23.1 million [13]. The negative economic and employment impacts of the COVID-19 pandemic have concentrated on workers who were already in precarious positions: those in low-productivity industries, service jobs, and those in the "gig" economy [14,15]. The economic changes due to the pandemic are ongoing. In addition to the shock of immediate job loss, the COVID-19 pandemic has upended the way work is conducted in many industries, with asymmetric consequences across employment sectors [14]. While remote work options may have changed the typical workday for the better for those in the information economy, automation instituted to minimize health risks may eliminate jobs for others [14]. Employers may also move to short-term, informal work arrangements to address a changing environment, which may exacerbate the precariousness of workers [16]. Even among those workers who continued to work throughout the pandemic, disruptions due to shuttered schools, daycare centers, and other organizations may negatively impact their productivity [17]. The implications of these upheavals have already resulted in measurably higher stress and anxiety levels among those affected [8,10, and 16].

In addition to the psychological stressors felt across society, those whose health was directly impacted by a COVID-19 infection have shown higher levels of neurological and psychological sequelae, including anxiety, substance abuse disorders, and cognitive performance [3,18]. Though severity of disease has been correlated with a greater incidence of neurological and psychiatric outcomes, the risk of these diagnoses increased even for those whose disease did not require hospitalization [3,18].

The psychological impacts of the pandemic may have real consequences for cognitive health. Unhealthy lifestyle behaviors during lockdowns (e.g., alcohol consumption, smoking, and lack of physical activity) were shown to negatively impact cognitive function, while loneliness, a key result of lockdowns and isolation strategies, is a significant predictor of cognitive decline over time [9,19]. Anxiety, an increase in which has been seen during the pandemic, is linked to increased levels of cortical amyloid deposition, which are predictive of mild cognitive impairment [7,20]. Stressful situations cause the body to release glucocorticoids, a class of stress hormones that travel freely to the brain [21]. Chronic exposure to elevated levels of glucocorticoids can impact cognitive function, a fact that may warrant greater vigilance on the part of clinicians as the pandemic continues [21].

Two years into the pandemic, the global response to COVID-19 has changed to reflect the tools available to fight the disease. Lockdowns have been lifted, the wearing of quality masks is common, and vaccines are now available. A longitudinal series of surveys, the first of which was conducted in Fall 2020, nearly one year in the pandemic, sought to gauge the prevalence of various stress-related factors over the course of one year among a sample of the US adult population. The objective of the survey detailed in this paper was to assess a difference between respondents who reported testing positive for the disease at any point and those who never reported a positive test result to better understand the potential impact of the pandemic on cognitive health.

Methods

Design of the Survey

Three surveys were conducted online via the QuestionPro platform, which draws a representative sampling from a diverse database consisting of more than 9 million individuals from across the US who had previously volunteered to participate in surveys concerning a variety of topics. Participant profiles on the platform include demographic information such as sex, age, and geographical region, as well as other targeting attributes (eg, cell phone usage, job type). All respondents were blinded to the sponsor of the survey and all responses were completely anonymous.

The survey was conducted in three waves. In the first wave, conducted in Fall 2020 (October/November), the survey included 62 questions overall, and included multiple choice or multi-part, Likert-format questions. Questions were used to determine demographic characteristics and respondent's experiences, activity participation, or perceptions prior to, and since, the onset of the COVID-19 pandemic. Participants were also asked whether they had ever received a positive COVID-19 test result.

The second wave of the survey, conducted in Spring 2021 (March/April/May), included 51 questions. Participants were asked to examine how their experiences, activity participation, and perceptions had changed vs when they had responded to the first survey in Fall 2020.

In the third wave of the survey, conducted in Fall 2021, slight changes were made to the questions, with a total of 50 included. Participants were again asked to compare their current experiences, activity participation, and perceptions to those in Spring 2021 (Table 1).

Population Selection

Participants were US adult's ≥18 years of age. The target sample size for the third wave of the survey was N=3,150. To account for attrition, 4,750 participants were targeted for Wave I and 3,940 for Wave II. The sample was balanced by age according to the most recent US census data across all demographics and US states.

Results

A total of 4,905 respondents completed Wave I of the survey; 3,940 completed Wave II, and 3,157 respondents completed Wave III. In Wave III, the largest age group was those 30 to 39 years of age (33.7% of respondents). A greater proportion of respondents were female (54.8%), had earned a Bachelor's degree as the highest level of education (34.1%), worked full-time (52.6%), and had health insurance through an employer (31.9%). Most respondents in Wave III reported that they had never tested positive for COVID-19 (87.2% of respondents), though the reported positivity rate rose over the course of the three surveys. The rate of those who reported ever receiving a positive COVID-19 test result was 7.5% in the Wave I survey, 12.7% in the Wave II survey, and 17.3% in the Wave III survey. Demographic information for respondents to the Wave III survey can be found in Table 2.

Respondents in Wave III of the survey who reported ever receiving a positive COVID-19 test result were more likely to report experiencing anxious symptoms (e.g., excessive worry, restlessness, difficulty concentrating) between the second and third surveys *vs.*

Table 1: Selected questions from the third survey wave.

COVID-19 positivity
• Have you ever tested positive for COVID-19?
Anxiety
• Since the last survey in the Spring, have you been experiencing anxious symptoms (eg, excessive worry, restlessness, difficulty concentrating)? • Have you received a formal diagnosis from a healthcare provider for an anxiety disorder (eg, generalized anxiety disorder, panic disorder)?
Depression
• Since the last survey in the Spring, have you been experiencing depressive symptoms (eg, irritability, fatigue, feeling sad/hopeless)? • Have you received a formal diagnosis from a healthcare provider for a depressive disorder (eg, major depressive disorder, dysthymia)?
Sleep
• Since the last survey in the Spring, to what degree do you feel your sleep difficulty (eg, unable to fall or stay asleep) has changed? • Have you received a formal diagnosis from a healthcare provider for a sleep-related disorder (eg, insomnia, sleep apnea, hypersomnolence)?
Social determinants of health
• Since the last survey in the Spring, how would you rate your level of concern regarding the following? o Affording housing o Employment/potential job loss o Affording basic necessities (food, medicine)

Table 2: Wave III respondent demographics (N=3,157).

Characteristic	Respondents, n (%)
Age, y	
<20	29 (0.9)
20-29	284 (9.0)
30-39	1,063 (33.7)
40-49	717 (22.7)
50-59	487 (15.4)
60-69	313 (9.9)
70-79	237 (7.5)
≥80	27 (0.9)
Gender	
Female	1,729 (54.8)
Male	1,420 (45.0)
Declined to answer	8 (0.3)
Education level	
Did not complete high school or equivalent	122 (3.9)
High school graduate or equivalent	610 (19.3)
Some college/Associate's degree	892 (28.3)
Bachelor's degree	1,077 (34.1)
Graduate or professional degree	456 (14.4)
Employment status	
Employed, full-time	1659 (52.6)
Employed, part-time	323 (10.2)
Unemployed, seeking work	247 (7.8)
Unemployed, not seeking work	355 (11.2)
Student	58 (1.8)
Retired	515 (16.3)
Primary health insurance	
Insured through employer	1,007 (31.9)
Insured through employer of spouse or parents	322 (10.2)
Policy purchased directly from an insurance company/ ACA Marketplace	309 (9.8)
Medicare/Medicare Advantage	648 (20.5)
Medicaid (including state Medicaid programs)	539 (17.1)
Tricare/Veterans Administration (VA)	48 (1.5)
Do not have health insurance	255 (8.1)
Other	29 (0.9)
COVID-19 status	
Never tested positive	2,610 (87.2)
Have tested positive	547(17.3)

those who never received a positive test result (70.5% *vs.* 47.5%, respectively) (Figure 1). The group of respondents who reported a positive COVID-19 test result were also more likely to have received a formal diagnosis from a healthcare provider for an anxiety disorder (e.g., generalized anxiety disorder, panic disorder) *vs.* those with no positive COVID-19 test result (79.5% *vs.* 33.5%, respectively).

Respondents in Wave III of the survey who reported ever receiving a positive COVID-19 test result were more likely to report experiencing depressive symptoms (e.g., irritability, fatigue, feeling sad/hopeless)

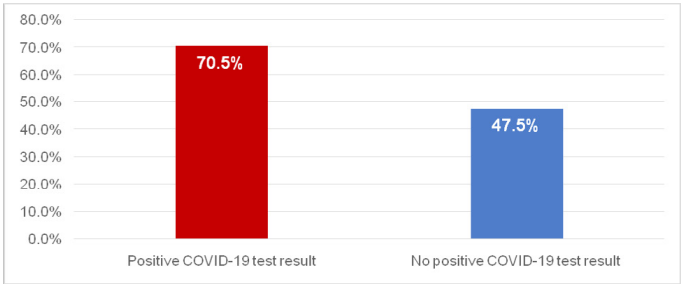

Figure 1: Respondents who reported experiencing anxious symptoms (e.g., excessive worry, restlessness, difficulty concentrating).

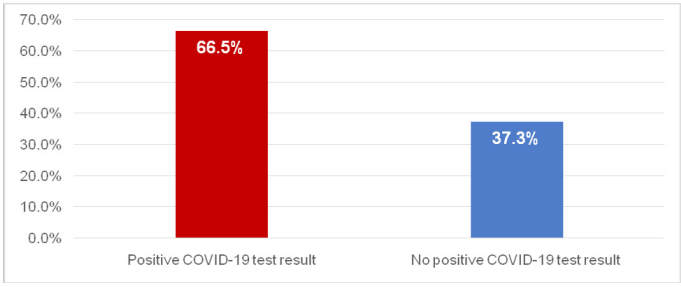

Figure 2: Respondents who reported experiencing depressive symptoms (e.g., irritability, fatigue, feeling sad/hopeless).

between the second and third surveys *vs.* those who never received a positive test result (66.5% *vs.* 37.3%, respectively) (Figure 2). The group of respondents who reported a positive COVID-19 test result were also more likely to have received a formal diagnosis from a healthcare provider for a depressive disorder (e.g., major depressive disorder, dysthymia) *vs.* those with no positive COVID-19 test result (79.1% *vs.* 31.1%, respectively).

Most respondents in Wave III of the survey reported that their difficulty falling asleep was "better" or "much better" since the Wave II survey was taken. However, respondents who reported ever receiving a positive COVID-19 test result were more likely to report receiving a formal diagnosis from a healthcare provider for a sleep-related disorder (e.g., insomnia, sleep apnea, hyper somnolence) *vs.* respondents without a positive COVID-19 result (53.7% *vs.* 19.1%) (Figure 3).

Respondents in Wave III of the survey who reported a positive test result were more likely to report experiencing "more" or "much more" concern *vs.* those without a positive test result since the second survey

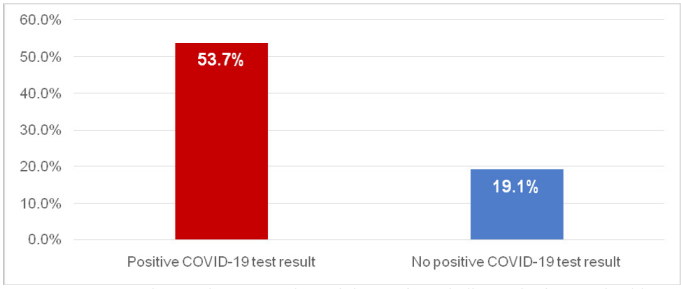

Figure 3: Respondents who reported receiving a formal diagnosis from a healthcare provider for a sleep-related disorder (e.g., insomnia, sleep apnea, hyper somnolence).

in the following areas: affording housing (49.5% *vs.* 25.3%, respectively); employment or potential job loss (33.6% *vs.* 20.0%, respectively); and affording basic necessities like food and medicine (44.8% *vs.*. 27.6%, respectively).

Discussion

In Wave I of this longitudinal survey, conducted in Fall 2020, the prevalence of stressors such as anxiety that are linked to a deleterious effect on cognitive health was high. In Wave I, 47.6% of respondents reported their anxious symptoms like excessive worry, restlessness, and difficulty concentrating were worse or much worse since the pandemic began. In Wave II, conducted in Spring 2021, 79.1% of respondents said these symptoms were the same, worse, or much worse compared with Fall 2021. These results are similar to that of a similar survey conducted in June 2020, the results of which were published in the journal *Neurological Sciences and Neurosurgery* in 2021. The results of that paper underscored the widespread psychological impact of the pandemic among the US adult population [22].

In Wave III, conducted in Fall 2021, the proportion of those who experienced stressors such as anxiety fell slightly, with 74.8% of participants reporting their anxious symptoms were the same, worse, or much worse. As the use of masks and protocols have become more commonplace and a growing proportion of the US population has been vaccinated against COVID-19, it may be hypothesized that the prevalence of COVID-19–related stress factors would have been reduced across the US population, a fact that is borne out by the results of the Wave III survey. However, the Wave III survey also showed a greater prevalence of stressors related to cognitive health among those respondents who reported receiving a positive COVID-19 test. The stressors have been linked to negative psychological outcomes, including a decline in cognitive function [20,21].

These findings are supported by a 2021 *Lancet* paper by Taquet M, et al. (2021) [3], which surveyed outcomes in over 200,000 survivors of COVID-19 and found an incidence of 33.6% of neurological and psychological effects in the six months after diagnosis [3]. For 12.8% of respondents this was their first such diagnosis [3].

Cognitive impairment due to COVID-19 infection is likely related to extreme levels of pro-inflammatory cytokines [23,24]. During infection, the body produces high levels of cytokines TNF-a, IL-6, IL-1a and IL-1b, which may induce neurotoxicity [23,24]. A study of the impact of COVID infection on cognition found that more severe disease was associated with greater cognitive deficits [18]. In the study, patients who were hospitalized with a ventilator experienced reductions in global cognitive scores that were greater than typical 10-year declines in cognitive performance between the ages of 20 and 70 and the deficit of patients who reported a previous stroke [18]. These reductions, 0.47 SD, equated to a 7-point difference in IQ on a classic intelligence test [18]. Though the impacts on cognition were greater as severity of COVID-19 infection increased, as with the Taquet study, even those with less severe disease faced a higher incidence of mental health challenges *vs.* those people who were not infected [3,18].

The impacts on cognition may have lasting consequences for those suffering from COVID-19. Research has shown these cognitive effects may still be present several months after infection [25]. In a study of 740 patients conducted a mean of 7.6 months from a COVID diagnosis, impairments in executive functioning, processing speed, category fluency, memory encoding, and recall were still seen among hospitalized patients [25]. These cognitive effects were seen regardless of age; though cognitive impairment may typically be associated with the elderly, COVID-related cognitive issues have been seen in in studies with a mean age of 49 (range 38 to 59 years) [25]. Though well-characterized neurological conditions may be relatively straight-forward to detect in the clinical setting, persistent effects such as mild cognitive impairment and memory issues may easily remain undetected or may be attributed to the passing stress of the pandemic [26].

Along with the landmark Taquet study, the present paper adds to the growing body of research detailing the psychological impacts of the COVID-19 pandemic, underscoring the importance of neurocognitive testing in the clinical setting, particularly among those who have tested positive for COVID-19.

Conclusions

In this longitudinal survey conducted roughly 1 year in the COVID-19 pandemic, respondents who reported receiving a positive COVID-19 test result *vs.* those who did not had a higher prevalence of stressors known to affect cognitive functioning, including anxiety, depression, sleep troubles, and concerns over issues recognized as social determinants of health. Routine neurocognitive assessment in clinical practice may be an important tool clinicians can use to track the long-term effects of the COVID-19 pandemic on overall cognitive health, allowing them to intervene as needed.

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