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# Severity and duration of post-acute sequelae of SARS-CoV-2 infection symptoms: Focus on physiological and cognitive effects

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## Abstract

The SARS-CoV-2 virus, responsible for the COVID-19 pandemic, has impacted the health of millions globally, with many individuals experiencing persistent symptoms even after testing negative, a condition known as post-acute sequelae of SARS-CoV-2 infection (PASC), or long COVID. This study analyzes demographic influences on the severity and duration of PASC symptoms, with an emphasis on physiological and cognitive effects. Using a self-reporting survey method, data were collected from a sample of 110 participants and analyzed using statistical methods such as exploratory factor analysis, Pearson correlation, and two-factor analysis of variance. The participants were primarily based in California, and a majority of them were ethnically Asian. The study found that females generally reported higher severity of cognitive and physiological symptoms compared to males, while symptom severity was generally lower among vaccinated individuals. Correlation analysis revealed a significant relationship between depression and cognitive impairments, underscoring the psychological impact of PASC. This study emphasizes the complexity of PASC, demonstrating how demographic characteristics such as age, gender, and vaccination status influence the severity and duration of symptoms, thereby contributing to the growing understanding of PASC. Further research should consider SARS-CoV-2 variant-specific impacts and broader population samples.

***Keywords:*** COVID-19; Long COVID; PASC; Brain fog; Symptoms; COVID severity; COVID duration; Vaccination

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## 1. Introduction

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has led to a global health crisis, affecting millions of individuals worldwide. As of June 2024, over 776 million cases and 7 million deaths have been reported globally, as regularly updated by the World Health Organization.[1] While most individuals recover from COVID-19 without long-term complications, a significant subset experience persistent symptoms, a condition known as long COVID or post-acute sequelae of SARS-CoV-2 infection (PASC). PASC represents a diverse set of symptoms, including cognitive dysfunction (e.g., brain fog), fatigue, respiratory distress, joint pain, and other neurological symptoms, which can

significantly impact an individual's quality of life. Emerging evidence has linked the activation of inflammation and the immune system to cognitive dysfunction (e.g., brain fog) and fatigue.[2] Similarly, mitochondrial dysfunction and autonomic nervous system dysregulation have been associated with prolonged fatigue, neurological symptoms, and post-exertional malaise, highlighting the systemic nature of PASC.

### 1.1. The emergence of PASC

PASC have emerged as a significant public health concern, affecting individuals across different demographic groups, including those who had mild or asymptomatic COVID-19 infections. According to data from the United States (US) Centers for Disease Control and Prevention (CDC),[3] up to 25.6% of adults who have had COVID-19 report persistent symptoms, which can last for months or even longer. These lingering effects not only burden healthcare systems but also affect economic productivity, as individuals struggle to return to work or engage in daily activities. The mechanisms behind PASC are not fully understood, but it is believed to involve a combination of factors such as viral persistence, immune system dysregulation, and prolonged inflammation.[2]

### 1.2. Demographic risk factors

Several demographic factors, especially age, play a crucial role in determining the likelihood of developing PASC. While older adults (especially those over 65 years) are more susceptible to severe acute outcomes from COVID-19 due to age-related declines in immune function and the presence of comorbidities such as diabetes and cardiovascular diseases,[4] middle-aged adults (35 – 49 years) exhibit higher prevalence rates of PASC symptoms compared to both younger and older age groups.[5]

### 1.3. Socioeconomic and racial disparities

Socioeconomic status significantly influences both the likelihood of initial infection and the development of PASC. Individuals from lower socioeconomic backgrounds, particularly those in marginalized communities, often face greater exposure to COVID-19 due to factors, such as crowded living conditions, inadequate healthcare access, and pre-existing health conditions such as obesity, diabetes, and cardiovascular diseases.[4] Moreover, racial disparities are evident, with Hispanic adults (8.3%) exhibiting the highest PASC prevalence, followed by White and Black adults. Asian adults report the lowest PASC prevalence, though the reasons for this disparity remain unclear and may be influenced by healthcare access, socioeconomic factors, or cultural differences.[5]

### 1.4. Prevalence and recovery of PASC

Recent surveys, such as those from the US CDC,[5] have shown that PASC symptoms are less common in large metropolitan residents. This is likely due to better healthcare infrastructure and access to preventative measures, such as vaccination. Recovery durations for PASC symptoms vary widely, ranging from several months to a year or even longer. Cognitive symptoms, such as brain fog, characterized by memory impairments, concentration difficulty, and mental fatigue, are particularly prevalent and often interfere with work and daily activities. PASC, particularly in terms of cognitive and neurological deficits, can severely affect daily functioning even after the infection has subsided.[2]

### 1.5. Aims of the study

This study aims to investigate the demographic influences on the SARS-CoV-2 infection. The symptom categories were centered primarily on physiological and cognitive effects. The study seeks to examine how demographic factors, including gender, age, vaccination status, and ethnicity, affect the development of PASC. In addition, this study analyzes the connections between symptoms through exploratory factor analysis (EFA), Pearson correlation, and other statistical methods to understand how specific symptoms are correlated. Ultimately, this study aims to contribute to a deeper understanding of PASC and provide valuable insights into its prevalence, which can shape global public health efforts to address and, eventually, treat PASC.

## 2. Methodology

This study employed a descriptive research design, collecting data through a self-reporting survey to evaluate the physiological and cognitive effects of PASC.[6,7] This method was chosen because it allows for a comprehensive analysis using a larger sample size. Participants were recruited through flyers, word of mouth, and online platforms (Figure 1), targeting individuals aged 18 – 55 with a confirmed COVID-19 diagnosis and no pre-existing health conditions (Figure 2). Exclusion criteria were implemented to minimize confounding variables, as pre-existing health conditions such as chronic pain, autoimmune diseases, and pregnancy can cause symptoms that overlap with PASC. For example, symptom severity might result from both COVID-19 and pre-existing health conditions. Participant age was limited to 55 due to the natural health decline associated with aging, which could confound the effects of age in our study. The online self-reporting survey consisted of 64 questions and was hosted on JotForm, a Health Insurance Portability and Accountability Act-compliant platform that ensures data privacy and security. Power analysis was not conducted

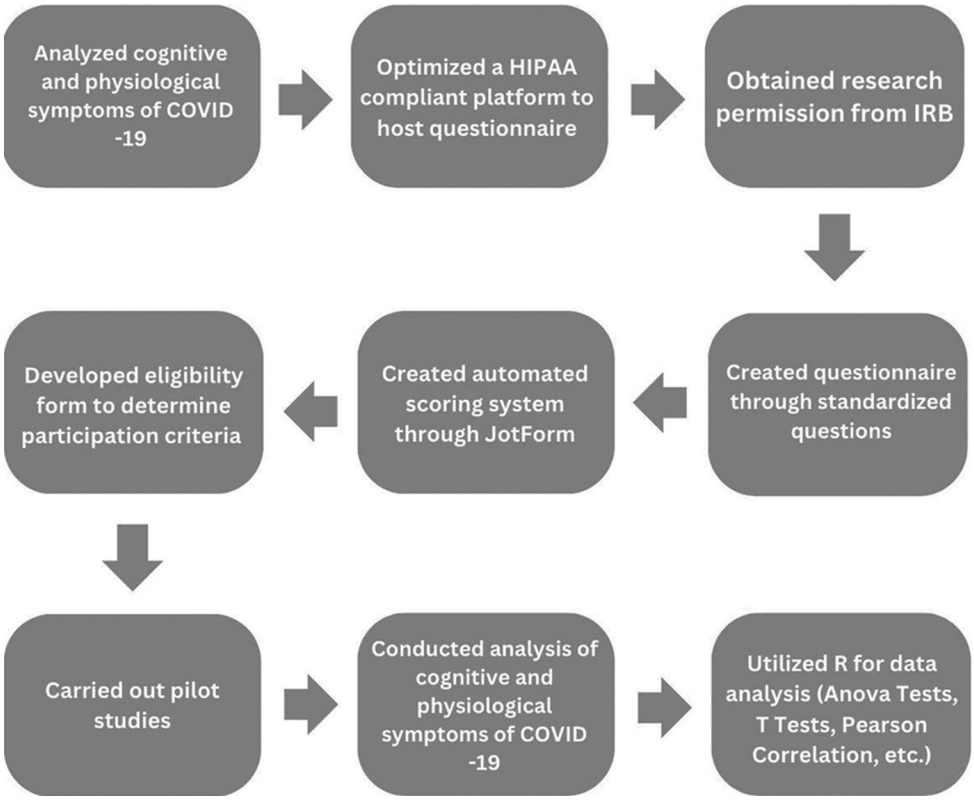


**Figure 1.** Outline of the sequential steps in our research process, including data collection and analysis
Abbreviations: HIPAA: Health insurance portability and accountability Act; IRB: Institutional review board.

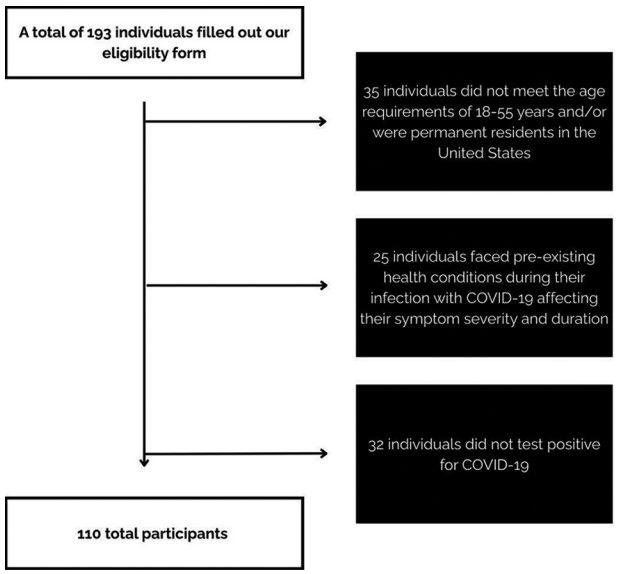


**Figure 2.** Participant eligibility pipeline, outlining the process to eliminate biases associated with pre-existing health conditions

due to the exploratory nature of this research and the constraints associated with participant recruitment. Validation of present findings requires further larger sample study.

All participants provided informed consent before the study and were informed about the aims and purposes. An internal institutional review board has reviewed and approved the research proposal and data privacy measures. In adherence to ethical guidelines, trigger warnings were implemented before survey sections containing potentially distressing content.

The 64 questions assessed 14 symptoms, categorized into physiological and cognitive domains. The physiological[6] category encompassed breathlessness, cranial nerve dysfunction, cough, anosmia, dysgeusia, fatigue, sleep, and throat sensitivity. The cognitive category contained suicidal thoughts, depression, behavior, stress, working memory, and fibromyalgia (Table 1). These specific symptoms were included to provide a comprehensive view of each category and to corroborate findings with previous studies.[7] The primary focus of this study is to gain a more in-depth understanding of brain fog.[6] Hence, we explored the impact of PACS on working memory, as well as the psychological impact. Demographics, including location, age, ethnicity, and vaccination status, were collected to observe patterns between symptoms experienced and an individual's demographic information (Tables 2 and S1, Figures S1-S3).

**Table 1. Categorization of 14 post-acute sequelae of SARS-CoV-2 symptoms with descriptions**

| Category | Description |
|---|---|
| Physiological | |
| Breathlessness | Shortness of breath/trouble breathing |
| Cranial nerve dysfunction | Impairment of cranial nerve indicated by weakness or loss of sensation |
| Anosmia | Loss of smell |
| Dysgeusia | Loss of taste |
| Cough | Persistent mild cough and wheezing as a result of cough |
| Fatigue | Feelings of tiredness |
| Sleep | Quality of sleep |
| Throat sensitivity | Itchy/blocked throat |
| Cognitive | |
| Suicidal thoughts | Preoccupied with thoughts of suicide |
| Depression | Constant feelings of sadness, loss of interest |
| Behavior | Anxiety and mood changes |
| Stress | Nervousness and stress |
| Fibromyalgia | Chronic disorder involving widespread pain |
| Working memory | Attention span and short-term memory |

**Table 2. Demographic characteristics of participants**

| Characteristic | Number | Percentage |
|---|---|---|
| Gender | | |
| Male | 40 | 36.4 |
| Female | 69 | 62.7 |
| Prefer not to say | 1 | 0.9 |
| Race | | |
| Asian | 79 | 71.8 |
| White | 12 | 10.9 |
| Multiracial | 10 | 9.1 |
| Hispanic, Latino, or Spanish Origin | 6 | 5.5 |
| Black or African American | 3 | 2.7 |
| Age | | |
| 18 – 20 years | 17 | 15.5 |
| 21 – 30 years | 20 | 18.2 |
| 31 – 40 years | 19 | 17.3 |
| 41 – 50 years | 33 | 30.0 |
| 51 – 55 years | 21 | 19.1 |
| Vaccination status | | |
| Vaccinated | 105 | 95.5 |
| Not vaccinated | 5 | 4.5 |

The sampling method used was a combination of random and convenience sampling. Participants' data were anonymized to ensure participant confidentiality. Preliminary data analysis was conducted upon completion of the pilot study. The pilot study data helped establish the scoring process for the severity and duration of each symptom experienced by participants. This study compiled various types of questions, including a selection of statements, each describing a different intensity level of the specified symptom. The severity scale ranged from 0 (never experiencing the symptom) to 3 (experiencing intensely), while the duration scale ranged from 0 (never experiencing the symptom) to 4 (enduring for a prolonged time). If a participant indicated that they never experienced a symptom (0 on the severity scale), the duration value would automatically be set to 0 as well.

In addition to the scoring scale, averages were calculated for both physiological and cognitive symptom severity/duration by grouping sub-symptoms and taking the mean. Pearson correlation, a statistical measure used to assess the strength and direction of the linear relationship between two variables, was employed to evaluate the connections among all the symptoms. Categories containing more than one question had the scores averaged to calculate the overall severity. For example, the severity of working memory was determined by adding the scores from the three related questions and dividing by three to obtain the mean. The pilot study of data analysis led to the use of automatic scoring in JotForm, eliminating human error in calculations.

Before completing the self-reporting survey, participants filled out a form to determine their eligibility for the study. If participants met the eligibility criteria, they completed the final survey; otherwise, they were removed from the system. This method eliminated the need to delete ineligible participants, reducing the possibility of human error. Data scrubbing was conducted to remove redundant data, such as instances where participants mistakenly submitted the form twice. If participants did not answer every question, leading to incorrect averages for the severity of symptoms, all their data throughout the self-reporting survey were scrubbed. This ensured that only valid data, free from accidental or random submissions, were included.Statistical data analyses were performed using the t-test (paired two samples for means)[8] and analysis of variance (two factors without replication tests).[9] Pearson correlations were calculated between each symptom's severity and duration and the severity/duration of different symptoms. R, a statistical analysis platform, was used to process and analyze the data for a more comprehensive analysis. EFA was conducted to uncover latent constructs underlying the symptoms of PACS, utilizing principal axis factoring with varimax rotation, as the data met sampling adequacy criteria.

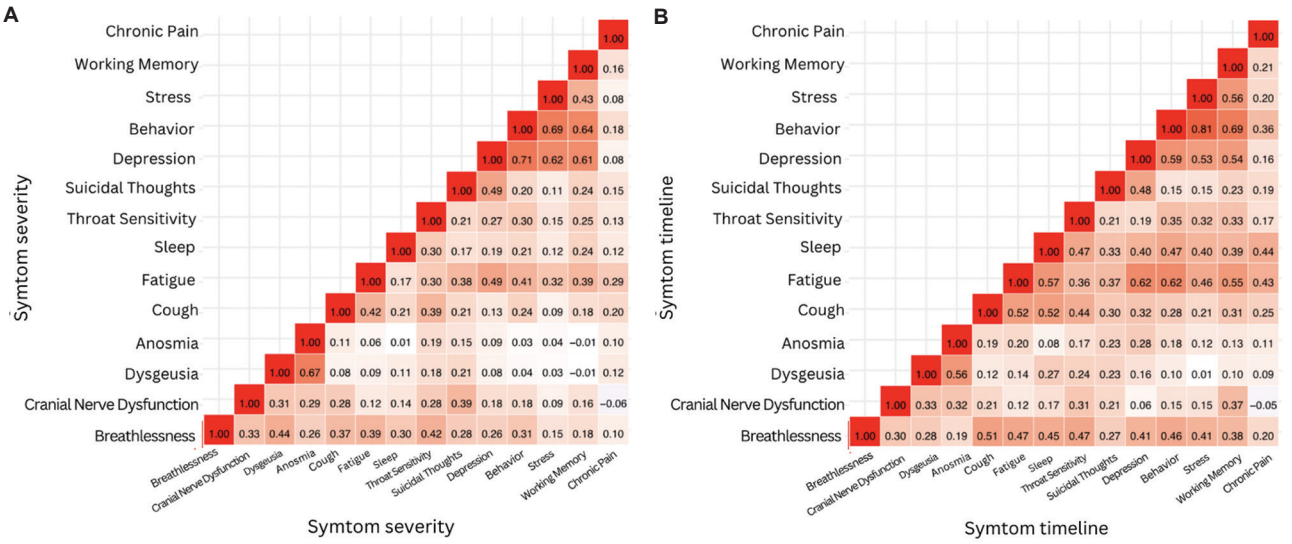


**Figure 3.** Pearson correlation heat maps represent the strength of correlations between (A) severity of symptoms and (B) duration of symptoms. The color of a square signifies the extent to which two symptoms are correlated: Dark red signifies a strong positive correlation (r>0.5), light red signifies a weak correlation (r≤0.5), and white signifies no correlation (r≈0).

## 3. Results

In this study, the results were analyzed through two correlations: The severity of symptoms and the duration of symptoms. Pearson correlation analysis and correlation matrix heatmaps (Figure 3) were performed to analyze and visualize the results. Upon assessing symptom severity, a strong positive correlation was observed between the severity of depression and working memory, with a Pearson correlation coefficient (r) of 0.73.

Across all demographics, most participants (n=44) reported testing negative for COVID-19 within 6 – 10 days post-infection (Figure S4). Similarly, the median duration for symptoms to disappear fell within 6 – 10 days (Figure S5).

Sleep was the most affected symptom of COVID-19 in the study, with the mean severity score being 1.155 on a scale of 0 – 3 (Table 3). Correspondingly, sleep also demonstrated the longest duration, with a mean of 2 – 4 weeks. Overall, 68% of participants reported changes in sleep, indicating that sleep disruptions are among the most common and persistent effects of COVID-19 infection.

In contrast, suicidal thoughts represented the least severe symptom found in this study, with a mean severity score of 0.06 (Table 3). This symptom also showed the shortest duration, with the mean being 0 – 1 week. Only approximately 0.04% of participants in our study reported experiencing suicidal thoughts during their COVID-19 illness, suggesting it is one of the rarest symptoms of COVID-19.

**Table 3. Severity and duration of post-acute sequelae of SARS-CoV-2 symptoms**

| Symptom | Severity mean | Severity SD | Duration mean | Duration SD |
|---|---|---|---|---|
| Breathlessness | 0.436 | 0.711 | 0.706 | 1.176 |
| Cranial nerve dysfunction | 0.100 | 0.357 | 0.147 | 0.556 |
| Dysgeusia | 0.555 | 0.711 | 0.468 | 0.786 |
| Anosmia | 0.545 | 0.973 | 0.431 | 0.840 |
| Cough | 0.595 | 0.679 | 0.803 | 1.007 |
| Fatigue | 0.602 | 0.754 | 0.954 | 1.309 |
| Sleep | 1.155 | 0.940 | 1.257 | 1.281 |
| Throat sensitivity | 0.564 | 0.894 | 0.550 | 0.963 |
| Suicidal thoughts | 0.058 | 0.355 | 0.092 | 0.517 |
| Depression | 0.245 | 0.711 | 0.560 | 1.169 |
| Behavior | 0.394 | 0.632 | 0.890 | 1.336 |
| Stress | 0.645 | 0.797 | 0.991 | 1.340 |
| Working memory | 0.385 | 0.668 | 0.890 | 1.423 |
| Chronic pain | 0.139 | 0.711 | 0.486 | 1.210 |

The physiological severity for both males and females encompasses eight symptom categories. Upon examination, the median and distribution were not statistically significantly different. The physiological severity of both males and females showed a median score of 0.47 (Figure S6). However, for the physiological duration, females exhibited a greater standard deviation (0.72) than males (0.52), despite a similar median value of 0.5 (Figure S7).

Gender differences were more pronounced in cognitive symptoms. Females reported a higher median score of 0.267 for mental severity compared to 0.033 in males (Figure S4). The standard deviation for females was also greater (0.41 versus 0.28 for males). These disparities were even more pronounced in the mental duration, where females showed a median score of 0.4 compared to 0.1 in males (Figure S3), with standard deviations of 0.91 and 0.47, respectively. Additional gender-based comparisons are presented in Figures S6-S11.

Vaccination status significantly influenced symptom severity across multiple categories (Figure 4). Dysgeusia showed a sharp difference between vaccinated and unvaccinated groups ($p$=0.033), as did anosmia ($p$=0.004), which was expected given their known correlation. Throat sensitivity showed a notable but not statistically significant trend ($p$=0.080), indicating a possible relationship. Further comparisons by vaccination status are available in Figures S12-S29. The analyses also examined the correlation between COVID-19 booster shot status (no booster, one, two, and three boosters) and symptom severity, specifically depression, behavior, stress, and chronic pain. In depression severity, those in the no-booster group showed a mean score of 0.357, while those with three boosters scored 0 for both depression severity and duration. In behavior symptoms, the no-booster group showed a mean severity score of 0.571, while the three-booster group scored 0.111. The stress duration averaged 1.143 for the no-booster group and 0.667 for the three-booster group. In addition, the two-booster group showed higher scores than the one-booster group for depression duration, behavior severity, behavior duration, stress severity, and chronic pain severity, indicating worsened symptoms after the third booster. Notably, only 8% of participants had received three boosters, with three participants contracting COVID-19 after the third booster. Overall, severity scores

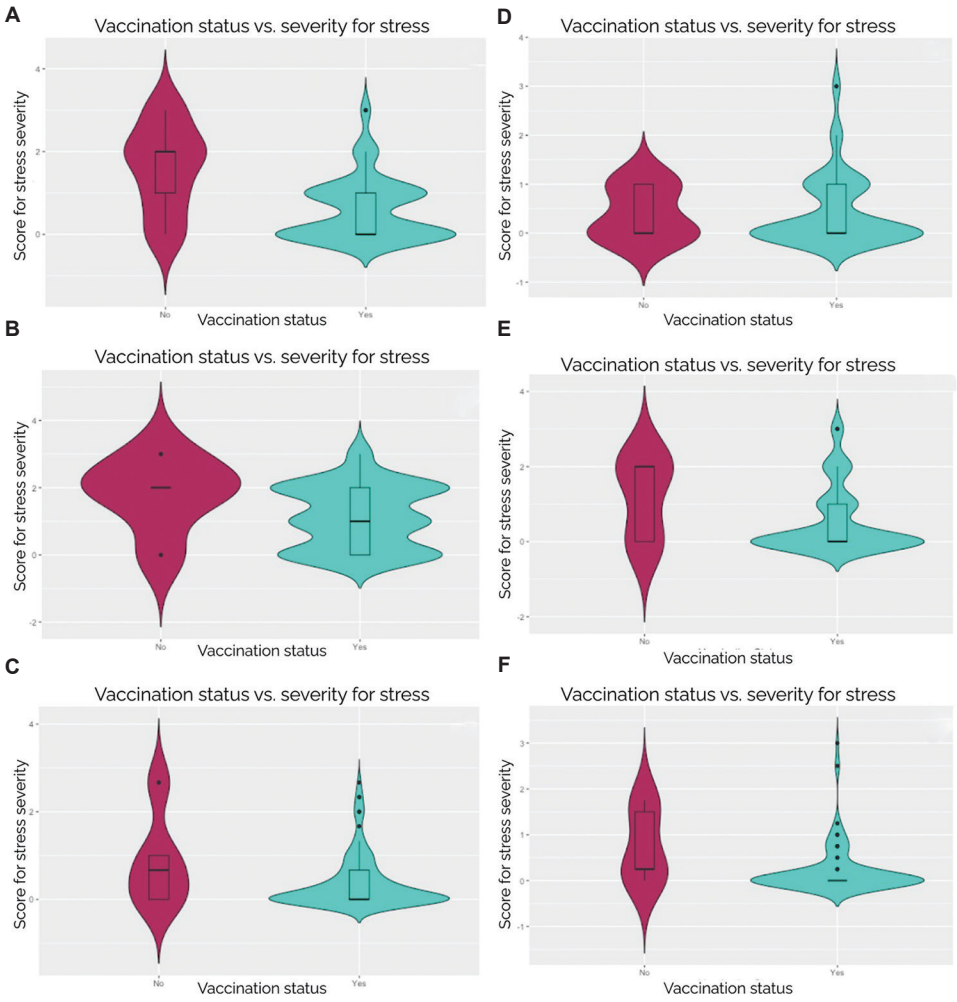


**Figure 4.** Violin plots of the distributions of individual symptom severities for (A) stress, (B) sleep, (C) behavior, (D) breathlessness, (E) throat sensitivity, and (F) depression for vaccinated and unvaccinated individuals

decreased from 0.319 for the no-booster group to 0.16 3 for the three-booster group, while duration scores decreased from 0.714 to 0.444, respectively, suggesting a downward trend with increasing boosters.

The majority of participants (67.3%) were infected with COVID-19 after receiving at least a second vaccine dose (Table 4). Of the remaining 32.7%, 1.8% were infected after their single-dose vaccine. Males were more likely to become infected before completing their first complete course of vaccination (two doses for double-dose vaccine, one dose for single-dose vaccine), with 35% of males being infected before a full vaccination compared to 29% of females. However, the variability in vaccination efficacy between genders may be due to sampling variability. The lower infection rate after the second booster compared to other categories is likely due to a lower rate of vaccination for the second booster (45.5%) and the timing of the second booster release.

EFA identified four factors for symptom severity: Respiratory and fatigue symptoms (e.g., cough and breathlessness), psychological and behavioral disturbance (e.g., brain fog and stress), sensory dysfunction (e.g., dysgeusia and anosmia), and depression (e.g., depression and suicidal thoughts) (Figure 5). We classified Factor 1 as respiratory and fatigue symptoms, including symptoms such as cough (loading=0.9), sleep disturbances (loading=0.7), throat sensitivity (loading=0.6), fatigue (loading=0.5), and breathlessness (loading=0.4). This cluster reflects symptoms associated with both respiratory and fatigue-related problems. The high loading value of cough indicates that it is a key symptom within this factor, consistent with the known respiratory effects of PASC. These findings suggest that patients in this cluster disproportionately suffer from breathing difficulties and energy level impairments.

Factor 2 revealed the psychological impact of PASC through psychological and behavioral disturbance, characterized by behavior (loading=1.0) and stress (loading=0.8). This factor demonstrates the significant mental strain affecting patients' behavior and mental health. The loading score of 1.0 for behavior indicates a strong correlation with the overall factor, suggesting that PASC patients experience severe behavior disruptions.

Factor 3, identified as sensory dysfunction, comprised of dysgeusia (loading=0.8), anosmia (loading=0.7), and cranial nerve dysfunction (loading=0.4). As all these symptoms are sensory nerve-related conditions, the high loading values for dysgeusia and anosmia, as well as their high correlation value, indicate their strong association.

Factor 4 was categorized as depression, encompassing depression (loading=0.9) and suicidal thoughts (loading=0.4), both of which also exhibited a high correlation in early analysis. The dominant loading for depression emphasizes the significant mental health implications of PACS, suggesting that affected patients would benefit from comprehensive neuropsychiatric evaluation and support.

For symptom duration, EFA similarly identified four factors: Psychological and cognitive (e.g., stress and working memory), respiratory and fatigue (e.g., cough and sleep), sensory dysfunction (e.g., dysgeusia and anosmia), and depression (e.g., depression and suicidal thoughts) (Figure 6). These categories, for the most part, aligned with the factors constructed for symptom severity, reinforcing the strong correlation between symptom severity and duration. We classified Factor 1 as psychological and cognitive strain, characterized by symptoms including behavioral severity (loading=0.9), stress (loading=0.8), and working memory (loading=0.6). This grouping contrasts with the duration analysis, which categorized behavioral and psychological symptoms separately from cognitive impairments (Figure 5). The severity analysis indicates that elevated stress and behavioral disruptions are closely linked to cognitive strain, suggesting that mental health challenges may worsen cognitive symptoms in patients with PACS.

Factor 2, identified as respiratory and fatigue severity, includes cough (loading=0.8), throat sensitivity

**Table 4. The distribution of participants' infection timing relative to vaccination status**

| Vaccination status | Number of people infected | Male infected | Female infected | Prefer not to say infected | Number of people infected (%) | Male infected (%) | Female infected (%) | Prefer not to say infected (%) |
|---|---|---|---|---|---|---|---|---|
| Before vaccination | 24 | 11 | 13 | 0 | 21.80 | 27.50 | 18.80 | 0 |
| After 1st dose | 12 | 4 | 8 | 0 | 10.90 | 10.00 | 11.60 | 0 |
| After 2nd dose | 33 | 13 | 20 | 0 | 30.00 | 32.50 | 29.00 | 0 |
| After 1st booster shot | 30 | 7 | 22 | 1 | 27.30 | 17.50 | 31.90 | 100.00 |
| After 2nd booster shot | 7 | 2 | 5 | 0 | 6.40 | 5.00 | 7.20 | 0 |
| After 3rd booster shot | 4 | 3 | 1 | 0 | 3.60 | 7.50 | 1.40 | 0 |

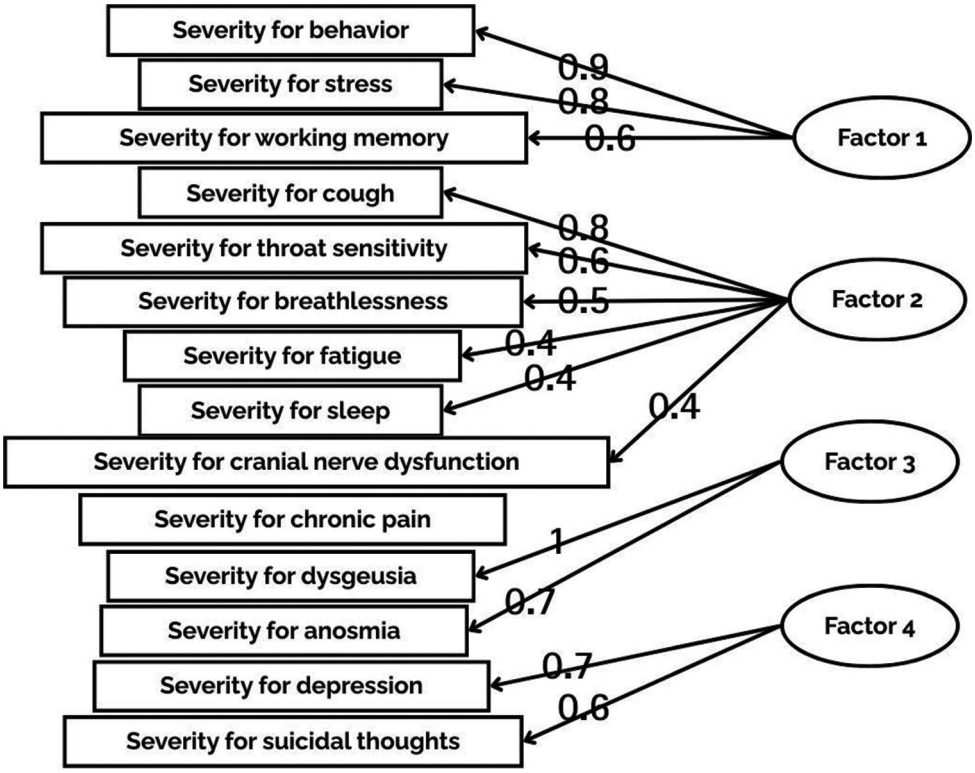


**Figure 5.** Exploratory factor analysis for symptom duration

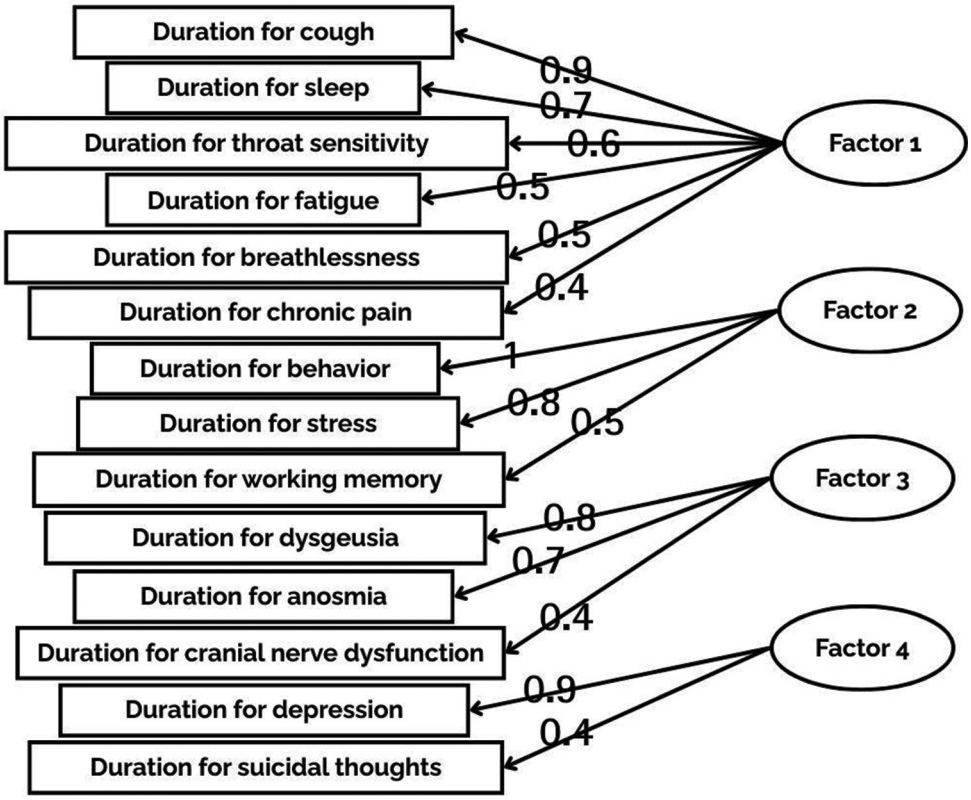


**Figure 6.** Exploratory factor analysis for symptom severities

(loading=0.6), breathlessness (loading=0.5), fatigue (loading=0.4), sleep issues (loading=0.4), and cranial nerve dysfunction (loading=0.4). This factor aligned with the respiratory cluster found in the duration analysis. Intriguingly, cough stands out as a particularly significant symptom due to its high loading in duration and severity analysis. The persistent nature of these respiratory symptoms highlights their substantial physical burden on patients.

Factor 3, labeled as sensory dysfunction, includes dysgeusia (loading=1) and anosmia (loading=0.7), indicating alterations in taste and smell perception in PACS patients. These sensory impairments can impact patients' quality of life, potentially worsening psychological distress, and complicating recovery efforts.

Finally, Factor 4, labeled as depression, consists of depression (loading=0.7) and suicidal thoughts (loading=0.6). While suicidal thoughts indicate a major area of worry, their relatively lower loading compared to depression indicates that depression is a core component of this factor. This relationship warrants further investigation into how clinical populations may experience depression, especially in light of other illnesses.

## 4. Discussion

The study was designed based on findings from extensive literature examining specific COVID-19 aftereffects and their symptoms.[10-38] Recent data from the 2022 National Health Interview Survey evaluating the ongoing symptoms of post-COVID-19 in the U S demonstrate that long-term symptoms are influenced by different demographics.[39] Regarding age distribution, the self-reporting survey revealed that adults aged 35 – 49 showed higher susceptibility to PACS compared to other group ages (18 – 34, 50 – 64, and 65 or older).[39] Previous studies have also indicated differences across biological sex, with women being 3.3% more likely than men to experience PACS symptoms following infection.[39] Furthermore, the interview showed that the percentage of adults with PACS varied by race. Asian adults were less likely to have PACS compared to Black, White, and Hispanic groups. Hispanic adults were the most likely to experience PACS (8.3%), followed by White and then Black adults.[39] Finally, the percentage of adults with PACS differed by the level of urbanization, as PACS was less prevalent in adults living in large central metropolitan areas compared to medium to small metropolitan areas.[39]

One initial goal of this study was to analyze variant-specific impacts. However, it is difficult to draw connections between specific SARS-CoV-2 variants, the severity of infection, and the duration of symptoms. Of the 110 participants, 58 (~53%) responded "I don't know" when asked which variant of COVID-19 they were infected with. Among the 52 participants who responded that they knew their variant, 4 (~8%) specified Delta, 22 (~42%) specified Omicron, 4 (~8%) specified a subvariant of Omicron, and 22 (~42%) specified the original strain of the virus. This variation in the proportion of participants affected could be a result of variation in the degree of contagiousness or time periods in which these variants were most prevalent. The original strain of SARS-CoV-2 was the dominant strain from January 2020 to June 2021, which may explain why 42% of participants reported being infected with it. On the other hand, the Delta variant was most prevalent from June to mid-December 2021.[40] The Omicron variant replaced the Delta variant in mid-December 2021 and remained prevalent until mid-2022 when it mutated into several subvariants, such as EG.5 ("Eris") and BA.2.86 ("Pirola"), which remain prevalent to this day. Yale Medicine has also noted that Omicron and its subvariants were the most contagious strains, which could contribute to the large proportion of participants infected with this strain. Among those who knew their variant, there was significant variation in the strain they were infected with and the time period of each variant's prevalence. Therefore, no clear conclusions can be drawn about the effects of a specific variant.

Due to COVID-19's worldwide prevalence, this study can educate others on the risks associated with the virus. More specifically, PACS, which continues to cause physiological and neurological effects with unknown timeframes, has affected millions of people across the US. By surveying individuals who tested positive for COVID-19, connections can be made between demographic factors and symptoms to better understand the longevity of COVID-19 effects. This study can aid clinics, research projects, and public health experts in understanding and improving the prevention and treatment of PACS. In addition, the findings can raise awareness about PACS among healthcare providers and the public to understand potential symptoms and support affected individuals. This study can also incentivize the establishment of community support groups for those dealing with the long-term impacts of COVID-19.

However, it is important to acknowledge that the participant sample size may be too limited to address such a significant issue. The geographic focus of this study is largely concentrated in the Western US, limiting its generalizability to other regions or populations. Expanding the geographic scope of future studies to an international scale would increase their relevance to the broader population. In addition, the study has a higher representation of participants of Asian descent, making the results more pertinent to the Asian-American population. Gender also serves as a limitation, with 63% of the participants being female compared to 36% male. While the data and implications are relevant to both groups, the higher female

representation may lead to more accurate predictions and analyses of symptoms for females. It is important to note that focusing on a demographic with lower susceptibility to the disease could underestimate its broader impact. Thus, expanding the sample to include a larger, more diverse group would provide a more comprehensive understanding.

## 5. Conclusion

This study aimed to investigate the prevalence, severity, and demographic influences on symptoms associated with PASC. The EFA identified four primary symptom clusters for PACS, both for the symptom severity and duration: (i) respiratory and fatigue symptoms (e.g., cough, fatigue, and breathlessness), including significant respiratory impacts; (ii) psychological and behavioral disturbance (e.g., stress and behavioral changes), which highlighted the mental strain of PACS; (iii) sensory dysfunction (e.g., dysgeusia and anosmia), indicating that neurological impacts on sensory pathways are still prevalent post-infection; and (iv) depression (e.g., depression and suicidal ideation), which highlighted neuropsychiatric effects. These findings demonstrate the multifaceted impact of PACS and highlight the need for multidisciplinary management strategies addressing physical, psychological, and neurological health.

The findings indicate that sleep disturbances were the most prevalent symptom, with a mean severity score of 1.15 and duration of 2 – 4 weeks. These conclusions align with previous studies, which highlight sleep disruptions as a common long-term consequence of COVID-19.[6] On the other hand, suicidal thoughts were the least reported symptom, with a mean severity of 0.06, suggesting that they are less commonly associated with PACS in the studied population.

Demographic factors played a significant role in the severity of the symptoms experienced. Female participants consistently reported higher severity scores for both physiological and cognitive symptoms compared to males, corroborating findings that women tend to experience more severe post-infection symptoms.[41] Possible explanations include immune system differences, as women generally have stronger immune responses, which may lead to increased inflammation post-infection, contributing to prolonged symptoms. Hormonal factors also play a role, as estrogen and progesterone influence immune responses and may affect symptom persistence. Meanwhile, age also influenced symptom reporting, with adults aged 35 – 49 demonstrating a higher likelihood of experiencing PACS. This trend may reflect age-related immune responses or occupational exposure risks.

As hypothesized, vaccination was a significant variable, with vaccinated participants reporting lower severity scores across symptoms, such as stress, sleep disturbances, and depressive symptoms. This finding highlights the importance of vaccination in mitigating the long-term effects of COVID-19, although the presence of breakthrough infections highlights the need for continued surveillance and tailored interventions.

Overall, this study contributes to the growing literature on COVID-19 by identifying demographic disparities and emphasizing the complex and multifactorial natures of PACS. However, limitations, such as the overrepresentation of female and Asian-American participants and reliance on self-reported data, suggest caution when generalizing the findings to the broader population. Future research should utilize a larger, more diverse sample and explore the influence of SARS-CoV-2 variants and socioeconomic factors on symptom severity and duration. The findings of this study could guide public health strategies and underscore the importance of tailored interventions for PACS based on demographic factors and symptom severity.

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## Conflict of interest

The authors declare that they have no competing interests.

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## Ethics approval and consent to participate

This study was reviewed and approved by the Ethics Board of the Aspiring Scholars Directed Research Program (ASDRP). All participants provided informed consent to participate.

## Consent for publication

All participants provided consent for the publication of their anonymized data. No personally identifiable information is included in this publication.

## Availability of data

Due to ethical restrictions, the datasets supporting this study's findings are not publicly available.

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