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Characteristics and Impact of Long COVID at a Neurology Clinic

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Keywords
Coronavirus disease 2019 · Long COVID · Quality of life · Brain fog · Fatigue

Abstract
Introduction: Long COVID can also lead to neurological sequelae that affect existing diseases. This study explored how COVID-19 infection affects neurological patients and the relationship between long COVID and exacerbating factors. ***Methods:*** This retrospective study was conducted on 85 patients with neurological diseases after COVID-19 at the Neurology Department, Inje University Busan Paik Hospital, Korea. The data were collected between August and October 2022. The patients had a medical history, including COVID-19 infection, and completed symptom questionnaires. A long COVID questionnaire consisting of 35 inquiries in 10 categories was completed. Anxiety, depression, fatigue, functional difficulties, QOL, and health status changes were assessed. ***Results:*** The analysis comprised 85 participants (age: 56.4 ± 15.2 years; 63.5% women). Of the categories, neurological symptoms (68.2%) were the most prevalent, followed by systemic symptoms (64.7%) and cardiopulmonary symptoms (56.5%). Anxiety, depression, and fatigue symptoms were reported by 36.5%, 34.1%, and 42.4% of the participants. Subjective neurological deterioration after COVID-19 was reported in 28 participants (28/81, 34.6%). Anxiety, depression, and fatigue were influenced by long COVID symptoms and the subjective deterioration of neurological conditions. ***Conclusion:*** This study analyzed the long COVID symptoms in patients with preexisting neurological conditions and their impact on mental health and quality of life. One-third of the participants reported a subjective worsening of their preexisting neurological conditions. This study highlights the need for comprehensive follow-ups and a multidisciplinary approach for patients with neurological conditions and prolonged COVID-19 symptoms.

Introduction

Coronavirus disease 2019 (COVID-19) came to be known after it was reported as pneumonia of unknown etiology in Wuhan City, China, in December 2019 and had a serious impact worldwide, including in Korea, to the extent that the COVID-19 pandemic was declared [1–6]. Since then, the development and administration of the COVID-19 vaccine have been carried out, and the pandemic has gradually subsided. On May 5, 2023, the World Health Organization (WHO) declared the lifting of the public health emergency for COVID-19 [7–10]; however, it is estimated that several million people are suffering from the long COVID-19 worldwide, and it is considered a risk factor in the field of long-term public health or quality of life (QOL) [11–14].

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Long COVID is mainly described as a set of symptoms that last 12 weeks after COVID-19 infection, and it is known to affect more than 200 symptoms and multiple organ systems, including fatigue, sleeping problems, memory or attention issues, generalized pain [13, 15–17]. In addition, long COVID appears as multiple adverse outcomes and common new-onset conditions, as well as cardiovascular, thrombotic, and cerebrovascular diseases; type 2 diabetes; myalgic encephalomyelitis/chronic fatigue syndrome; and dysautonomia, especially postural orthostatic tachycardia syndrome. Globally, the prevalence of long COVID varies, with estimates suggesting millions are affected, highlighting the widespread impact of this condition. The pathophysiology of long COVID remains undetermined; potential hypotheses include direct toxicity, inflammatory dysregulation, vascular insult, and other mechanisms [11, 14, 16]. The occurrence of a long COVID is explained by multiple potentially overlapping causes, persisting reservoirs of SARS-CoV-2 in tissues, immune dysregulation with or without reaction of underlying pathogens, impacts of SARS-CoV-2 on the microbiota, autoimmunity, priming of the immune system from molecular mimicry, microvascular blood clotting with endothelial dysfunction, and dysfunctional signaling in the brainstem and/or vagus nerve [11, 12, 14, 16].

Long COVID is a new neurological sequelae that sometimes appear as dysautonomia and brain fog, but they are of great interest because they can affect existing diseases [14, 17]. In the context of COVID-19 infection and its sequelae, symptoms can be caused or aggravated by systemic inflammation or inflammation in the nervous system. These symptoms have been identified through the elevation of various inflammatory markers [11, 14, 18, 19]. Fatigue, a major symptom of long COVID, is assumed to be related to neural circuitry related to physical and cognitive activity, but it has not been sufficiently explained [14, 20]. Therefore, we investigated that long COVID in patients with neurological diseases affects neurological symptoms or the overall course and analyzed the relationship between the types of long COVID and various exacerbating factors.

Methods

Samples and Data Collection

We retrospectively collected data from 85 patients registered at the Neurology Department of Inje University Busan Paik Hospital in Busan, Republic of Korea, between August 2022 and October 2022. Inclusion criteria were (1) registration at the neurological department for treatment or management of neurological conditions, (2) a history of COVID-19 infection, and (3) age 19 years or older. Patients with a history of trauma or major surgery within the previous 3 months were excluded. All the participants provided a detailed medical history, including the date of COVID-19 diagnosis, physical examination, and a questionnaire assessing their symptoms.

Demographic data, including age, sex, and body mass index (BMI) were included. Disease criteria included the following: (1) central nervous system inflammatory diseases (e.g., multiple sclerosis, neuromyelitis optica spectrum disorder), (2) neurodegenerative diseases (e.g., dementia, parkinsonism), (3) neuromuscular diseases (e.g., myopathy, myasthenia gravis, motor neuron disease, peripheral neuropathy), and (4) others (e.g., dizziness, stroke, headache).

Data on oral prednisolone administration (>10 mg/day) for other conditions like MS relapse and comorbidities (hypertension, diabetes mellitus, cancer, chronic renal disease, chronic lung disease, chronic heart disease, and non-neurological autoimmune disease) were collected. The severity of COVID-19 at the acute period, presence of respiratory symptoms, pneumonia, symptomatic treatment, hospitalization, administration of oxygen treatment, COVID-19 infection-specific treatment, and admission to the intensive care unit were investigated. The COVID-19 vaccines were investigated, and potential complications were assessed, including pain at the injection site, redness and swelling, headache, dizziness, muscle pain, fatigue, fever, and chills.

Long COVID Questionnaire

Participants with COVID-19 infection history completed a questionnaire when they visited a neurologic clinic. We constructed a questionnaire regarding symptoms after COVID-19 infection based on Jung et al.'s [15] study and modified some items included in Jung et al. [15]. In the systemic category, arthralgia and myalgia were added to the systemic category. Decreased attention shifts from the psychiatric to the neurological category. Hyposmia and hypogeusia were investigated as single items. Symptoms corresponding to the last 1 week can be checked in duplicate based on the inquiries. The frequency of each item and the organs involved were also investigated.

Our questionnaire consisted of 35 detailed inquiries divided into 10 categories according to symptoms as follows: (1) general or systemic categories included fatigue, generalized weakness/asthenia, weight loss,

arthralgia/joint pain, and myalgia. (2) Neurologic categories included decreased attention, headache, dizziness, sleep problems, cognitive decline, and tingling sensation/paresthesia. (3) Neuropsychiatric categories include depression, anxiety, and post-traumatic stress disorder. (4) Cardiopulmonary categories included coughing, productive sputum, shortness of breath, chest discomfort, chest pain, and palpitation. (5) Otorhinolaryngologic categories included hyposmia and hypogeusia. (6) Ophthalmologic category included eye discharge and blurred vision. (7) The dermatological categories included hair loss and skin rashes. (8) Gastrointestinal symptoms included dyspepsia, heartburn, abdominal pain, diarrhea, and nausea/vomiting. (9) Gynecologic category included dysmenorrhea and vaginal bleeding. (10) Urologic categories included bladder-related symptoms, sexual dysfunction, and foamy urine.

Assessment of Depression and Anxiety, Fatigue

The Hospital Anxiety and Depression Scale (HADS) was used to assess the levels of anxiety and depression (HADS-anxiety and HADS-depression) [21]. To measure fatigue, the fatigue severity scale was used as one of the commonly used scales in fatigue measurement, which is a self-reported questionnaire proposed by Krupp et al. [22].

Assessment of General Function, QOL, Health Status

Patients were asked about their functional difficulties, general QOL, and general health status while comparing their health status before COVID-19 infection with their current status after infection. Functional difficulties were classified as follows: (1) communications, (2) mobility, (3) personal care, (4) activities of daily living, and (5) social functioning [23]. Overall QOL and overall health status were also investigated. It consists of seven items scored on a Likert scale ranging from 0 to 10 (0 = normal, 10 = severely impaired).

Neurological and Systemic Changes after COVID-19 Infection

The overall change in suffering neurological disorders was measured using the Clinical Global Impressions-Improvement (CGI-I) [24]. For this patient's condition, one of the following queries consisting of a five-point scale was indicated for the state after COVID-19 infection: 1 = much improved, 2 = minimally improved, 3 = no change, 4 = minimally worse, and 5 = much worse. Among the neurological symptoms, we inquired about any worsening or new symptoms, and the following items were additionally evaluated: decreased attention, headache, dizziness, sleep disturbance, cognitive decline, motor weakness, gait disturbance, tremor, aggravated pain, tingling/paresthesia, visual disturbance, bladder/bowel disturbance, and seizure/convulsion.

Statistical Analysis

Statistical analyses were conducted using the Statistical Package for Social Sciences software (version 22.0; SPSS Inc., Chicago, IL, USA). Descriptive statistics were calculated for each variable, using frequencies and means for categorical and continuous variables, respectively. To test for group differences, Pearson's χ^2 test, independent *t* test, and ANOVA test (with Scheffe comparison) were used. We conducted a descriptive analysis of the baseline characteristics. Mean ± standard deviation and 95% confidence interval values were calculated for each value.

Differences in patient characteristics were defined using Fisher's exact test and the Mann-Whitney U test. Wilcoxon matched-pair test was used to assess the differences between baseline and follow-up tests. Statistical significance was set at $p < 0.05$.

Continuous variables are presented as median (interquartile range) or mean ± standard deviation, and categorical values are presented as numbers (percentage, %). Categorical variables were analyzed using the χ^2 test or Fisher's exact test, and non-categorical variables were analyzed using the *t* test. Logistic regression analysis was used to examine factors associated with the presence of symptoms and worse changes in the CGI-I. The logistic regression analysis was adjusted for age, sex, BMI, smoking status, underlying medical conditions, hospitalization, severity of COVID-19 infection, and vaccination status.

Results

The final analysis included 85 participants. The participants had a mean age of 56.35 ± 15.24 years, and 63.5% (n = 54) were women (Table 1). Approximately half of the participants were diagnosed with neuropathy (n = 39, 45.9%), while the remaining participants were diagnosed with myasthenia gravis (n = 9, 10%), demyelinating diseases (n = 7, 8.2%), dementia (n = 4, 4.7%), stroke (n = 4, 4.7%), myopathy (n = 3, 3.5%), movement disorders (n = 2, 2.4%), motor neuron disease (n = 2, 2.4%), and others (n = 15, 17.6%). Fifty-five participants (64.7%) were overweight (BMI of >23, and 27 (31.8%) received steroid therapy. Thirty participants

Table 1. General characteristics of participants (n = 85)

Variable	Category	Mean or n	SD or %
Age, years		56.35	15.24
	≤44	18	21.2
	45–64	41	48.2
	>65	26	30.6
Sex	Male	31	36.5
	Female	54	63.5
Diagnosis	Demyelinating	7	8.2
	NDD	9	10.6
	NMD	49	57.6
	Other	19	22.4
BMI	Underweight (<18 kg/m^2)	3	3.5
	Normal weight	27	31.8
	Overweight (≥23 kg/m^2)	55	64.7
Steroid	Yes	27	31.8
Comorbidity	Hypertension	30	35.3
	Diabetes	17	20.0
	Cancer	7	8.2
	Cardiovascular diseases	7	8.2
	Respiratory diseases	2	2.4
	Renal diseases	5	5.9
Days from contracting COVID-19, days		154.94	93.14
	<90 days	19	22.4
	≥90 days	65	77.6
Treatment for COVID-19	Only medication	69	81.2
	Hospitalization (including incentive care unit)	6	7.1
Vaccinations, n	0	3	3.5
	1	4	4.7
	2	20	23.5
	3	41	48.2
	4	17	20.0
HADS-A		5.94	5.06
	≥8	31	36.5
HADS-D		6.28	4.87
	≥8	29	34.1
FSS		31.91	18.23
	>36	36	42.4

BMI, body mass index; HADS-A, Hospital Anxiety and Depression Scale-Anxiety; HADS-D, Hospital Anxiety and Depression Scale-Depression; FSS, Fatigue Severity Scale.

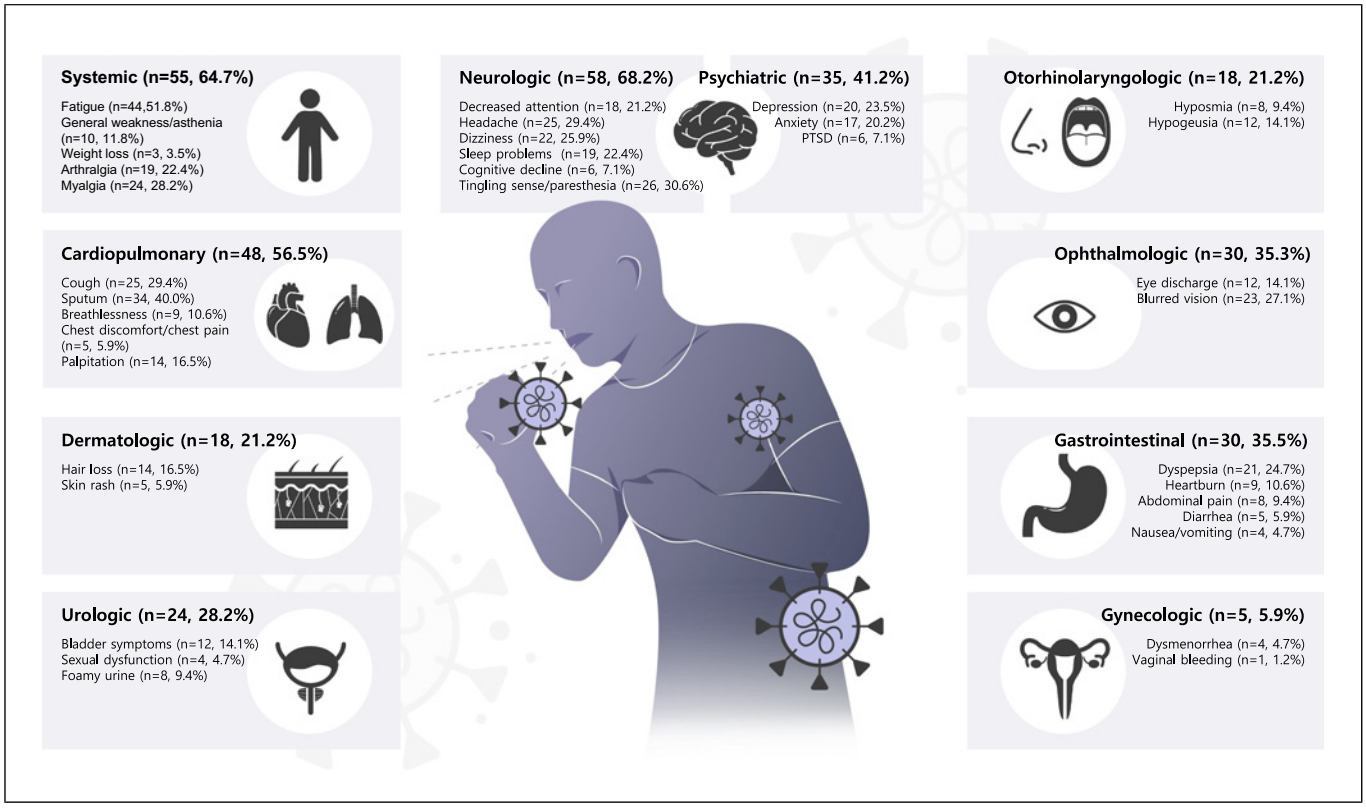


Fig. 1. Long COVID symptoms. PTSD, posttraumatic stress disorder.

had hypertension and 17 had diabetes mellitus as a comorbidity. The majority of participants had COVID-19 more than 90 days prior (n = 65, 77.6%), received medication for COVID-19 without hospital admission (n = 69, 81.2%), and received more than two vaccinations for COVID-19 (n = 68, 80.0%). Among them, 31 (36.5%) reported anxiety, 29 (34.1%) reported depression, and 36 (42.4%) reported fatigue.

As shown in Figure 1, neurological symptoms (n = 58, 68.2%) were the most commonly reported category of long COVID symptoms, followed by systemic symptoms (n = 55, 64.7%), cardiopulmonary symptoms (n = 48, 56.5%), psychiatric symptoms (n = 31, 41.2%), ophthalmological symptoms (n = 30, 35.3%), digestive symptoms (n = 30, 35.3%), urological symptoms (n = 24, 28.2%), dermatologic symptoms (n = 18, 21.2%), and gynecologic symptoms (n = 5, 5.9%). The most frequently reported persistent symptoms were fatigue (n = 44, 51.8%), sputum (n = 34, 40.0%), tingling sensation (n = 26, 30.6%), cough (n = 25, 29.4%), and headache (n = 25, 29.4%). Among the neurological symptom categories, tingling sensation, headache, and dizziness were the most common (n = 22, 25.9%).

After contracting COVID-19, 28 participants reported that their neurological disease had subjectively deteriorated, whereas 53 reported that their disease status had remained the same (n = 50) or had improved (n = 3) (Fig. 2). The most commonly reported worsening or newly emerging symptoms related to neurological conditions after contracting COVID-19 were a tingling sensation (n = 18), followed by dizziness (n = 14), decreased attention (n = 13), headache (n = 13), and muscle weakness (n = 13) (Fig. 3). Participants reported their current QOL and QOL before COVID-19, and significant differences were found in most areas (walking and movement, daily life, social roles, general QOL, and general health conditions) (Fig. 4).

Table 2 presents the logistic regression results for the subjective deterioration of preexisting neurological conditions, anxiety, depression, and fatigue. The number of long COVID symptoms had an impact on the subjective deterioration of the disease after controlling for the duration after COVID-19, admission therapy, and vaccination in Model 2. Demographic factors are also considered in Model 3. The subjective

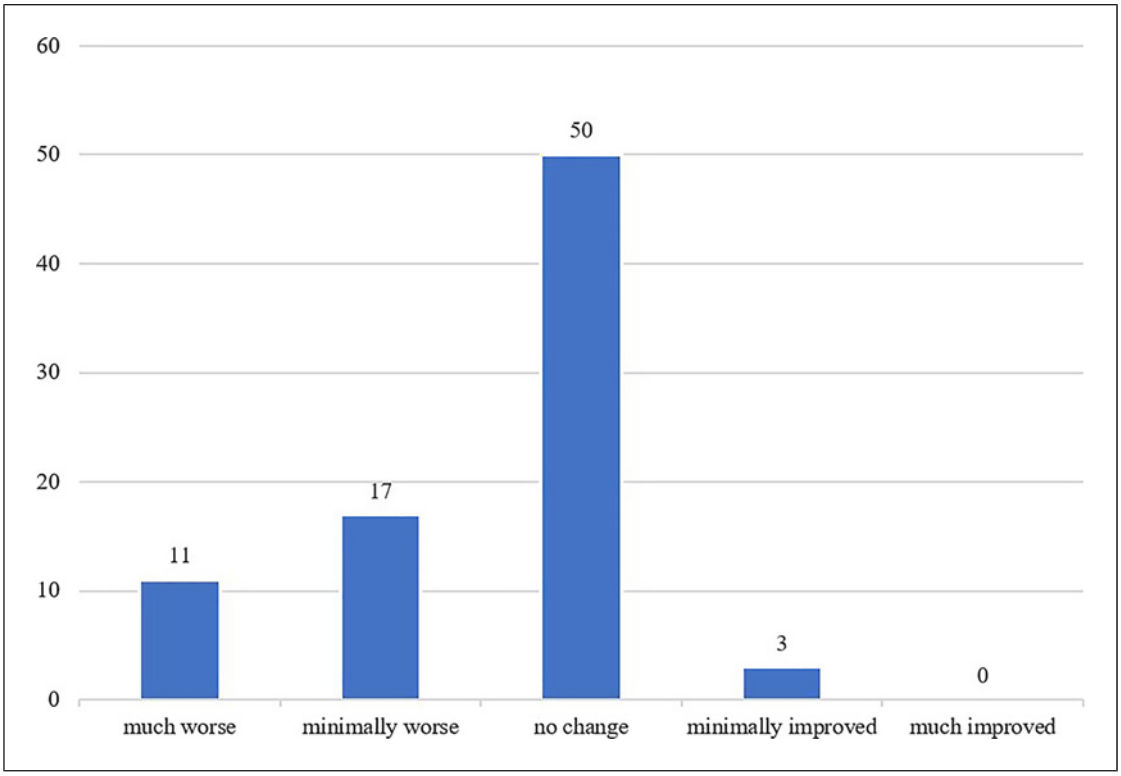


Fig. 2. Clinical impression (n = 81).

deterioration of neurological conditions affected anxiety, depression, and fatigue in the univariate analysis (Model 1). However, it no longer had an impact on depression after controlling for COVID-19 variables in model 2. Nevertheless, it continued to significantly impact anxiety and fatigue in models 2 and 3. The number of long COVID symptoms significantly influenced anxiety, depression, and fatigue in models 2 and 3. Additionally, female sex had an impact on fatigue in model 3.

Discussion

This study analyzed the symptoms associated with prolonged COVID-19 and how they are related to preexisting neurological conditions and mental health in patients with neurological disorders. The findings of this study indicated that patients encountered a range of long COVID symptoms, and roughly one-third of the participants reported subjective worsening of their preexisting neurological conditions. The number of long COVID symptoms not only contributed to the subjective worsening of preexisting neurological disorders but also demonstrated a correlation with feelings of depression, anxiety, and fatigue. This study suggests that patients with neurological disorders experience diverse long COVID symptoms that significantly impact their overall health, emphasizing the need for comprehensive follow-up and a multidisciplinary approach.

The category of neurological symptoms had the highest prevalence among the reported COVID-19 symptoms in this study, which contrasts with the findings of Jung et al. [15]. Jung et al. [15] analyzed patients attending a post-COVID-19 clinic and found that the categories of cardiopulmonary and general symptoms had the highest response rates. The variation in results can be attributed to the fact that our study specifically focused on patients with preexisting neurological disorders. The high response rate for fatigue symptoms observed in our study is consistent with the findings of previous studies conducted by Jung et al. [15] and Malik et al. [25], who identified fatigue as the most common post-COVID-19 symptom. Commonly reported symptoms, such as sputum, cough, and headache, aligned with the findings of a previous study [15]. However, in the previous study, these symptoms were classified as acute COVID-19 symptoms that usually

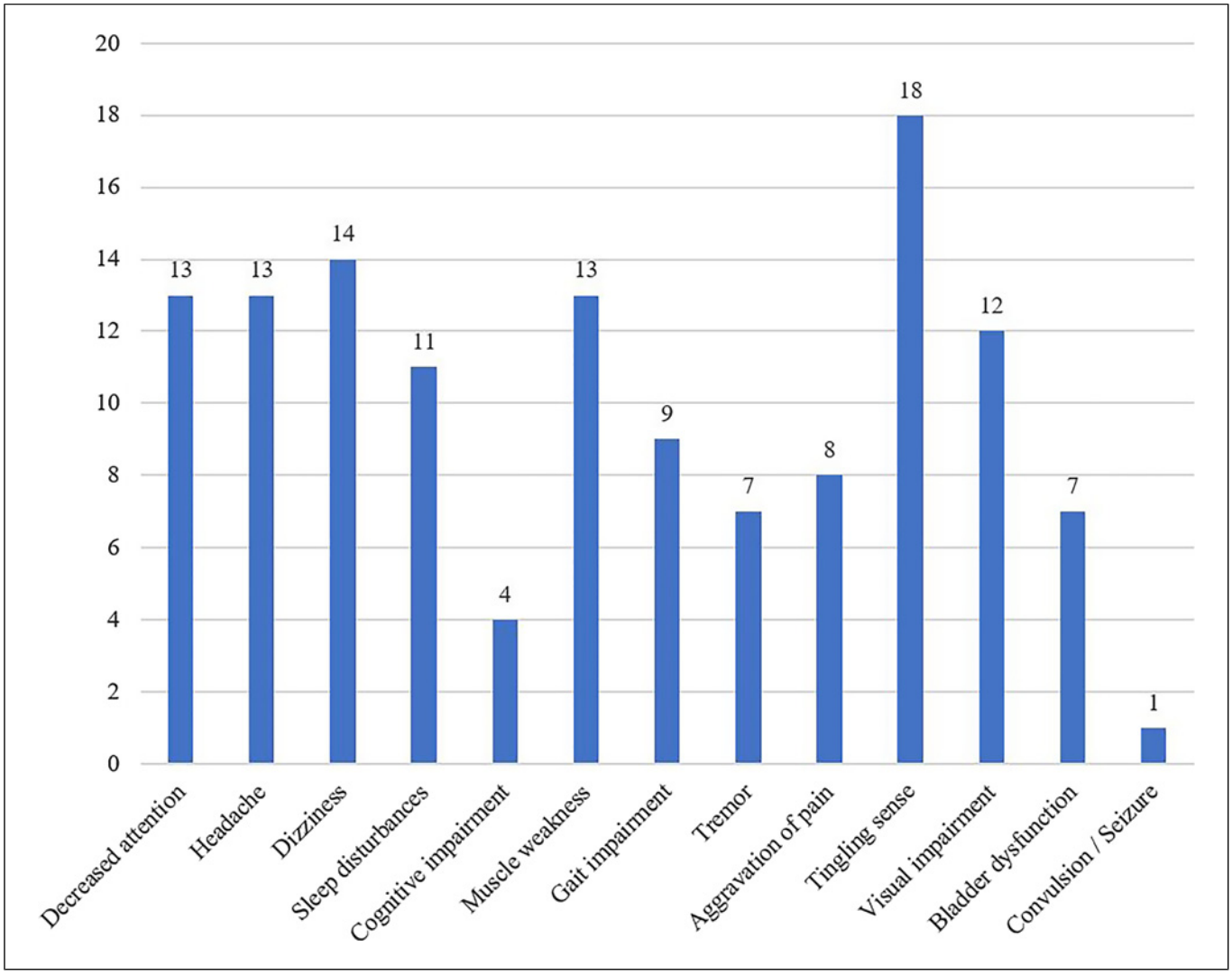
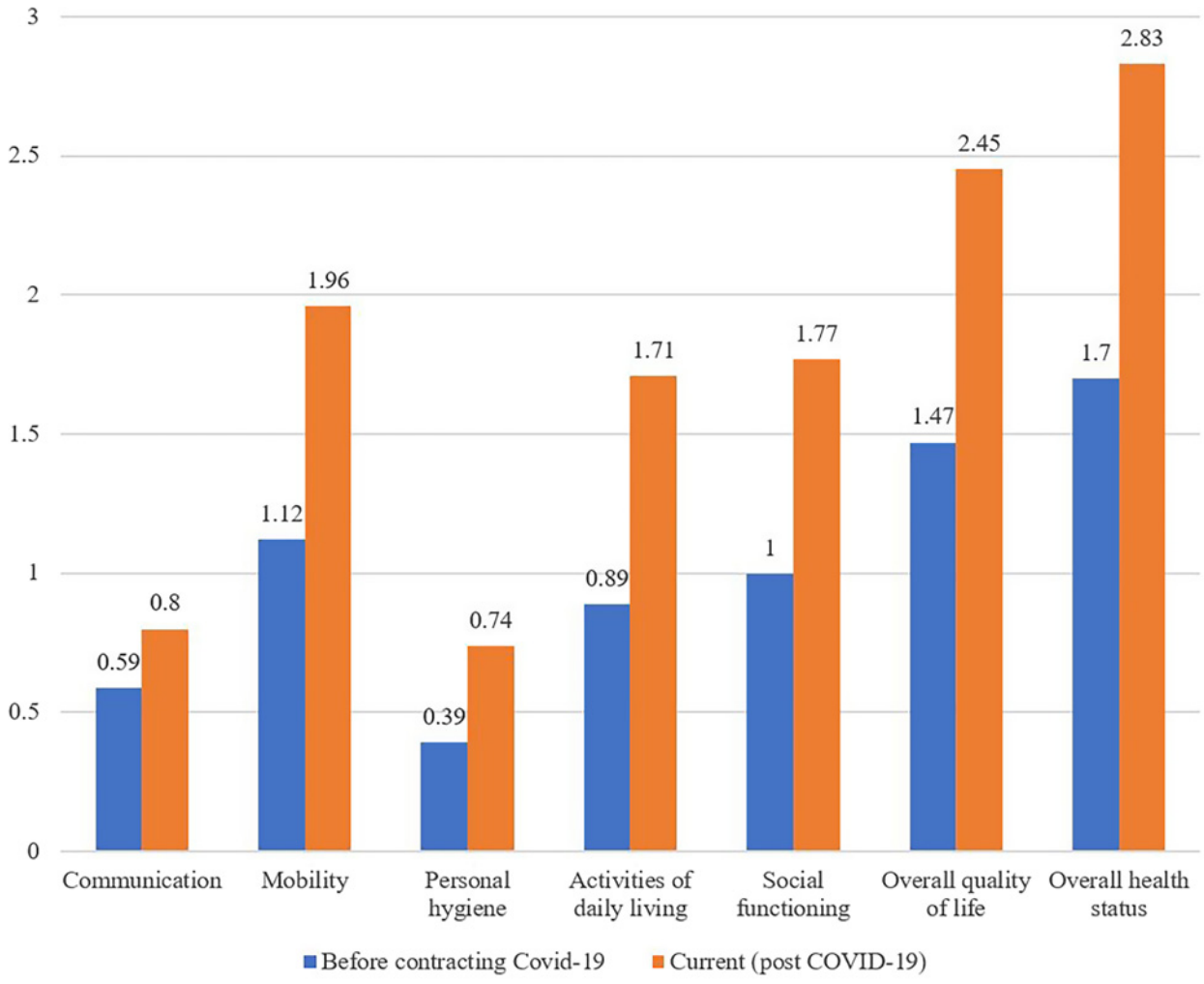


Fig. 3. Worsening or new neurological symptoms after COVID-19 infection.

occurred within a 4-week period. In contrast, the majority of our study participants were in the post-acute phase (>90 days) and experienced prolonged acute COVID-19 symptoms. Furthermore, unlike previous studies conducted by Malik et al. [25] and Taboada et al. [26], which identified shortness of breath as one of the most common sequelae, this symptom was not prevalent in our study population. This difference may be attributed to the relatively mild disease severity of the participants included in our study, who predominantly received outpatient care for COVID-19.

After contracting COVID-19, the participants reported a variety of worsened or newly emerging symptoms related to neurological conditions, such as sensory abnormalities, dizziness, decreased concentration, headache, muscle weakness, visual impairments, and sleep disturbances. Although the exact mechanism underlying the occurrence of central nervous system symptoms in long COVID remains uncertain, previous studies have highlighted cognitive dysfunction, brain fog, sleep disorders, and olfactory disorders as significant long COVID symptoms. The presence of these prolonged COVID-19 sequelae may aggravate existing neurological disorders and impede recovery. In this study, approximately one-third of the patients subjectively reported deterioration of their preexisting neurological conditions. Although neurological disorders generally exhibit a progressive worsening pattern, studies have previously documented deteriorating symptoms after contracting COVID-19



	Before contracting Covid-19	Current (post COVID-19)	*t*	*p*
Communication	0.59	0.80	1.80	0.075
Mobility	1.12	1.96	3.48	0.001
Personal hygiene	0.39	0.74	1.90	0.061
Activities of daily living	0.89	1.71	3.50	0.001
Social functioning	1.00	1.77	3.06	0.003
Overall quality of life	1.47	2.45	3.18	0.002
Overall health status	1.70	2.83	3.99	<0.001

Fig. 4. Quality of life before and after contracting COVID-19 (n = 85).

among individuals with Parkinson's disease [27]. Consequently, future research should aim to explore the causal relationship between prolonged COVID-19 symptoms and the deterioration of preexisting neurological conditions.

Anosmia or ageusia has been frequently reported as a symptom that appears after an initial infection and is also known as a symptom that has long-term sequelae [28, 29]. In particular, since olfactory or gustatory dysfunction has previously been suggested to be associated with

Table 2. Logistic regression (n = 81)

Model	Predictors	Deterioration of preexisting neurological condition				Anxiety				Depression				Fatigue			
		OR	95% CI		p value	OR	95% CI		p value	OR	95% CI		p value	OR	95% CI		p value
			LLCI	ULCI			LLCI	ULCI			LLCI	ULCI			LLCI	ULCI	
Model 1	Deterioration of preexisting neurological condition					6.75	2.50	18.26	<0.001	4.00	1.53	10.47	0.005	5.20	1.98	13.65	0.001
Model 2	Deterioration of preexisting neurological condition					5.26	1.48	18.69	0.010	2.16	0.62	7.48	0.224	3.55	1.22	10.36	0.020
	Long COVID symptoms, n	1.14	1.04	1.25	0.006	1.38	1.17	1.62	<0.001	1.43	1.20	1.71	<0.001	1.21	1.08	1.37	0.001
	>90 days after contracting COVID-19	1.75	0.51	6.04	0.374	0.79	0.14	4.37	0.786	0.67	0.12	3.67	0.644	1.17	0.31	4.44	0.818
	Hospitalization for COVID-19 treatment	1.22	0.15	9.80	0.851	9.50	0.66	136.69	0.098	4.08	0.36	45.80	0.254	3.03	0.33	27.52	0.325
	Vaccination once or none (ref: twice)	1.30	0.17	9.67	0.801	0.11	0.00	3.12	0.193	0.30	0.01	6.11	0.434	2.63	0.31	22.39	0.376
	Vaccination more than three times (ref: twice)	0.87	0.28	2.74	0.811	0.64	0.15	2.75	0.550	1.05	0.25	4.45	0.946	1.63	0.45	5.86	0.455
Model 3	Deterioration of preexisting neurological condition					5.69	1.28	25.40	0.023	2.67	0.65	11.01	0.173	3.88	1.10	13.63	0.035
	Number of long COVID symptoms	1.14	1.03	1.26	0.009	1.37	1.16	1.61	<0.001	1.46	1.20	1.79	<0.001	1.22	1.07	1.39	0.003
	>90 days after contracting COVID-19	2.29	0.59	8.82	0.230	0.83	0.12	5.83	0.852	0.57	0.09	3.54	0.548	1.12	0.23	5.38	0.888
	Hospitalization for COVID-19 treatment (ref: non-hospitalization)	2.64	0.26	26.36	0.409	9.45	0.49	183.66	0.138	4.15	0.31	55.45	0.282	3.10	0.21	45.23	0.408
	Vaccination once or none (ref: twice)	1.67	0.21	13.33	0.627	0.07	0.00	3.24	0.177	0.25	0.01	5.92	0.391	2.86	0.27	30.74	0.387
	Vaccination more than three times (ref: twice)	0.92	0.23	3.69	0.901	0.91	0.17	4.92	0.917	1.53	0.29	8.16	0.617	3.51	0.75	16.32	0.109
	Age: 45–64 years (ref: <45 years)	0.12	0.02	0.79	0.027	3.73	0.36	38.68	0.269	2.34	0.23	24.03	0.475	4.40	0.62	31.34	0.139
	Age: >65 years (ref: <45 years)	0.35	0.09	1.29	0.116	2.43	0.38	15.39	0.345	4.90	0.75	32.12	0.098	2.68	0.59	12.08	0.200
	Sex: female	1.35	0.43	4.21	0.607	3.53	0.74	16.74	0.112	1.09	0.27	4.49	0.904	4.64	1.27	16.90	0.020
	BMI: ≥23 kg/m^2	0.31	0.09	1.11	0.073	0.84	0.16	4.28	0.833	1.06	0.23	4.89	0.944	0.39	0.10	1.60	0.191
	Comorbidities, n	0.85	0.44	1.64	0.633	1.01	0.43	2.35	0.989	1.12	0.53	2.37	0.763	1.29	0.60	2.75	0.518

BMI, body mass index; OR, odds ratio; 95% CI, 95% confidence interval; LLCI, lower level of the 95% confidence interval; ULCI, upper level of the 95% confidence interval.

neurodegenerative diseases, the significance of studies on the occurrence of neurodegenerative diseases after infection is increasing [30, 31]. In Daegu, where COVID-19 infection was severe in Korea in mid-2020, anosmia or ageusia was reported by 15.3% of individuals in the early stage after COVID-19 infection. Additionally, 15.7% of patients with asymptomatic to mild severity also reported these symptoms [28]. In a European study conducted with 417 patients who had mild-to-moderate COVID-19, olfactory and gustatory dysfunctions were reported in 85.6% and 88.0% of patients, respectively. A much larger proportion of patients complained [32]. Even in the study conducted by Khan et al. [29] in 2021, 52.7% of the patients appeared in the acute phase, with most of them being improved; however, 4.7% were left as sequelae.

In particular, given the elevated occurrence of anosmia or ageusia among older adults, it raises concerns about the potential for long-term postinfectious neurodegeneration leading to dementia or parkinsonism; therefore, attention should be paid to this matter [33]. This may be due to the fact that patients with a relatively short period of <6 months were also included in this study; however, hyposmia (9.4%) and hypogeusia (14.1%) appeared relatively small. Nevertheless, additional research on the long-term sequelae of these symptoms is needed. Brain fog after COVID-19 infection mainly appears as a dysexecutive syndrome [34], and this study showed decreased attention (21.2%) and cognitive decline (7.1%). Chronic post-COVID "brain fog" is significantly associated with female sex, respiratory symptoms at the onset, and the severity of the illness (intensive care unit admission), so caution is needed when these risk factors are present [20, 35]. Fatigue and cognitive impairment are experienced by a significant proportion of patients as part of post-COVID-19 syndrome, and understanding the evaluation and management of both conditions is becoming increasingly important [20, 35].

Logistic regression analysis revealed that the number of long COVID symptoms significantly predicted subjective deterioration of preexisting neurological conditions. Furthermore, both the number of long COVID symptoms and the deterioration of preexisting conditions had an impact on depression, anxiety, and fatigue. Even after controlling other variables, the number of symptoms remained a significant factor affecting depression, anxiety, and fatigue. Approximately one-third of the participants experienced symptoms of depression, anxiety, and fatigue, which were similar to or slightly higher than those reported by Han et al. [36] and Shanbehzadeh et al. [37]. However, in this study, variables, such as demographics, COVID-19 severity, number of vaccinations, and duration since COVID-19 infection, were not associated with depression, anxiety, and fatigue in the regression model, except for a greater impact of females on fatigue. This may be due to the small sample size of the present study. Additionally, participants reported a significant decrease in their QOL compared to before contracting COVID-19. This is consistent with systematic literature reviews that have indicated a decline in QOL in at least one domain after COVID-19 [20]. In summary, long COVID symptoms not only subjectively worsen neurological conditions but also have a broad impact on mental health and overall QOL.

This study has several limitations. First, convenience sampling from a single hospital limits the generalizability of the findings. However, efforts were made to ensure a diverse representation of participants with various neurological disorders and the distribution of disease severity resembled the actual distribution of COVID-19 severity. Second, the data collection relied on self-reporting, which introduced the possibility of subjective bias, and the degree of disease deterioration was not objectively assessed. Additionally, the retrospective nature of the data collection may lead to reduced reliability when evaluating the participants' health status prior to their current state. Therefore, future studies should consider incorporating prospective data collection methods to obtain a more objective assessment of the health status and severity of post-COVID-19 sequelae.

Conclusion

This study provides valuable insights into the management of patients with neurological conditions and a history of COVID-19. These findings indicate that patients with neurological disorders experience a range of post-COVID-19 symptoms associated with the subjective deterioration of neurological conditions, mental health, and overall QOL. Given the various management options available for long COVID, including pharmaceutical and rehabilitation treatments, close observation and proactive management are crucial when caring for patients with neurological conditions.

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Statement of Ethics

This study was approved by the Ethics Committee of Inje University Busan Paik Hospital (IRB No. 2022-11-042). The requirement for informed consent was waived due to the retrospective study design.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Juyeon Oh and Seong-il Oh contributed to the study concept, design, and data analysis. Juyeon Oh, Eun Joo Chung, Jin Ho Jung, Jin San Lee, and Seong-il Oh contributed to the data acquisition and interpretation. Juyeon Oh and Seong-il Oh contributed to the drafting of the manuscript. Juyeon Oh, Eun Joo Chung, Jin Ho Jung, Jin San Lee, and Seong-il Oh have read and approved the final draft of the manuscript.

Data Availability Statement

The datasets supporting the conclusions of this article are available from the corresponding author upon reasonable request. Data are not publicly available due to ethical reasons. Further inquiries can be directed to the corresponding author.

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