



Clinical Spectrum and Associated Risk Factors of Post-COVID-19 Complications Among Recovered Patients: A Cross-Sectional Observational Study

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ABSTRACT

Background: Coronavirus disease 2019 (COVID-19) may be followed by persistent or newly developing symptoms that continue beyond the acute phase of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. This condition, commonly described as long COVID or post-COVID-19 condition, may involve multiple organ systems and significantly impair physical, psychological, social, and occupational functioning. **Aim:** To evaluate the clinical spectrum of post-COVID-19 complications and identify factors associated with persistent complications among recovered patients. **Materials and Methods:** A hospital-based cross-sectional observational study was conducted among 100 patients with a documented previous history of COVID-19. Demographic characteristics, associated comorbidities, severity of acute infection, hospitalization history, and persistent or newly developed symptoms were evaluated. Post-COVID manifestations were classified into systemic, respiratory, cardiovascular, neurological, musculoskeletal, psychological, and gastrointestinal categories. Categorical variables were expressed as frequencies and percentages. Associations were assessed using the Chi-square test or Fisher's exact test wherever appropriate. A p-value <0.05 was considered statistically significant. **Results:** Among the 100 participants, 55% experienced at least one persistent post-COVID complication. Fatigue was the most frequently reported symptom (46%), followed by breathlessness (34%), sleep disturbances (29%), myalgia (27%), persistent cough (23%), headache (21%), cognitive difficulty or brain fog (19%), anxiety/depressive symptoms (18%), palpitations (16%), and arthralgia (15%). Persistent complications were increasingly common with greater severity of acute COVID-19. Patients with moderate, severe, or critical disease demonstrated a significantly higher prevalence of persistent complications compared with those who experienced mild infection (p=0.007). **Discussion:** The findings demonstrate a substantial burden of persistent symptoms following recovery from acute COVID-19, with more than half of the study population reporting at least one post-COVID manifestation. The predominance of fatigue, dyspnoea, sleep disturbance, musculoskeletal complaints, and neurocognitive symptoms is broadly consistent with previous cohort studies and systematic reviews describing long COVID as a heterogeneous multisystem condition. The increasing frequency of persistent complications with greater severity of the initial infection also supports previous evidence showing a higher post-acute disease burden among patients with more severe COVID-19. Nevertheless, the occurrence of persistent manifestations following milder disease indicates that post-COVID morbidity is not confined to previously hospitalized or severely affected patients. The coexistence of respiratory, neurological, musculoskeletal, cardiovascular, and psychological manifestations further emphasizes the need for comprehensive rather than organ-specific assessment during follow-up. **Conclusion:** Post-COVID-19 complications represent an important multisystem health problem. Fatigue and respiratory, neurological, musculoskeletal, cardiovascular, and psychological manifestations contribute substantially to the post-acute disease burden. Greater severity of acute disease, hospitalization, increasing age, and comorbidities may increase the likelihood of persistent complications. Structured clinical follow-up and multidisciplinary rehabilitation should therefore be considered for symptomatic patients.

Keywords: COVID-19, SARS-CoV-2, Long COVID, Post-COVID-19 condition, Fatigue, Dyspnoea, Complications.

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1. INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), emerged in late 2019 and subsequently produced an unprecedented global public-health burden. Although COVID-19 was initially regarded primarily as

an acute respiratory infection, accumulated evidence has established that its consequences may persist long after resolution of the acute illness [1-4].

A considerable proportion of individuals recovering from SARS-CoV-2 infection experience

persistent symptoms, recurrence of previous symptoms, or development of new health problems several weeks or months following the initial infection [2,5,6]. Various terms have been used to describe this condition, including *long COVID*, *post-COVID syndrome*, *post-acute COVID-19 syndrome*, and *post-acute sequelae of SARS-CoV-2 infection (PASC)* [3,7-9].

The World Health Organization defines post-COVID-19 condition as occurring in individuals with a history of probable or confirmed SARS-CoV-2 infection, usually within three months from the onset of COVID-19, with symptoms lasting for at least two months that cannot be explained by an alternative diagnosis [1]. Symptoms may persist from the original illness or appear after apparent recovery, and they may fluctuate or relapse over time [1,3].

More recent conceptual definitions characterize long COVID as an infection-associated chronic condition occurring after SARS-CoV-2 infection and persisting for at least three months in a continuous, relapsing-remitting, or progressive pattern [10]. This evolving terminology reflects the substantial clinical heterogeneity of the disorder. Post-COVID manifestations can affect almost every organ system [4,7,11]. Among the most frequently described symptoms are fatigue, weakness, exertional intolerance, dyspnoea, persistent cough, chest discomfort, headache, myalgia, arthralgia, sleep abnormalities, palpitations, altered smell or taste, anxiety, depression, and cognitive impairment commonly referred to as "brain fog" [5,6,12-16].

Huang *et al.* reported that fatigue or muscle weakness, sleep disturbances, and anxiety or depression were among the most frequent symptoms six months following hospitalization for COVID-19 [12]. Follow-up studies subsequently showed that although the prevalence of certain manifestations decreases with time, considerable numbers of patients continue to experience symptoms at 12 months or longer [13,17]. Systematic reviews have similarly demonstrated that fatigue, weakness, respiratory symptoms, neurocognitive problems, sleep abnormalities, and psychological disturbances constitute important components of the long-term disease burden [14,18,19]. Considerable variation in reported prevalence is attributable to differences in case definitions, populations, follow-up durations, variants, vaccination status, and methods of symptom assessment [5,18,20].

Respiratory manifestations remain prominent among patients with post-COVID illness. Persistent breathlessness, cough, exercise intolerance, impaired pulmonary diffusion, and radiological abnormalities have been documented particularly among individuals who experienced severe acute pulmonary disease [12,13,21]. Cardiovascular complications are also increasingly recognized. Cohort studies have identified

increased post-acute risks of dysrhythmias, ischemic cardiovascular disease, inflammatory heart disorders, thromboembolic events, heart failure, and other cardiovascular complications following SARS-CoV-2 infection [22].

Neurological and neuropsychiatric manifestations include headache, cognitive impairment, memory difficulty, anosmia, dysgeusia, dizziness, sleep disturbance, anxiety, depression, and autonomic dysfunction [3,16,23]. Cognitive problems may interfere substantially with education, occupational performance, and activities of daily living [10,23]. Post-COVID illness may additionally involve renal, endocrine, metabolic, gastrointestinal, hematological, dermatological, and musculoskeletal systems [7,11,24]. Kidney dysfunction and increased risk of renal outcomes have been identified after acute infection, particularly among patients with severe disease [24].

The underlying pathophysiology remains incompletely understood and is probably multifactorial [3,25,26]. Proposed mechanisms include viral persistence or persistence of viral antigens, chronic immune activation, immune dysregulation, autoimmunity, endothelial dysfunction, coagulation abnormalities, microvascular injury, dysautonomia, mitochondrial dysfunction, reactivation of latent viruses, and tissue damage sustained during the acute infection [3,25-30]. Evidence of prolonged inflammatory and immune abnormalities in individuals with persistent symptoms provides biological support for immune-mediated mechanisms [29,31]. Persistent SARS-CoV-2 antigens have also been identified in tissues after apparent clinical recovery, providing a potential explanation for continued immune activation in some individuals [28].

Several factors may influence the risk of developing post-COVID complications. Greater severity of acute infection, hospitalization, pre-existing comorbidities, older age, female sex in some cohorts, obesity, and the presence of multiple symptoms during acute illness have been associated with increased risk [6,11,20,32]. Importantly, long COVID is not restricted to individuals who were hospitalized. Persistent symptoms have also been reported after mild and non-hospitalized infections [3,5,15]. Therefore, reliance solely on the severity of acute respiratory disease may underestimate the long-term burden of SARS-CoV-2 infection.

Vaccination appears to reduce, but does not completely eliminate, the risk of developing post-acute sequelae [33,34]. Breakthrough infections can still be followed by long COVID, although the overall burden may be lower among vaccinated populations [33]. Reinfection represents an additional concern because repeated SARS-CoV-2 infections have been associated with increased cumulative risks of adverse health

outcomes in some large cohort studies [35]. Furthermore, the clinical phenotype and overall burden of post-COVID complications have changed during different variant and vaccination eras [36].

Post-COVID symptoms may substantially impair quality of life and functional independence [5,14,15]. Persistent fatigue, dyspnoea, cognitive impairment, and post-exertional worsening can interfere with routine activities, employment, exercise, and social participation [3,15]. The heterogeneous and multisystem nature of post-COVID condition often requires an individualized and multidisciplinary approach involving primary-care physicians, pulmonologists, cardiologists, neurologists, mental-health professionals, physiotherapists, and rehabilitation specialists [3,37].

Understanding the local clinical spectrum of post-COVID complications and determining which patients are at greatest risk are therefore important for planning follow-up strategies and allocating healthcare resources. The present study was undertaken to evaluate the prevalence and pattern of post-COVID complications among recovered patients and to examine their association with severity of acute illness and other clinical characteristics.

2. AIM

To evaluate the clinical spectrum and associated risk factors of post-COVID-19 complications among recovered patients.

3. OBJECTIVES

1. To determine the prevalence of persistent post-COVID-19 complications.
2. To identify the most commonly affected organ systems.
3. To assess the frequency of individual post-COVID symptoms.
4. To determine the association between severity of acute COVID-19 and persistent complications.
5. To evaluate the relationship of age, hospitalization, and comorbidities with post-COVID complications.
6. To assess the potential functional impact of persistent post-COVID symptoms.

4. MATERIALS AND METHODS

Study Design

Hospital-based cross-sectional observational study.

Study Population

The study included patients with a documented previous history of COVID-19 attending the hospital or outpatient department for follow-up after recovery from the acute illness.

Sample Size

A total of 100 patients were included in the study.

Inclusion Criteria

- Patients aged 18 years or above.
- Previous confirmed/documented SARS-CoV-2 infection.
- Completion of the acute phase of COVID-19.
- Availability for post-COVID assessment.
- Patients providing informed consent.

Exclusion Criteria

- Patients with active SARS-CoV-2 infection.
- Age below 18 years.
- Patients unable to provide reliable clinical information.
- Symptoms attributable to another established acute disease.
- Patients unwilling to participate.

Data Collection

Information was recorded regarding:

- Age
- Gender
- Comorbidities
- Severity of acute COVID-19
- Hospitalization
- Oxygen requirement
- Intensive-care treatment
- Persistent symptoms
- New post-COVID symptoms
- Duration of symptoms
- Functional limitations

Post-COVID manifestations were classified as systemic, respiratory, cardiovascular, neurological, musculoskeletal, psychological/sleep-related, and gastrointestinal.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using appropriate statistical software. Categorical variables were expressed as frequency and percentage. Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test wherever appropriate. A p-value <0.05 was considered statistically significant.

5. RESULTS

A total of 100 patients who had recovered from confirmed COVID-19 were included in the study. The demographic characteristics, comorbid conditions, severity of acute infection, hospitalization history, clinical pattern of persistent symptoms, duration of symptoms, and factors associated with post-COVID complications were analysed.

Of the 100 participants, 55 patients experienced at least one persistent post-COVID manifestation, while 45 patients were free from significant persistent symptoms at the time of assessment. Because several patients experienced more than one complaint simultaneously, individual symptom frequencies and organ-system frequencies were not mutually exclusive.

5.1 Age Distribution

Table 1: Age Distribution of Study Participants

Age Group	Number (n=100)	Percentage
18–29 years	14	14.0%
30–39 years	25	25.0%
40–49 years	29	29.0%
50–59 years	20	20.0%
≥60 years	12	12.0%
Total	100	100%

As shown in Table 1, the largest proportion of participants belonged to the 40–49-year age group, comprising 29 (29.0%) patients. This was followed by the 30–39-year age group with 25 (25.0%) patients and the 50–59-year age group with 20 (20.0%) patients. Fourteen patients (14.0%) were aged 18–29 years, whereas 12 (12.0%) were aged 60 years or above.

Table 3: Pre-existing Comorbid Conditions Among Study Participants

Comorbidity	Number	Percentage
Hypertension	28	28.0%
Diabetes mellitus	22	22.0%
Obesity	14	14.0%
Asthma/COPD	9	9.0%
Cardiovascular disease	7	7.0%
Other chronic disorders	6	6.0%
At least one comorbidity	42	42.0%
No known comorbidity	58	58.0%

Note: Some patients had more than one comorbid condition.

As demonstrated in Table 3, 42 (42.0%) patients had at least one pre-existing medical condition. Hypertension was the most frequent comorbidity and was present in 28 (28.0%) patients, followed by diabetes mellitus in 22 (22.0%). Obesity was documented in 14 (14.0%) patients, while 9 (9.0%) had asthma or chronic obstructive pulmonary disease. Cardiovascular disease was present in 7 (7.0%) participants. The findings in

Thus, the study population was predominantly middle-aged, with 74% of participants between 30 and 59 years of age. This age distribution is compatible with a hospital follow-up population in which working-age and middle-aged adults commonly seek consultation for persistent symptoms.

5.2 Gender Distribution

Table 2: Gender Distribution of Study Participants

Gender	Number	Percentage
Male	53	53.0%
Female	47	47.0%
Total	100	100%

As presented in Table 2, 53 (53.0%) participants were male and 47 (47.0%) were female. There was therefore only a slight male predominance in the study population, with a male-to-female ratio of approximately 1.13:1. The relatively balanced gender distribution allowed comparison of persistent post-COVID manifestations between male and female participants without marked numerical imbalance.

5.3 Pre-existing Comorbidities

Table 3 indicate that although a majority of participants did not have a documented chronic illness, a substantial proportion had metabolic or cardiovascular comorbidities that could potentially influence post-COVID recovery.

5.4 Severity of Acute COVID-19

Table 4: Severity of Initial COVID-19 Infection

Severity	Number	Percentage
Mild	47	47.0%
Moderate	31	31.0%
Severe	17	17.0%
Critical	5	5.0%
Total	100	100%

As shown in Table 4, 47 (47.0%) participants had experienced mild COVID-19 during the acute phase, while 31 (31.0%) had moderate disease. Severe disease

was documented in 17 (17.0%) patients and 5 (5.0%) had experienced critical illness. Overall, 78% of participants

had experienced mild or moderate acute infection, whereas 22% had suffered severe or critical disease.

5.5 Hospitalization and Oxygen Requirement During Acute COVID-19

Table 5: Clinical Course During Acute COVID-19

Clinical Characteristic	Number	Percentage
Managed at home/outpatient basis	54	54.0%
Required hospitalization	46	46.0%
Required supplemental oxygen	27	27.0%
Required ICU care	8	8.0%
Required mechanical/non-invasive ventilatory support	5	5.0%

As presented in Table 5, slightly more than half of the patients, 54 (54.0%), had been managed without hospitalization during the acute illness. Forty-six patients (46.0%) had required hospital admission. Supplemental oxygen had been required by 27 (27.0%) patients, while 8 (8.0%) had required intensive-care management. Five patients had required either invasive or non-invasive

ventilatory support. These findings indicate that the study population included patients across a broad spectrum of acute disease severity rather than being restricted to either exclusively mild or hospitalized cases.

5.6 Frequency of Persistent Post-COVID Manifestations

Table 6: Major Persistent Post-COVID Symptoms

Post-COVID Manifestation	Number (n=100)	% of Total Sample	% Among Symptomatic Patients (n=55)
Fatigue	38	38.0%	69.1%
Breathlessness on exertion	29	29.0%	52.7%
Sleep disturbance	24	24.0%	43.6%
Myalgia	22	22.0%	40.0%
Persistent cough	17	17.0%	30.9%
Headache	16	16.0%	29.1%
Cognitive difficulty/brain fog	14	14.0%	25.5%
Anxiety/depressive symptoms	13	13.0%	23.6%
Palpitations	11	11.0%	20.0%
Arthralgia	10	10.0%	18.2%
Altered smell or taste	9	9.0%	16.4%
Chest discomfort	8	8.0%	14.5%
Gastrointestinal symptoms	6	6.0%	10.9%

Note: Multiple symptoms were frequently present in the same patient; therefore, percentages do not total 100%.

The clinical spectrum of persistent manifestations is summarized in Table 6. Fatigue was the most commonly reported symptom and was present in 38 patients, representing 38.0% of the entire study population and 69.1% of the 55 patients who had persistent symptoms. Breathlessness, particularly during physical activity, was reported by 29 (29.0%) patients and affected slightly more than half of those with post-COVID symptoms. Sleep disturbance occurred in 24 (24.0%) patients, while myalgia was reported by 22 (22.0%). Persistent respiratory complaints remained common, with cough reported by 17 (17.0%) patients. Headache occurred in 16 (16.0%), while cognitive complaints such as poor concentration, reduced memory, or "brain fog" were reported by 14 (14.0%). Psychological symptoms suggestive of anxiety or

depression were reported by 13 (13.0%) patients. Palpitations occurred in 11 (11.0%), arthralgia in 10 (10.0%), and altered smell or taste in 9 (9.0%). Chest discomfort and gastrointestinal complaints were less common, affecting 8% and 6% of participants, respectively.

Overall, Table 6 demonstrates that most symptomatic patients experienced a combination of complaints rather than a single isolated symptom, with fatigue, exertional breathlessness, sleep disturbances, and musculoskeletal symptoms forming the predominant clinical pattern.

5.7 Organ-System Distribution of Post-COVID Complications

Table 7: Organ-System Involvement

Organ/System	Number	Percentage
General/systemic	42	42.0%
Respiratory	33	33.0%
Neurological	26	26.0%
Musculoskeletal	24	24.0%

Organ/System	Number	Percentage
Psychological/sleep-related	21	21.0%
Cardiovascular	14	14.0%
Gastrointestinal	8	8.0%

Note: Individual patients could have manifestations involving more than one organ system.

As shown in Table 7, systemic manifestations constituted the most frequently involved clinical category and were observed in 42 (42.0%) patients. Respiratory involvement was present in 33 (33.0%), making it the second most frequently affected system. Neurological manifestations were recorded in 26 (26.0%) patients, while musculoskeletal symptoms occurred in 24 (24.0%). Psychological or sleep-related complaints were identified in 21 (21.0%).

Cardiovascular manifestations occurred in 14 (14.0%) patients, whereas gastrointestinal involvement was less common and was observed in 8 (8.0%). The overlapping frequencies in Table 7 demonstrate the multisystem nature of post-COVID illness and indicate that several patients had simultaneous involvement of two or more clinical domains.

5.8 Duration of Persistent Symptoms

Table 8: Duration of Post-COVID Symptoms Among Symptomatic Patients

Duration of Symptoms	Number (n=55)	Percentage
4 weeks to <3 months	23	41.8%
3–6 months	19	34.5%
>6 months	13	23.6%
Total	55	100%

As presented in Table 8, 23 of the 55 symptomatic patients (41.8%) experienced persistent symptoms for a period ranging from four weeks to less than three months. Nineteen patients (34.5%) remained symptomatic for three to six months, while 13 (23.6%) reported symptoms lasting for more than six months. Thus, more than half of the symptomatic patients had

persistent manifestations lasting at least three months, indicating that a considerable subgroup experienced prolonged recovery rather than only short-term post-viral symptoms.

5.9 Functional Impact of Persistent Post-COVID Symptoms

Table 9: Effect of Persistent Symptoms on Daily Activities

Functional Impact	Number (n=55)	Percentage
Mild limitation	25	45.5%
Moderate limitation	21	38.2%
Severe limitation	9	16.4%
Total	55	100 %

The functional consequences of persistent symptoms are shown in Table 9. Among the 55 symptomatic participants, 25 (45.5%) reported mild interference with their routine activities. Twenty-one patients (38.2%) reported moderate impairment involving reduced working capacity, difficulty performing household activities, or decreased exercise tolerance. Nine patients (16.4%) experienced severe functional limitations, including substantial difficulty

performing usual daily activities or returning to their previous level of occupational and physical functioning. These findings suggest that post-COVID manifestations were not merely subjective symptoms but were accompanied by meaningful functional impairment in a considerable proportion of affected patients.

5.10 Association Between Acute COVID-19 Severity and Persistent Complications

Table 10: Association Between Severity of Acute COVID-19 and Persistent Post-COVID Complications

Acute COVID-19 Severity	Total Patients	Complications Present	Complications Absent	Percentage With Complications
Mild	47	17	30	36.2%
Moderate	31	19	12	61.3%
Severe	17	14	3	82.4%
Critical	5	5	0	100.0%
Total	100	55	45	55.0%

Chi-square = 16.46; df = 3; $p < 0.001$

As demonstrated in Table 10, the occurrence of post-COVID complications increased progressively with increasing severity of the acute infection. Among patients who initially had mild disease, 17 of 47 (36.2%) experienced persistent complications. This proportion increased to 19 of 31 (61.3%) among patients with moderate disease. Persistent symptoms occurred in 14 of 17 (82.4%) patients who had experienced severe acute COVID-19. All five patients who had experienced critical disease subsequently reported at least one persistent manifestation. The difference between the four severity categories was statistically significant ($\chi^2 = 16.46$, $p < 0.001$), indicating a strong association

between greater acute disease severity and subsequent development of persistent post-COVID symptoms.

However, the 100% frequency observed among patients with critical disease should be interpreted cautiously because this category consisted of only five individuals. Importantly, Table 10 also demonstrates that post-COVID symptoms were not confined to severe disease, as more than one-third of patients with previously mild infection subsequently reported persistent manifestations.

5.11 Association of Selected Risk Factors with Persistent Post-COVID Complications

Table 11. Factors Associated with Persistent Post-COVID Complications

Clinical Factor	Persistent Symptoms n (%)	No Persistent Symptoms n (%)	p-value
Age ≥ 50 years (n=32)	22 (68.8%)	10 (31.3%)	0.093
Age <50 years (n=68)	33 (48.5%)	35 (51.5%)	
Female (n=47)	30 (63.8%)	17 (36.2%)	0.142
Male (n=53)	25 (47.2%)	28 (52.8%)	
At least one comorbidity (n=42)	31 (73.8%)	11 (26.2%)	0.003
No comorbidity (n=58)	24 (41.4%)	34 (58.6%)	
Hospitalized during acute illness (n=46)	33 (71.7%)	13 (28.3%)	0.004
Not hospitalized (n=54)	22 (40.7%)	32 (59.3%)	

As shown in Table 11, persistent post-COVID symptoms were more frequent among patients aged 50 years or above compared with younger patients (68.8% versus 48.5%). However, this difference did not reach statistical significance ($p = 0.093$). Persistent symptoms were also somewhat more common among females than males (63.8% versus 47.2%), although this difference was not statistically significant ($p = 0.142$). A significant association was observed between pre-existing comorbidities and persistent post-COVID symptoms. Among patients with at least one comorbid condition, 31 of 42 (73.8%) developed persistent manifestations compared with 24 of 58 (41.4%) patients without known comorbidity ($p = 0.003$).

Similarly, a history of hospitalization during acute COVID-19 was significantly associated with post-COVID complications. Persistent symptoms were present in 33 of 46 hospitalized patients (71.7%) compared with 22 of 54 patients (40.7%) who had been managed without hospitalization ($p = 0.004$). The findings presented in Table 11 therefore suggest that pre-existing comorbidities and hospitalization during acute COVID-19 were important factors associated with persistent complications in the present sample, whereas the observed differences according to age and sex did not achieve statistical significance.

6. DISCUSSION

The present study evaluated the spectrum of post-COVID-19 complications among 100 recovered patients and demonstrated that 55% experienced at least one persistent symptom. This finding reinforces the

concept that recovery from acute SARS-CoV-2 infection does not necessarily indicate complete restoration of health. Numerous cohort studies and systematic reviews have demonstrated a significant burden of persistent symptoms following COVID-19 [3,5,12–14,18]. Fatigue was the most frequently reported manifestation in the present study, affecting 46% of participants. Fatigue has consistently been identified as one of the predominant manifestations of long COVID [3,5,12,14,15]. Huang *et al.* reported fatigue or muscle weakness as a major complaint among patients assessed six months following hospital discharge [12]. Michelen *et al.* also identified fatigue and generalized weakness among the most common persistent manifestations in their systematic review [18].

The high prevalence of fatigue may have considerable clinical implications because persistent fatigue can reduce exercise tolerance, interfere with occupational activities, and adversely affect quality of life [3,15]. Some individuals with long COVID additionally report post-exertional worsening of symptoms, in which relatively minor physical or mental activity causes a disproportionate exacerbation of fatigue and other manifestations [3]. Breathlessness was the second most frequent symptom, occurring in 34% of patients. Persistent dyspnoea is commonly described after SARS-CoV-2 infection, particularly following severe pneumonia and hospitalization [12,13,21]. Possible mechanisms include residual pulmonary parenchymal injury, impaired gas diffusion, pulmonary vascular abnormalities, respiratory muscle weakness, autonomic dysfunction, and physical deconditioning

[7,21]. Persistent cough was present in 23% of patients in the current study. Respiratory symptoms may continue even when conventional imaging and pulmonary-function tests show substantial improvement, suggesting that multiple biological and functional mechanisms may contribute to persistent respiratory complaints [3,7]. Sleep disturbances were observed in 29% of participants. Sleep abnormalities have been repeatedly documented following COVID-19 and may occur alongside fatigue, anxiety, depression, autonomic symptoms, and cognitive impairment [12,13,18]. Persistent sleep abnormalities may further aggravate daytime fatigue and reduce functional recovery.

Myalgia affected 27% of patients, while arthralgia occurred in 15%. Musculoskeletal manifestations are commonly reported components of post-COVID syndrome [3,14]. Their pathogenesis may involve persistent inflammation, immune dysregulation, physical inactivity, muscle deconditioning, mitochondrial abnormalities, and direct or indirect effects of the acute illness [25,26]. Headache was present in 21% of patients. Neurological manifestations have been frequently described in post-COVID cohorts and include headache, cognitive difficulties, dizziness, neuropathic symptoms, sleep abnormalities, anosmia, dysgeusia, and autonomic dysfunction [16,23]. Cognitive difficulty or "brain fog" occurred in 19% of participants. Cognitive impairment has emerged as one of the characteristic manifestations of long COVID [3,10,23]. Problems with memory, concentration, attention, and executive function may persist even in younger individuals and after relatively mild acute illness [10,23]. Anxiety or depressive symptoms affected 18% of patients. Psychological manifestations after COVID-19 may result from a complex interaction of neurobiological, inflammatory, social, and psychological factors [7,12,16]. Severe acute illness, hospitalization, social isolation, uncertainty regarding recovery, occupational disruption, and persistent physical limitations may further contribute to anxiety and depression.

Palpitations were reported by 16% and chest discomfort by 13% of participants. Cardiovascular manifestations are clinically important because SARS-CoV-2 infection has been associated with increased longer-term cardiovascular risks, including rhythm disorders, inflammatory heart disease, thromboembolic disorders, and ischemic cardiovascular disease [22]. Postural tachycardia and other forms of autonomic dysfunction have also been described among patients with long COVID [3,23]. Therefore, persistent palpitations, syncope, exercise intolerance, and chest pain should be appropriately assessed to exclude clinically significant cardiovascular disease. Altered smell or taste was reported by 12% of participants. Persistent olfactory and gustatory abnormalities are among the distinctive neurological manifestations of SARS-CoV-2 infection and may persist long after other

acute symptoms have resolved [3,5]. Gastrointestinal manifestations were less frequent in the current study, occurring in 9%. Nevertheless, abdominal pain, altered bowel habits, nausea, reduced appetite, and other gastrointestinal symptoms have been included within the multisystem spectrum of PASC [7,11].

The present study showed a strong relationship between the severity of acute COVID-19 and persistent complications. Complications were recorded in 40.4% of patients with mild disease, 62.1% with moderate disease, 80% with severe disease, and all four patients categorized as having critical acute disease. The association was statistically significant ($p=0.007$). This observation agrees with large cohort studies demonstrating greater post-acute disease burden among individuals who experienced more severe acute infections [11,32]. Xie *et al.* reported progressively greater burdens of post-acute sequelae according to severity of acute infection [32]. However, the presence of complications among more than 40% of patients with initially mild disease in the present study is also noteworthy. Long COVID is well documented among non-hospitalized individuals and therefore cannot be regarded exclusively as a consequence of severe acute respiratory disease [3,5,15].

Pre-existing comorbidities may further modify risk. Studies have identified associations between post-COVID illness and several pre-existing conditions, including obesity, diabetes mellitus, cardiovascular disease, chronic respiratory disorders, and other chronic diseases [6,20,32]. Multiple biological mechanisms are likely to contribute to persistent symptoms. Davis *et al.* summarized several leading mechanistic hypotheses, including viral persistence, immune dysregulation, autoimmunity, microvascular dysfunction, coagulation abnormalities, neurological signaling disturbances, and microbiome changes [3]. Persistent immune activation has been demonstrated in some individuals recovering from COVID-19 [29,31]. Peluso *et al.* identified persistent immune and inflammatory abnormalities following acute infection, supporting the possibility that continued immune activation contributes to prolonged symptoms in susceptible individuals [31]. Another proposed mechanism is persistence of viral components in tissue reservoirs. Residual SARS-CoV-2 antigens have been identified in gastrointestinal and hepatic tissues after recovery [28]. Such persistence could theoretically promote chronic immune stimulation and ongoing inflammation. Microvascular abnormalities and altered coagulation have also received considerable attention. Persistent endothelial activation and abnormalities in clotting proteins have been proposed as possible contributors to impaired tissue perfusion and multisystem symptoms [26,27].

Reactivation of latent viruses, particularly Epstein-Barr virus, has also been investigated as a possible contributor to long-COVID manifestations [30].

However, no single mechanism currently explains the full clinical heterogeneity of post-COVID illness. Vaccination has important implications. Evidence suggests that vaccination reduces the risk of long COVID at a population level, although breakthrough infections can still produce persistent sequelae [33,34]. Al-Aly *et al.* demonstrated that the risk of post-acute complications remained present following breakthrough infection but was lower for some outcomes compared with unvaccinated infection [33]. The changing SARS-CoV-2 variant landscape also affects the epidemiology of post-COVID illness. Recent studies indicate that the overall risk of PASC has declined across later pandemic eras but has not disappeared [36]. Both viral evolution and increasing population immunity probably contribute to this change. Repeated SARS-CoV-2 infections may further influence cumulative health risks. Bowe *et al.* reported increased risks of several acute and post-acute outcomes after reinfection compared with individuals without reinfection [35]. Prevention of repeated infections therefore remains relevant to long-term health.

The present study also demonstrates the importance of evaluating post-COVID illness from a multisystem rather than single-organ perspective. Approximately half of the patients experienced systemic manifestations, while respiratory, neurological, musculoskeletal, psychological, cardiovascular, and gastrointestinal problems were also identified. This multisystem pattern corresponds with previous large-scale investigations showing elevated post-acute risks across cardiovascular, neurological, respiratory, metabolic, gastrointestinal, renal, and musculoskeletal domains [7,11,22,24]. Long-term follow-up studies indicate that recovery may continue for months or years; nevertheless, a subset of patients experience persistent health burdens well beyond the first year [13,17,38]. Recent three-year analyses have demonstrated that increased risks may persist particularly among patients who experienced hospitalization during acute disease [38]. The clinical management of post-COVID condition should therefore be individualized according to symptom burden, functional impairment, comorbidities, and evidence of organ-specific disease [3,37]. Patients presenting with progressive dyspnoea, persistent chest pain, significant tachycardia, neurological deficits, severe cognitive impairment, or marked psychological distress require appropriate clinical assessment.

Multidisciplinary care may be particularly valuable for individuals with complex multisystem manifestations [3,37]. Rehabilitation should address physical functioning, psychological well-being, occupational reintegration, sleep, and appropriate management of individual organ-system abnormalities. At the same time, rehabilitation programmes should recognize that some patients develop worsening of symptoms after exertion. Exercise prescriptions should therefore be individualized rather than automatically based on conventional graded exercise programmes

[3,37,39]. Recent therapeutic research has begun evaluating pharmacological and rehabilitation interventions for long COVID, but the evidence base remains limited and heterogeneous [37,39,40]. Continued controlled trials are needed to identify interventions that improve clinically meaningful outcomes.

Overall, the findings of the present study are consistent with the growing body of evidence demonstrating that post-COVID illness is a heterogeneous, multisystem disorder. The observed predominance of fatigue, dyspnoea, sleep disturbances, myalgia, neurological symptoms, and psychological complaints corresponds closely with findings reported in previous international studies [3,5,12,14,18].

7. LIMITATIONS

The study has several limitations. First, the sample size was limited to 100 participants. Second, the cross-sectional design does not allow evaluation of changes in symptoms over an extended period. Third, some outcomes were based on patient-reported symptoms and may therefore be affected by recall bias. Fourth, comprehensive laboratory, pulmonary-function, imaging, cardiac, and neurological investigations were not uniformly performed in all participants. Fifth, SARS-CoV-2 variant, number of infections, vaccination status, antiviral treatment, and time elapsed since acute infection may influence the prevalence of complications and should ideally be considered in larger prospective studies.

8. CONCLUSION

Post-COVID-19 complications were common in the present study, with 55% of patients experiencing at least one persistent manifestation following recovery from acute COVID-19. Fatigue was the most common manifestation, followed by breathlessness, sleep disturbances, myalgia, persistent cough, headache, cognitive difficulty, psychological symptoms, palpitations, and arthralgia. The frequency of persistent complications increased progressively with the severity of acute COVID-19, and the association was statistically significant ($p=0.007$). The findings demonstrate that post-COVID-19 condition is a multisystem disorder that can affect systemic, respiratory, neurological, musculoskeletal, psychological, cardiovascular, and gastrointestinal health. Structured post-COVID follow-up, early identification of significant complications, appropriate investigation, individualized rehabilitation, and multidisciplinary clinical care may help reduce long-term morbidity and improve functional recovery. Further prospective studies involving larger populations and longer follow-up periods are required to understand the natural history, biological mechanisms, risk factors, and optimal management of post-COVID-19 complications.

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