
REVIEW ARTICLE**Beyond recovery: A systematic review and meta-analysis of post-COVID symptomatology and impacts**

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Abstract

The long-term health effects of COVID-19, commonly referred to as post-COVID conditions, have emerged as a significant public health concern. Characterized by persistent symptoms across multiple domains, post-COVID symptoms impact a substantial proportion of individuals following the acute phase of infection. This systematic review and meta-analysis aimed to provide a comprehensive overview of the prevalence and variability of post COVID symptoms: A systematic search of the PubMed and Medline database was conducted from March 2020 to March 2025 using predefined keywords. Peer-reviewed interventional and observational studies, including cross-sectional, case-control, and cohort designs, reporting post-COVID symptoms were included. Data extraction and quality assessment were performed independently by two reviewers. Meta-analysis was conducted for symptoms with sufficient data pooled proportion using Random effects model, and heterogeneity was evaluated using the I² statistic. Out of 1,647 studies retrieved, 16 were included in the final analysis, encompassing 4,542 post-COVID-19 patients, of whom 66% were male and 34% female. Neurocognitive symptoms emerged as the most frequently reported issues, with sleep disorders being the most common. Other prominent symptoms included dyspnoea, fatigue, cognitive impairment, chest pain, and headache. These symptoms highlight the diverse and persistent health challenges faced by individuals in the post-COVID phase. The variability in study populations, methodologies, and reporting standards observed across the included studies underscores the complexity of understanding the long-term impacts of COVID-19 and the need for consistent research frameworks. This systematic review highlights the diverse and significant burden of long COVID symptoms, with sleep disorders, dyspnoea, cognitive impairment, and fatigue emerging as the most prevalent. These symptoms have profound implications for individuals' health, productivity, and quality of life. The findings emphasize the need for ongoing research, evidence-based interventions, and multidisciplinary care strategies to effectively address the long-term impacts of COVID-19 and improve outcomes for affected individuals. These findings should be interpreted with caution due to substantial heterogeneity across studies and the limited geographical diversity of the available evidence.

Keywords: COVID-19, Post-COVID Conditions, Sleep Disorders, Dyspnoea, Cognitive Impairment, Fatigue

Introduction

The COVID-19 pandemic, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has had a profound and far-reaching global impact, affecting millions of individuals across the world. As of November 2024, the World Health

Organization (WHO) has confirmed over 776 million cases of COVID-19, along with approximately 7 million reported deaths globally [1]. While the majority of infected individuals remain asymptomatic or experience only mild to moderate symptoms

that do not require emergency medical intervention, a significant proportion of cases progress to more severe forms of the disease. It is estimated that approximately 15% of infected individuals develop severe illness requiring hospitalization, with around 5% of these cases advancing to critical conditions necessitating intensive medical care, such as mechanical ventilation and organ support [2]. Initially perceived as a primarily respiratory illness, COVID-19 has since been recognized as a systemic disease capable of affecting multiple organ systems beyond the respiratory tract, including the cardiovascular, neurological, renal, and gastrointestinal systems [3]. While the scientific community has made considerable progress in understanding the acute phase of SARS-CoV-2 infection, the characterization and long-term consequences of post-COVID conditions remain an evolving area of research. Current estimates suggest that more than 20% of individuals who contract SARS-CoV-2 may develop persistent symptoms that extend beyond three months following the initial infection, a condition widely referred to as post-COVID syndrome [4]. According to the WHO, post-COVID symptoms commonly include fatigue, shortness of breath, and cognitive dysfunction (often described as brain fog), which can significantly impair an individual's ability to carry out daily activities. However, beyond these commonly reported symptoms, more than 200 distinct symptoms have been identified, affecting various organ systems and contributing to a substantial decline in overall health and well-being [5]. It is estimated that more than 65 million people worldwide are currently experiencing post COVID-related health complications, making it a significant public health concern with implications for healthcare systems, workforce productivity, and social functioning [6]. Studies have shown that individuals experiencing post-COVID

symptoms often report a lower health-related quality of life compared to otherwise healthy individuals, further emphasizing the need for targeted interventions and management strategies [7]. Recent research highlights exercise particularly those involving multimodal programmes (aerobic, resistance and respiratory training), as an effective intervention to target the COVID-19 related symptoms and improve physical functions and overall quality of life [8].

This systematic review aimed to consolidate the current body of evidence regarding the prevalence and distribution of post-COVID symptoms across different organ systems. By analyzing patterns of symptom manifestation and evaluating the heterogeneity in reported outcomes, this study sought to provide a comprehensive understanding of post-COVID conditions. The findings from this review will contribute to the growing body of knowledge on the long-term consequences of SARS-CoV-2 infection, aiding healthcare providers, researchers, and policymakers in formulating evidence-based strategies to address the needs of affected individuals in both clinical and public health settings.

Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) recommendations,

Research question

“What is the variability and proportion of self-reported or clinically observed signs and symptoms among post-COVID-19 individuals?”

Search strategy

A systematic search of PubMed and MEDLINE databases was conducted to identify studies published between March 2020 and March 2025.

The search was performed using the terms “Post COVID conditions,” “COVID Sequelae,” and “Post COVID,” combined using the Boolean operator OR. The final search strategy was: (“Post COVID conditions” OR “COVID Sequelae” OR “Post COVID”). Searches were limited to articles published in English. The last search was conducted in March 2025. References were managed and screened using Rayyan.ai software. The search was restricted to PubMed and MEDLINE databases; additional databases, preprint servers, and citation tracking methods were not included in the search strategy.

Study selection

All retrieved records were imported into Rayyan.ai for duplicate removal and screening. Two reviewers independently screened titles and abstracts against the predefined eligibility criteria. Full texts of potentially eligible studies were then assessed independently by the same reviewers. Any disagreements during the screening and eligibility assessment process were resolved through discussion and consensus.

Eligibility criteria

Peer-reviewed interventional and observational studies, including cross-sectional, case-control, and cohort studies, discussing self-reported or clinically observed symptoms in individuals during the post-acute phase of COVID-19 were included. Exclusion criteria encompassed studies that lacked symptom-specific data for the post-COVID-19 phase, reviews, case report, case series and editorials. Additionally, studies not published in English or without accessible full texts were excluded from the final analysis.

Data extraction

Data extraction was conducted using Microsoft

Excel to systematically capture relevant information, including author details, year of publication, country, study design, sample size, participant characteristics (age and sex), post-COVID symptoms, associated comorbidities, and outcome measures relevant to the review objectives. The initial data extraction was performed by one reviewer and independently checked by a second reviewer to ensure accuracy and consistency. Any discrepancies were resolved through discussion and consensus.

Where data were missing, unclear, or insufficiently reported, the information was extracted as reported in the original publication and no additional assumptions were made. Study authors were not contacted for missing information. To avoid duplication of data, studies were assessed for potential overlap in study populations based on author names, study setting, recruitment period, and participant characteristics.

Quality assessment

The Joanna Briggs Institute (JBI) tools were chosen for assessing the quality of the included studies (JBI Critical Appraisal Tools | JBI n.d.) [9]. JBI offers a range of tools tailored to different study designs, ensuring appropriate evaluation criteria. The JBI tools provide a comprehensive set of criteria for evaluating the methodological quality of studies. These criteria typically cover aspects such as study design, participant selection, intervention description, outcome measurement, statistical analysis, and risk of bias assessment. The JBI tools typically provide response options such as "Yes," "No," "Not Applicable (N/A)," and "Unclear" for each assessment criterion. Reviewers selected the most appropriate response based on their evaluation of whether the study adequately addressed the criterion.

The risk-of-bias assessments were used to inform

the interpretation of the findings. No studies were excluded from the review or meta-analysis based on their risk-of-bias ratings. Sensitivity analyses according to risk-of-bias categories were not performed because of the limited number of eligible studies available for quantitative synthesis.

Statistical analysis

Statistical analyses were conducted using "R software (Version 3.6.0+). A random-effects model was applied to account for variability both within and between studies. Pooled prevalence estimates were calculated along with 95% Confidence Intervals (CIs) to quantify the proportion of post COVID symptoms.

The I^2 statistic was used to evaluate heterogeneity among studies, with thresholds of 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively. Additionally, prediction intervals were computed to provide an estimate of the range in which the true prevalence is expected to fall in future studies. A value of $p < 0.05$ for Cochran's Q test was considered indicative of statistically significant heterogeneity.

The effect estimate used for the meta-analysis was the proportion of patients experiencing specific post-COVID symptoms. Forest plots were generated to visually present individual study estimates, pooled prevalence rates, and the overall heterogeneity. Statistical significance was determined at a threshold of $p < 0.05$.

Results

Study selection

A total of 1,647 publications were identified

through the search strategy (Fig. 1). After removing 34 duplicates, 1,613 publications were screened based on the relevance of their titles and abstracts, leading to the exclusion of 1,561 publications. Subsequently, 52 publications were assessed for full-text review. Of these, 36 articles were excluded for the following reasons: 10 studies did not report post-COVID-19 symptoms, 17 were case reports/case series/review articles, or editorial commentaries, 5 lacked accessible full texts, and one study each was excluded due to language barriers and technical issues. Finally, 16 studies met the inclusion criteria and were included in this systematic review for analysis.

Study characteristics

Overall, this review included 16 studies encompassing 4542 patients in the post-COVID-19 phase. Among these, 66% (2992) were males and 34% (1550) were females, with ages ranging from 20 to 80 years (Table 1). Most of the studies (81%) were carried out in the European region including England, France, Spain, Italy, Switzerland, Austria, Poland, Germany, Hungary and Sweden. Two studies (10%) were carried out from the region of the Americas [10, 11] and, two studies (10%) were conducted in the eastern Mediterranean region including Saudi Arabia [12], and Tunisia [13]. The map (Fig. 2) illustrates the geographical distribution of the identified studies, with the grading indicating the combined population size of the studies by country. Out of the 16 selected studies, 12 studies were observational while the remaining 4 were clinical trials [12, 14-16]

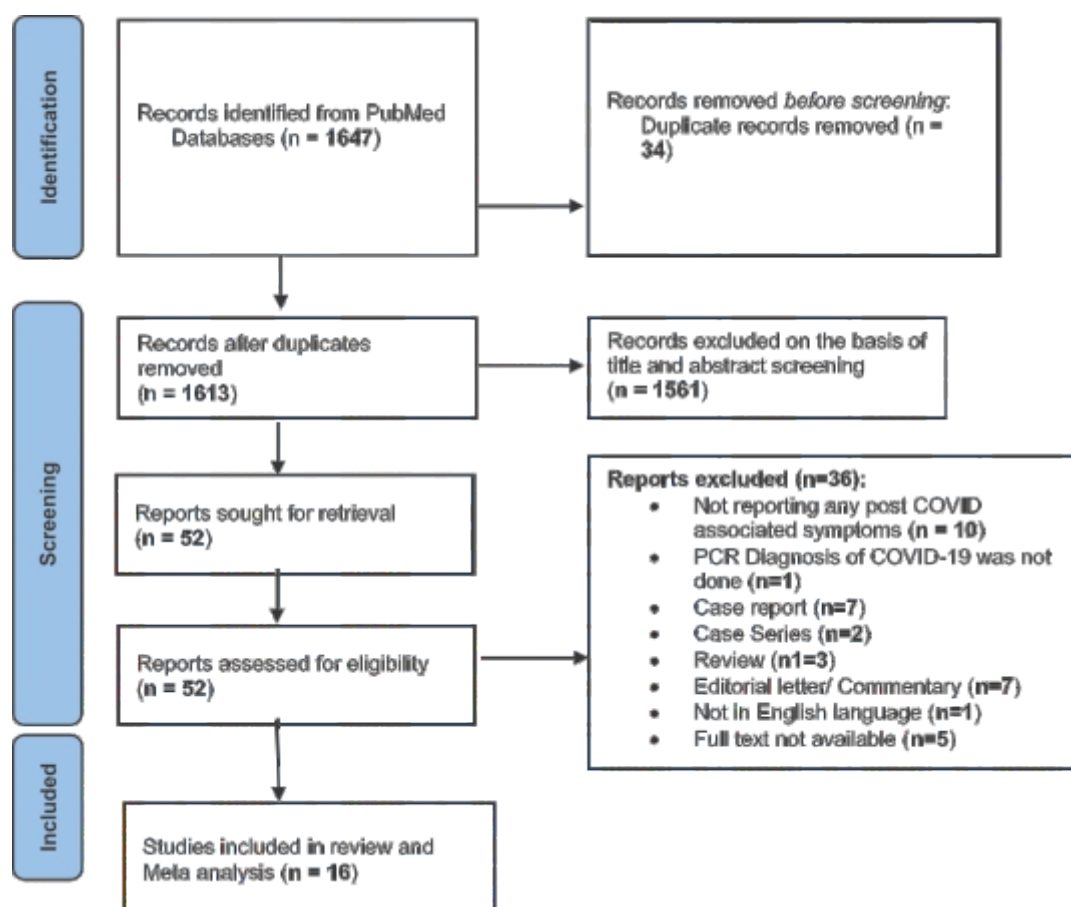


Figure 1: PRISMA flow chart for the process of study selection

Table 1: Study characteristics

Source (Reference) and Origin	Sample Size (Female/ Male)	Mean Age	Prevalent Post COVID symptoms	Mean BMI	Associated Comorbidities
Almazán <i>et al.</i> , 2022, Spain [14]	19 (6/13)	44.6	Low-grade fever (4), fatigue (16), dyspnoea (11), myalgia (8), headache (8), loss of appetite (2), weight loss (2), chest pain (2), cough (3), loss of smell/taste (5), low mood (7), anxiety (6), lack of concentration (12), brain fog (11), memory problems (11), sleep disturbances (9), dizziness (4), palpitations (4), hair loss (5), abdominal pain (3).	31.1	Hypertension (1), diabetes (1), asthma (2)
Nambi <i>et al.</i> , 2022, Saudi Arabia [12]	76 (All male)	63.65	Sarcopenia (76)	22.95	Not reported

Continued...

Gloeckl <i>et al.</i> , 2021, Germany [18]	50 (22/28)	59	Dyspnoea (22), fatigue (19), cough (14), cognitive impairment (4)	25.8	Arterial hypertension (21), dyslipidaemia (13), coronary heart disease (8), diabetes mellitus (7), chronic lung disease (12), obstructive sleep apnoea (18), chronic kidney disease (6), obesity (10), stroke (1)
Nopp <i>et al.</i> , 2022, Austria [35]	58 (33/25)	46.8	Dyspnoea (41), fatigue (37), neuro-cognitive sequelae (22), lung residues (10), cardiac sequelae (1), gastro-intestinal sequelae (5), hematologic sequelae (6)	26.2	Chronic obstructive pulmonary disease (1), emphysema (2), coronary artery disease (3), arterial hypertension (13), diabetes mellitus (6), atrial fibrillation (1), hyperlipidemia (18), hyperuricemia (5), thyroid disease (5), liver disease (steatosis hepatitis) (3)
Gruenewaldt <i>et al.</i> , 2022, Sweden [36]	17 (10/7)	49.5	Dyspnoea (13), fatigue (11), palpitations (7), chest pain (10)	25.4	Not reported
Barros <i>et al.</i> , 2022, Brazil [10]	26 (14/12)	51.73	Fatigue (26)	31.72	Hypertension (16), Diabetes (6), Obesity (14) Lung diseases (7), Chronic kidney disease (2)
Ostrowska <i>et al.</i> , 2023, Poland [37]	97 (44/53)	60	Exercise intolerance (39), sleep disturbance (25), fatigue (21), hair loss (15), difficult concentrating (14), dyspnoea (14), sweating (14), cough (13), chest pain (12), cardiovascular symptoms (9), joint pain (9), headache (7), hearing loss (7), neurological issues (6), anosmia (3), parosmia (2), nausea/vomit (1), weight loss (1), pulmonary embolism (1)	27.4	Hypertension (45), hyperlipidemia (24), coronary artery disease (18), heart failure (6), chronic obstructive pulmonary disease (12)
Toulgui <i>et al.</i> , 2022, Tunisia [13]	14 (male)	61	Dyspnoea (14)	31	Diabetes-mellitus (8), arterial-hypertension (6), chronic obstructive pulmonary disease (5), dyslipidemia (3), dysthyroidism (1)
Colas <i>et al.</i> , 2022, France [38]	15	52	Fatigue (15)	26.95	Not reported
Martinez <i>et al.</i> , 2022, Switzerland [39]	39 (29/10)	63.85	Respiratory sequelae (23), central sensitization (10), musculoskeletal sequelae (5), dermatological sequelae (1), cardiovascular (3)	27.7	Not reported

Continued...

Lacavalerie <i>et al.</i> , 2022, France [40]	51 (21/30)	60	Fatigue (46), dyspnoea (43), chest pain (13)	31 ±6	Hypertension (20), diabetes (14), chronic obstructive pulmonary disease (5)
Coscia <i>et al.</i> , 2023, Italy [41]	444 (121/323)	20-40	Poor sleep quality (248), mild cognitive impairment (191)	22.33	Not reported
Petek <i>et al.</i> , 2022, England [17]	3393 (1154/2239)	20	Shortness of breath (66), cough (6), chest pain (55), headache (2), fatigue (1), decreased appetite (1), nasal congestion (1), rhinorrhea (1), light headiness (1), exercise intolerance (32), palpitations (10), syncope (5)	Not reported	Not reported
Babity <i>et al.</i> , 2022, Hungary [43]	165 (43/122)	20	Decreased exercise capacity (4), Palpitations (3), Exercise induced dyspnoea (2), Worsening symptoms of asthma bronchial (2), Peripheral skin symptoms (1)	Not reported	Not reported
Almazán <i>et al.</i> , 2023, Spain [16]	60 (41/19)	43.8	Fatigue (53), dyspnoea (42), lack of concentration (39), memory problems (38), brain fog (38), sleep disorder (36), myalgia (34), low mood (31), headache (31), anxiety (27)	26.8	Asthma (10), hypertension (6) diabetes (3), structural heart disease (3), cerebrovascular disease (1), chronic obstructive pulmonary disease (1)
Alba <i>et al.</i> , 2021, United States [11]	18 (12/6)	40.5	Dyspnoea (18), exercise intolerance (17), cough (3)	26.7	Hypertension (3), hyperlipidemia (4), coronary artery disease (2), congestive heart failure (1) diabetes mellitus (1), hypothyroidism (2), depression (4), anxiety (4), migraines (5), asthma (2)

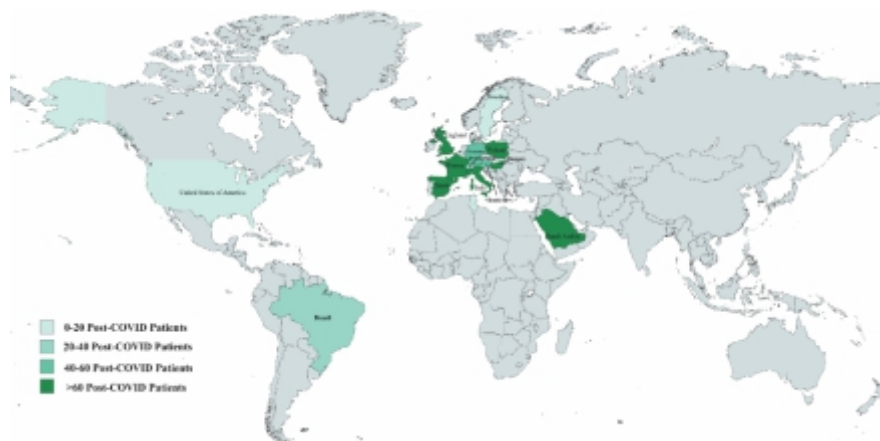


Figure 2: Geographical distribution of the studies included; the grading shows the population size included in the studies from the respective country

Risk of bias in studies

As described in the methodology JBI tool was used to check the risk of bias. The risk of bias was calculated on the basis of various factors reported in the JBI tool. Out of all the articles included in this systematic review 14 articles were having moderate risk of bias, as the articles were having bias score in between the range of 50-80%. Likewise, 2 articles were having high risk of bias as the score was below 50%. Figure 3 illustrates the articles and the score they obtained following the JBI tool. Although two studies were classified as having a high risk of bias, they were retained in the review and quantitative synthesis to ensure comprehensive reporting of the available evidence. The potential influence of methodological limitations was considered during interpretation of the pooled estimates.

Meta-analysis**Post-COVID symptoms**

This systematic review analyzed studies reporting a wide range of post-COVID symptoms affecting multiple organ systems including pulmonary, neurocognitive, cardiac, and muscular system.

Sleep-disorder

Out of all the reported symptoms, sleep disorder was found to be most common symptom. The sleep disorder was reported by 318 individuals from a total of four studies encompassing 620 participants. The pooled proportion of participants experiencing sleep disorders was 47% (95% CI: 31% – 63%), as illustrated in Figure 4. The heterogeneity across studies was substantial ($I^2 = 92\%$, $p < 0.01$), indicating significant variability in the reported prevalence rates.

Dyspnoea

The prevalence of dyspnoea in post-COVID-19 patients was assessed in 10 studies, involving a total

of 3,860 participants. The pooled prevalence of dyspnoea was 63% (95% CI: 42%–85%) (Figure 5). Individual study estimates varied widely, ranging from 2% [17] to 100% [11]. There was significant heterogeneity among studies ($I^2 = 99\%$, $p < 0.001$), likely due to differences in study populations, measurement tools, and reporting methods.

Cognitive issues

Five studies, comprising 631 participants, were included in the meta-analysis to evaluate the prevalence of cognitive impairment in post-COVID-19 patients. The pooled prevalence was 41% (95% CI: 22%–61%) (Figure 6). Individual study estimates varied widely, ranging from 8% [17] to 63% [16]. Substantial heterogeneity was observed across studies ($I^2 = 95\%$, $p < 0.01$).

Fatigue

The prevalence of fatigue in post-COVID-19 patients was reported in 11 studies, involving a total of 3,786 participants. The pooled prevalence of fatigue was 66% (95% CI: 43%–87%) (Figure 7). There was significant heterogeneity among studies ($I^2 = 99\%$, $p < 0.001$).

Other symptoms

Apart from the most prevalent symptoms, chest pain, lack of concentration and headache were also reported in the included studies.

The prevalence of chest pain was studied across five studies with a total of 3577 participants. The pooled estimate, derived from a random-effects model, indicates that 20% of participants experienced chest pain (95% CI: 0.02-0.37). Substantial heterogeneity was observed across studies ($I^2 = 92\%$), suggesting significant variability in the prevalence estimates. Individual study prevalence ranged from 2% to 59%, highlighting the considerable variation in the

reporting of chest pain across different populations and contexts.

The pooled estimate, derived from a random-effects model, indicates that approximately 47% of participants in the included studies experienced lack of concentration. Substantial heterogeneity was observed across studies ($I^2 = 97\%$), suggesting significant variability in the prevalence estimates. The individual study results ranged from 14% to 65%, with the pooled estimate falling within the range of these individual estimates.

The forest plot presents the results of a meta-analysis investigating the prevalence of headache

across four studies with a total of 3569 participants. The pooled estimate, derived from a random-effects model, indicates that 24% of participants experienced headache (95% CI: 0.00-0.49). Substantial heterogeneity was observed across studies ($I^2 = 96\%$), suggesting significant variability in the prevalence estimates. Individual study prevalence ranged from 0% to 52%, highlighting the considerable variation in the reporting of headache across different populations and contexts (Figure 8).



Figure 3: Risk of bias according to the items of the JBI checklist. Categorized into High, Moderate, Low, and Unclear or Not Applicable (NA). High Risk (Less than 50%, Moderate 51–80%, and Low 81–100%). Color coding: Red (High Risk), Orange (Moderate Risk), Green (Low Risk), and Yellow (Unclear/Not Applicable).

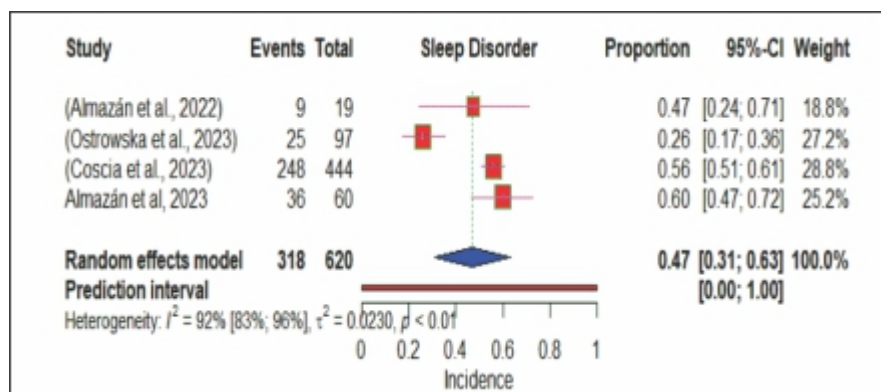


Figure 4: Forest plot for sleep-disorder

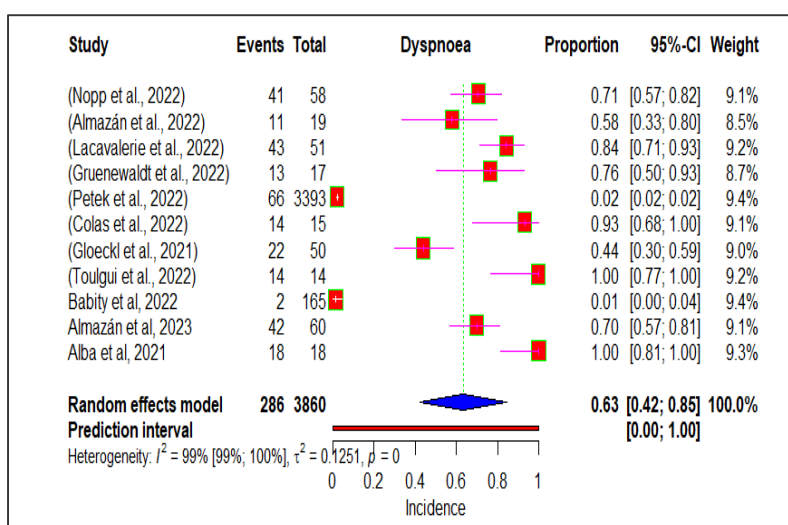


Figure 5: Forest plot for dyspnoea

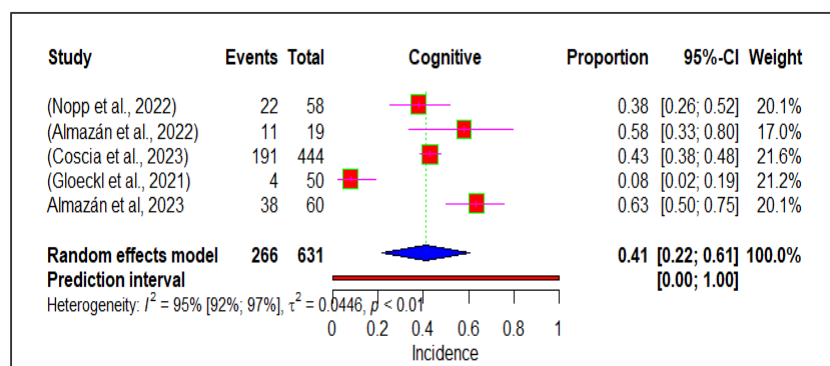


Figure 6: Forest plot for cognitive issues

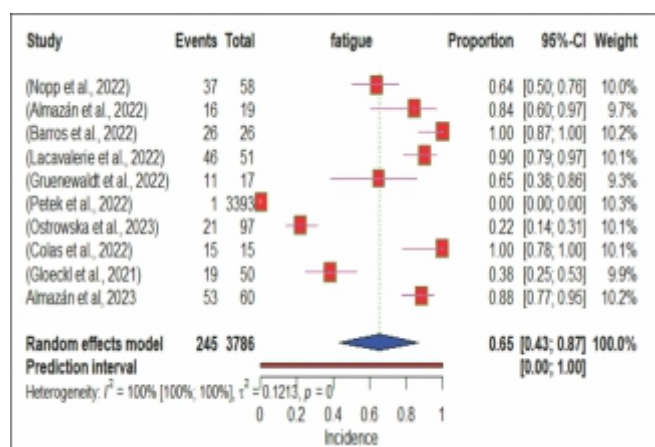


Figure 7: Forest plot for fatigue

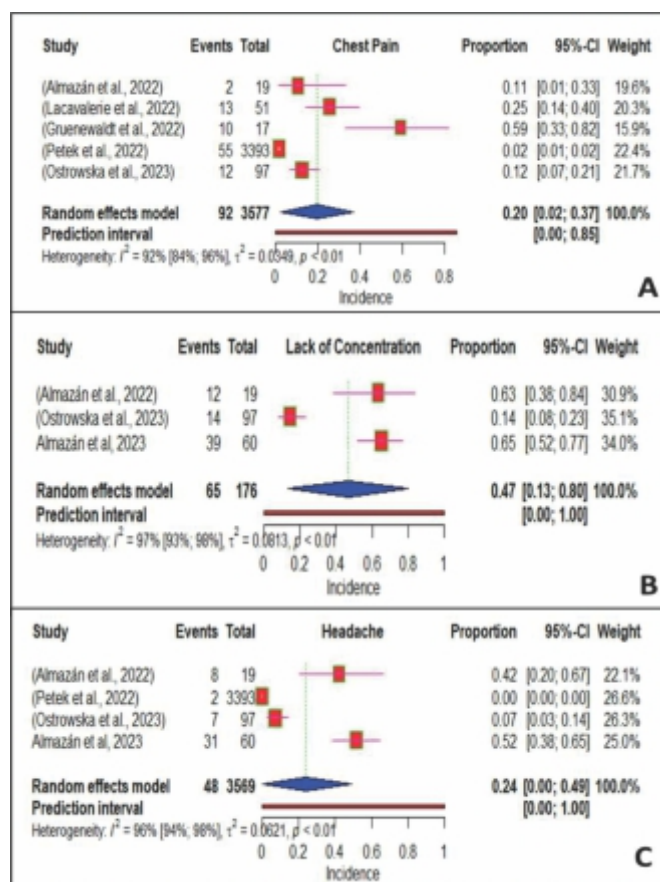


Figure 8: Forest plots of post COVID symptoms (A) chest pain, (B) lack of concentration, (C) headache

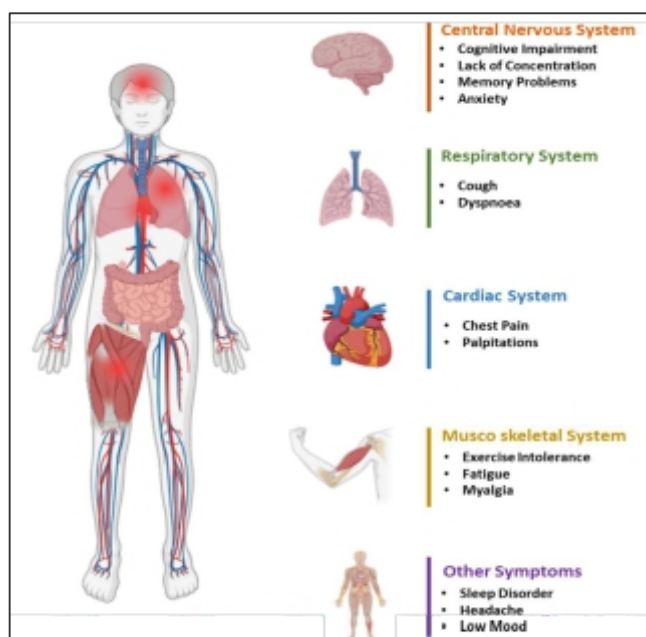


Figure 9: The Post COVID symptoms reported in the studies (Created with BioRender.com)

Discussion:

This systematic review provides a comprehensive analysis of post-COVID symptoms across multiple organ systems, highlighting their proportion and variability. The findings underscore the significant and diverse long-term health consequences of COVID-19, which persist well beyond the acute phase of the illness.

Acute phase of SARS-CoV-2 infection subsides in 7-14 days depending on the severity of the infection, but current evidence suggests approximately 10–20% of people experience a variety of mid and long-term effects after they recover from their initial illness referred to as post-COVID conditions [5]. WHO has identified common post-COVID symptoms such as fatigue, shortness of breath, and cognitive dysfunction but the spectrum is vast, with over 200 reported symptoms impacting daily functioning [5].

The studies related to the post-COVID are limited, with a recent study reporting that most of the studies

related to the post-COVID phase had been carried out in the Western Europe. This gap due to the unavailability of the relevant study poses a significant challenge in understanding the global effect of post-COVID. Similarly, this review is majorly based on the consolidated information on post-COVID phase on the studies conducted in the European regions, and a few originate from the Mediterranean and the Americas. The limited geographical distribution of the conducted studies globally reflects a constraint in acquiring a comprehensive understanding of post-COVID conditions and potential prognoses. Furthermore, the scarcity of these studies imposes limitations on our ability to generalize findings. Moreover, the studies encompassed in this review exhibit heterogeneity, characterized by variations in study settings, designs, patient follow-up procedures in hospitals, and the absence of control groups.

Development of the post-COVID sequelae is dependent on various factors including age, BMI, comorbidities, and sex [19]. Various studies have reported a higher susceptibility to post-COVID symptoms among females when compared to their male counterparts [20,21]. However, in this systematic review, contradictory results were observed concerning the gender of the enrolled patients as majority of the post COVID-19 patients were males.

This systematic review and meta-analysis comprehensively evaluate the proportion of post-COVID symptoms, highlighting the multifaceted burden of post-COVID-19 sequelae across various organ systems (Figure 9). The neurocognitive system was identified as the primary organ system affected by post-COVID symptoms, which included sleep disorders, cognitive impairment, lack of concentration, memory problems, and headache. Among these, sleep disorders (47%) and lack of concentration (47%) emerged as the most frequently reported symptoms followed by cognitive impairment (41%). Supporting the findings of this review, numerous studies have demonstrated a significant proportion of sleep disorders among post-COVID patients, highlighting the substantial impact on their overall well-being and quality of life [22,23]. Similarly various studies globally have reported the occurrence of cognitive impairment in patients with post-COVID conditions [24]. The pathophysiological mechanisms underlying post-COVID-19 conditions remain unclear, but several theories have been proposed, including persistent viral infection, chronic inflammation, autoimmune involvement, and mitochondrial dysfunction [25]. Persistent viral infection, in particular, has been highlighted, with evidence of SARS-CoV-2 RNA persisting for up to 230 days after symptom onset in various anatomical

areas, including regions of the brain —[26]. The impact of SARS-CoV-2 on the hypothalamus and brainstem is of particular concern, as it may disrupt the sleep-wake cycle, leading to insomnia or poor sleep quality [27]. Likewise, other neurological symptoms including cognitive or mental disorders, headache, and olfactory/gustatory dysfunction could depend on a pathophysiology that is independent from the acute phase. Indeed, the spreading of SARS-CoV-2 into the brain through either the nasal cavity or bloodstream has been suggested to trigger neuroinflammation. Many studies hypothesized on the role of sustained neuro inflammation in the onset of symptoms: through either an activation of microglia or auto-immune reactions, persistent neuroinflammation could account for neurocognitive impairment or mental health disorders [28-31]. The neurocognitive burden of post-COVID syndrome goes beyond physical symptoms, deeply affecting mental health, especially in Indian communities. A cross-sectional study from Kerala found that during the COVID-19 outbreak, nearly 40% of healthcare workers experienced extremely severe anxiety, and about 15% suffered from extremely severe depression. Additionally, more than 80% reported moderate-to-high stress and frequent sleep problems [32]. Strikingly, two-thirds of these participants had previously tested positive for COVID-19, pointing to a strong link between infection and ongoing mental health challenges [32]. These findings echo our observation that sleep disturbances and cognitive issues are the most common neurocognitive symptoms, and they also highlight the need to consider regional differences when addressing post-COVID mental health.

In addition to the predominantly reported neurocognitive symptoms, this review identified various

other post-COVID symptoms. Cardiac manifestations, such as chest pain and palpitations, were frequently reported as part of post-COVID symptoms. These symptoms are often associated with persistent cardiovascular and autonomic dysfunction, which are commonly observed during recovery from SARS-CoV-2 infection [33]. The effects of post-COVID syndrome reach far beyond the usual respiratory, neurological, and heart-related symptoms with skin conditions also emerging as an important concern. Recent reports from India highlight a growing link between immune system changes after COVID and skin issues, particularly Pityriasis Lichenoides [34]. In one case series, more people developed this skin problem after COVID became widespread. Notably, all patients had been vaccinated, and two previously had COVID-19, pointing to immune system changes after infection as a possible cause [34]. These findings strengthen the view that post-COVID problems can affect many parts of the body and support the hypothesis that ongoing immune system disruption is at the root of long COVID.

The persistence of respiratory symptoms aligns with previous findings indicating residual pulmonary damage, such as interstitial lung changes or impaired lung function, even in patients with mild acute disease. In this review, fatigue (66%) was marked as a dominant symptom of post-COVID. The high proportion underscores its multifactorial nature, involving immune dysregulation, deconditioning, and psychological stress. Fatigue in patients with post-COVID-19 can result from a range of biological and physical dysfunctions, including genetic factors. Additionally, the cytokines released during SARS-CoV-2 infection may impair psychological defense mechanisms, further contributing to the development of fatigue.

Moreover, the higher prevalence of pre-existing autoimmune diseases and elevated antinuclear antibodies (ANA) observed in post-COVID-19 cohorts compared to the general population suggests a potential autoimmune contribution to this condition [34].

The findings of this review highlight the pervasive impact of post-COVID across multiple organ systems, emphasizing the need for a multidisciplinary approach to care. The high prevalence of sleep disorders, dyspnoea, cognitive impairment, and fatigue underscores the necessity for targeted rehabilitation and mental health support services. Furthermore, the variability observed across studies calls for the standardization of diagnostic criteria and assessment tools to improve comparability and ensure accurate prevalence estimates.

This study has several limitations, significant heterogeneity was observed across the included studies, likely due to differences in populations, study designs, and symptom assessment methods, which may affect the generalizability of the findings. The analysis was limited to peer-reviewed studies published in English, potentially introducing publication and language bias. Some studies had small sample sizes, limiting the precision of pooled prevalence estimates. The search strategy was restricted to selected post-COVID terminology and may not have captured all studies indexed under alternative terms such as Long COVID, Post-Acute Sequelae of COVID-19 (PASC), or persistent post-SARS-CoV-2 symptoms. Furthermore, the literature search was limited to PubMed and MEDLINE and did not include Embase, Scopus, Web of Science, the Cochrane Library, preprint repositories, or citation tracking approaches. Consequently, some relevant studies may not have been identified and included in the review. The geographical and

demographic focus of the studies may not represent global populations, as certain groups were overrepresented. Studies without full texts, those in non-English languages, and those lacking specific data on post-COVID symptoms were excluded, which may have omitted relevant findings. Finally, as evidence on post-COVID is rapidly evolving, newer studies could impact the conclusions drawn in this review. The presence of studies with moderate to high risk of bias may have influenced the pooled prevalence estimates. As sensitivity analyses based on risk-of-bias categories were not performed, the potential impact of study quality on the pooled results should be considered when interpreting the findings. Despite these limitations, the study offers valuable insights into the prevalence and diversity of post-COVID symptoms and underscores the need for further research in this area.

Conclusion

This study provides a comprehensive summary of the published evidence on the spectrum of post-COVID symptoms, highlighting a wide-ranging

burden that impacts multiple physiological systems. The most frequently reported symptoms include sleep disorders, dyspnoea, cognitive impairment, and fatigue, alongside other common issues such as chest pain, lack of concentration, and headaches. These symptoms have profound implications for individuals' productivity, economic well-being, and overall health. The included studies reveal significant heterogeneity in study designs, populations, symptom assessment tools, and reporting standards, reflecting the complexity of understanding and interpreting long COVID symptoms across diverse contexts. This variability emphasizes the urgent need for standardized definitions and methodologies in future research to enhance the comparability of findings. The results underscore the importance of continued investigation and the development of evidence-based interventions to address the long-term consequences of COVID-19. Multidisciplinary and comprehensive care approaches are essential to meet the diverse and evolving needs of this affected population.

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