*COVID*

*Review*

# Long COVID: A Narrative Review and Meta-Analysis of Individual Symptom Frequencies

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**Abstract:** Objective: To summarize the prevalence of Long COVID symptoms among the general population reported in published articles from the pre-omicron SARS-CoV2 era. This narrative review examined 21 symptoms. Methods: A PubMed/manual search returned 114 articles on general Long COVID symptoms. Manuscripts were excluded if they were not research studies, did not report symptom prevalence, or used a pediatric population. Ninety-eight studies were selected for review and fifty-nine met the criteria for inclusion. The risk of bias was assessed with the Hoy critical appraisal tool. Results: After excluding studies with a high risk of bias, meta-analysis of prevalence for 21 symptom categories ranged from 2.6–28.7% in studies based on surveys to 0.3–7.1% in studies based on electronic health record data. Conclusions: Long COVID symptom studies are limited by the variability in study design and representation of the general population. Further research is needed to effectively cluster symptoms in meaningful ways that enable focused treatment.

**Keywords:** PASC; Long COVID; narrative review

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## 1. Introduction

### 1.1. Overview

It is now well recognized that severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is associated with post-viral sequelae and these appear to be heterogeneous. The definition of post-acute sequela of SARS-CoV-2 (PASC), better known as "Long COVID", is generally defined as new, recurrent, or continuous symptoms starting 3 to 4 weeks after SARS-CoV2 infection [1–5]. COVID-19 has been reported in multiple studies from throughout the world, most of which have focused on individual symptom frequency; the primary goal of this narrative review is to summarize the current literature on this topic focusing on the reported prevalence of individual symptoms among the general population infected with SARS-CoV2 prior to the omicron wave. Commonly reported symptoms are dyspnea, fatigue, pain, cognitive problems, and changes in or loss of smell or taste. It is likely that Long COVID is a heterogeneous set of syndromes, potentially with variable etiopathogenesis (e.g., initial organ injury from acute infection, viral persistence, immune dysregulation, autoimmunity, unrepaired tissue damage, dysbiosis of microbiome or virome) [6,7]. Moreover, it is possible that Long COVID may have evolved over the course of the pandemic because of different viral strains, treatments, and vaccination rates. The time period analyzed in this review reflects the epidemiology of early virus strains, relatively low vaccination levels in the population, and low natural immunity in the population.

### 1.2. Historical Perspective

Long COVID was first reported in small clinical follow-up studies published in mid- to late 2020 soon after the initial wave of the coronavirus disease 2019 (COVID-19) pandemic, which were focused on post-hospital discharge cohorts [4,8–19]. These publications were followed by outpatient studies that led to recognition that mild COVID-19 cases could suffer from post-viral sequelae [20–23]. The Patient-Led Collaborative's high impact manuscript on more than 200 symptoms, many of which were exacerbated by physical or mental exertion or stress, produced a paradigm shift with widespread media attention [24]. Their presentation to the US Congress ultimately lead to USD 1.3B in funding to study post-acute sequelae of SARS-CoV-2. The NIH-funded Researching COVID to Enhance Recovery (RECOVER) Adult Cohort (RECOVER-Adult), a longitudinal cohort study of adults with and without SARS-CoV-2 infection across 85 recruitment sites in the USA, includes acute-onset COVID-19 cases with data collected during the first 5–28 days post-infection and symptom surveys every 3 months [25]. A primary goal of this initiative is to provide prospective data on symptom frequency and patterns over time, as well as impacts on quality of life and overall physical health. RECOVER has reported Long COVID symptom prevalence of 10% among acute infected participants based on symptoms reported 6 months after infection [26]. Further deep phenotyping and testing among individuals with prolonged symptoms will enhance the discovery of Long COVID etiology(ies).

### 1.3. Goal of Current Review

The goal of this narrative review was to identify and synthesize the Long COVID symptoms most commonly reported as occurring longer than 3 weeks after SARS-CoV2 infection in published scientific articles and provide data to future studies to aid in better defining Long COVID phenotypes. The current review examined the 21 most prevalent individual Long COVID symptoms reported by more than one study in the included total of 59 studies published July 2020–February 2023 reflecting symptoms reported primarily prior to the omicron variant era. The studies were evaluated for their potential bias in order to determine a more accurate reflection of symptom prevalence. In addition, analyses were conducted to understand how study design impacts symptom detection and how acute COVID-19 severity impacts symptom prevalence.

## 2. Materials and Methods

### 2.1. Article Search Strategy

This article search was conducted on PubMed and through a manual review of recent systematic reviews. The specific medical subject headings (MeSH) terms and queries used in the PubMed search were as follows: (Long COVID[MeSH Major Topic]) OR (PASC[MeSH Major Topic]) AND symptoms. The PubMed database was searched at least thrice monthly from October 2022 to February 2023. As of February 2023, the search returned 111 potentially eligible papers.

### 2.2. Eligibility Criteria

Peer-reviewed studies were considered eligible if they included at least 30 individuals with laboratory confirmed and/or clinically diagnosed COVID-19. We included studies that reported symptoms or outcomes assessed at 3 or more weeks post COVID-19 onset. Articles were excluded if they were systematic or narrative reviews, book chapters, editorials, responses, case studies, research design descriptions, or focused on institutional topics such as research management. The remaining full texts were assessed and excluded if they were meta-analyses, assessed symptoms at less than 3 weeks post-infection, addressed only acute COVID-19 symptoms, symptom outcomes were relative to a specific disease in addition to COVID-19, focused on treatment, did not report prevalence data, contained no symptom data, used a pediatric sample, or in one case, a mixed adult/pediatric sample for which results were not reported separately (Figure 1). See Table 1 for a complete overview

of study characteristics. Three other eligible studies were identified through a review of the references of other scientific articles.

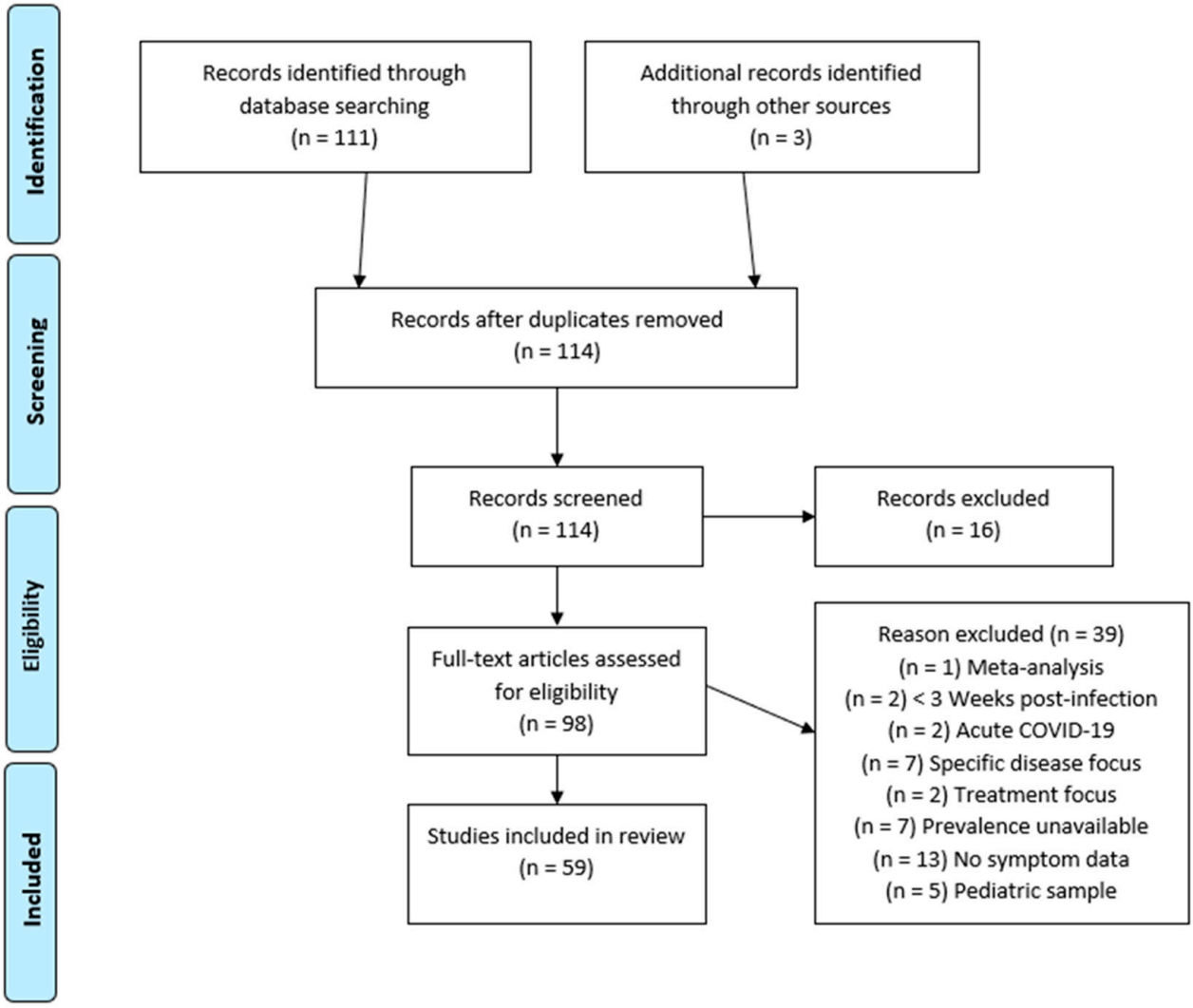



**Figure 1.** PRISMA diagram.

**Table 1.** Summary review table for Long COVID symptom studies.

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Anastascio et al. [27] | September 2021 | Patients at Eugenio Morelli Hospital (pulmonary function test, 6MWT, survey) | 379 (Italy) | Dyspnea; weakness; joint or muscular pain; thoracic pain; anosmia or aguesia; depression; cough; heart palpitations; headache; sleeping disorders; hair loss; memory disorders; dizziness | 4 mo. (n = 379) | Previous pulmonary disease excluding ashma | Longitudinal cohort | Patients 18–80 with COVID-19 diagnosis | n/a | n/a |
| Arnold et al. [28] | December 2020 | Patients admitted with COVID-19 in Bristol (radiographs, pulmonary function testing, blood, survey) | 163 (UK) | Breathlessness; fatigue; insomnia; myalgia; chest pain; cough; anosmia; arthralgia; fever; headache; abdominal pain; diarrhea; nausea | 12 weeks since hospital admission (n = 110) | n/a | Cohort | PCR positive or clinico-radiological diagnosis | n/a | Age-matched with population norms for survey |
| Baruch et al. [29] | November 2022 | PCR positive patients in Malta (survey) | 2665 (Malta) | Shortnesss of breath; anxiety; sadness; fatigue; memory loss; cough | 3–6 mo. range (n = 2665) | Had COVID-19 more than once, did not have working email, asylum seekers/refugees, deceased | Cross-sectional | PCR positive in 2020, had COVID-19 only once | n/a | n/a |
| Becker et al. [30] | October 2021 | Patients hospitalized at two Swiss tertiary-care hospitals (phone interview and surveys) | 126 (Switzerland) | Fatigue; concentration difficulties; shortness of breath; post-exertional malaise; joint pain; sleep disorder; dysosmia; muscle pain; anxiety; dysgeusia; chest pain/tightness; palpitations; depression; headache; paraesthesia; cough; loss of appetite/nausea; vomiting/diarrhea; skin disorders; PTSD symptoms; fever | 30 (n = 126) and 90 days (n = 90) | Insufficient proficiency in local languages, cognitive impairment | Prospective cohort | Patients with COVID-19 admitted for inpatient care, discharged | n/a | n/a |
| Bellan et al. [31] | January 2021 | Patients at Azienda Ospedaliero-Universitaria Maggiore della Carita University Hospital (phone interview, pulmonary function and physical performance tests, psychological inventory) | COVID-19 = 238 (Italy) | Arthralgia; myalgia; dyspnea; ageusia; anosmia | 4 mo. (n = 238) | n/a | Cohort | Positive PCR or serotological test, clinical diagnosis | n/a | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Bliddal et al. [20] | June 2021 | Patients in Danish Civil Registration System (online survey) | 198 symptomatic (Denmark) | Fatigue; concentration or memory difficulties; shortness of breath; reduced sense of smell; headache; other; muscle and joint pain; taste loss; coughing; chest pain; sore throat; runny or stuffy nose; sneezing; diarrhea; lack of appetite; stomach pain; nausea; chills; colored sputum; fever; red runny eyes | 4 weeks (n = 198) and 12 weeks (n = 129) | Symptoms started less than 12 weeks before survey | Cohort | Positive PCR, non-hospitalized, samples available in biobank | n/a | n/a |
| Blomberg et al. [32] | September 2021 | Patients diagnosed at testing facility in Bergen, patients hospitalized at Haukeland University Hospital or Haraldsplass Deaconess Hospital (clinic interview) | 267 home-isolated patients (Norway) | Fatigue; disturbed taste/smell; concentration problems; memory problems; dyspnea; headache; dizziness; palpitations; stomach upset; cough; sleep problems; tingling in arms or fingers; fever | 2 (n = 267) and 6 months (n = 247) | Address outside Bergen, admitted to hospital | Prospective cohort, longitudinal | Diagnosed and/or hospitalized with COVID-19 | Patients' household members who were seronega-tive | n/a |
| Buttery et al. [33] | October 2021 | Respondents to UK national online post-COVID support survey, n = 3290 | 3290 (UK) | Breathing problems; fatigue; joint stiffness; problems with mental abilities including anxiety and depression; sleep problems; mood changes/anxiety/depression; cough; loss of taste or smell; loss of appetite/weight loss; PTSD symptoms; nightmares or flashbacks; hair loss | 4–8 weeks (n = 494); 8–12 weeks (n = 641); >12 weeks (n = 1865) | Missing data, duplicates | Mixed-methods analysis | People who considered themselves to have long COVID | n/a | n/a |
| Carfi et al. [8] | July 2020 | Patients at Fondazione Policlinico Universitario Agostino Gemelli IRCCS (survey) | 143 (Italy) | Fatigue; dyspnea; joint pain; chest pain; cough; anosmia; sicca syndrome; rhinitis; red eyes; dysguesia; headache; sputum production; lack of appetite; sore throat; vertigo; myalgia; diarrhea | Mean 60.3 days (n = 143) | Refused participation, current positive test | Case series | Discharged from hospital after recovery from COVID-19, negative test at time of enrollment | n/a | n/a |
| Carvalho-Schneider et al. [34] | October 2020 | Patients at Centre Hospitalier Universitaire (EHR, phone call) | 150 (France) | Other respiratory signs; flulike symptoms; anosmia/ageusia; fever; abnormal auscultation; dyspnoea/shortness of breath; diarrhea; chest pain | 2 months (n = 130) | Admitted to intensive care, deceased, resident of retire-ment/nursery home or long-term care facility, transferred to another facility, unable to answer phone questionnaire, lost to follow-up at Day 30 | Case series | PCR positive | n/a | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Chopra et al. [35] | April 2021 | Patients admitted to any of 38 hospitals in Michagin/MI-COVID 19 Initiative (EHR) | 488 (USA) | Breathlessness walking up stairs; shortness of breath/chest tightness/wheezing; cough; continued loss of taste and/or smell; difficulty ambulating due to chest problems; new use of CPAP or other breathing machine while asleep; oxygen use | 60 days post-discharge (n = 488) | n/a | Cohort | Admitted with COVID-19, discharged, alive at 60 days | n/a | n/a |
| Cirulli et al. [17] | December 2020 | Participants in Healthy Nevada Project and Helix DNA Discovery Project (online survey); 21,359 respondents, COVID+ 357, COVID− 5497, 19,095 not tested | 21,359 (USA) | Dry cough; difficulty breathing; anosmia; difficulty concentrating; ageusia; weak muscles; chest pain; pain deep breaths; tachycardia; heart palpitations; memory loss; confusion; headache; dizziness; notice heartbeat; acid reflux; back or joint pain; insomnia; fatigue; decreased alertness; tingling; diarrhea; tinnitus; nocturnal dyspnea; difficulty balancing; nausea | >30 days (n = 357 COVID+) | Contradictory questionnaire entries, symptoms starting before 2020, diagnosis of COVID-19 despite negative test; symptoms less than 30 days | Prospective | Self-report COVID-19 positive | Self-report COVID-19 negative | n/a |
| Daitch et al. [36] | September 2022 | Multinational COVID positive patients (visit or survey) | 2333 (Israel, Switzerland, Spain, Italy) | Fatigue; dyspnea; emotional distress; myalgia; memory impairment; concentration impairment; anosmia; chest pain; cough; arthralgia; headache; hair loss; palpitations | Mean 5 mo. (n = 2333) | n/a | Prospective cohort | PCR positive at least 30 days before visit or interview | n/a | n/a |
| Daher [9] | October 2020 | Hospitalized patients (physical and laboratory tests, questionnaires) | 33 (Germany) | Fatigue; tiredness; cough; dyspnea; angina pectoria; cognitive disorders; myalgia; headache; rhinorrhea; loss of smell; loss of taste; diarrhea; nausea; stomach pains; fever | 6 weeks after discharge (n = 33) | Nonsymptomatic, not hospitalized, ARDS patients who needed mechanical ventilation | Prospective | Hospitalized patients not requiring mechanical ventilation, positive PCR | n/a | n/a |
| Danesh et al. [37] | November 2022 | Patients seeking COVID-19 recovery care clinic (medical assessments) | 441 (USA) | Dyspnea; brain fog; headache; anxiety; palpitations; impaired concentration; insomnia; memory loss; cough; anosmia; chest pain; depressed mood; ageusia; other neurological; dizziness; nausea; word finding difficulty; other otolaryngologic; diarrhea; other pulmonary; anorexia; confusion; paresthesia; congestion; other cardiovascular | Median 58 days (n = 441) | n/a | Cohort | Laboratory-confirmed COVID 19 | n/a | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Darcis et al. [38] | August 2021 | Patients hospitalized at University Hospital of Liège (survey, biological data, pulmonary function tests, CT scans of chest) | 199 (Belgium) | Exertional dyspnea; fatigue; dry cough; chest pain; memory impairment; productive cough; myalgia; rhinorrhea; headaches; loss of appetite; dyspnea at rest; anosmia; ageusia; parasthesia; diarrhea; pharyngeal pain; confusion | 1 mo. (n = 59), 3 mo. (n = 101), and 6 months (n = 78) | Died before follow-up | Prospective cohort | Confirmed COVID-19 infection, discharged between March-October 2020 | n/a | n/a |
| Davis et al. [24] | July 2021 | COVID-19 support groups, social media (online survey) | 3762 (Global/ 56 countries) | Fatigue; post exertional malaise; elevated temperature; shortness of breath; tightness in chest; muscle aches; palpitations; dry cough; tachycardia; breathing difficulty normal O level; sore throat; diarrhea; chills/flushing/sweats; joint pain; pain or burning in chest; loss of appetite; nausea; skin sensations; weakness; temperature lability; night sweats; stiff neck; abdominal pain; blurred vision; extreme thirst | >6 months (n = 3762) | Incomplete survey, no onset date, onset before December 2019 or after May 2020, ≤28 days of symptoms | Cohort | Confirmed (diagnosed or antibody positive) or suspected COVID-19 | n/a | n/a |
| Dryden et al. [39] | September 2022 | COVID patients discharged from hospital (phone interview with ISARIC questionnaire), random sample of 241,159 eligible, 8309 invited, 3094 contacted, 2410 enrolled | 2410 (South Africa) | Fatigue; shortness of breath; confusion or lack of concentration; headache; problems seeing or blurred vision; joint pain; muscle aches; chest pain; dizziness or lightheadedness; dry cough; loss of taste; abdominal pain; loss of smell; back pain or backache; cough with sputum; diarrhea; skin rash; fever; nausea or vomiting; nasal congestion or sinusitis; bleeding; loss of appetite or anorexia; body pain or body ache; seizures | 3 mo. (n = 1873) | Self-report that they are fully recovered or neutral about being fully recovered | Prospective observational cohort | Hospitalized patients infected with COVID-19 | n/a | n/a |
| Elkan et al. [40] | August 2021 | Patients hospitalized with COVID-19 (survey) | 66 (Israel) | Fatigue; myalgia; dyspnea; decreased stamina; weakness; memory and concentration impairment; headaches; hair loss; sleep disturbance; anxiety or depression | Median 9 mo. (n = 66) | Could not complete questionnaire due to physical or cognitive impairment | Retrospective cross-sectional case-control | Positive PCR test, discharged from hospital | Hospitalized pneumonia patients | Age and gender |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| FAIR Health White [41] | June 2021 | Patients in FAIR Health database (EHR) | 1,959,982 (USA) | Pain; breathing difficulties; hyperlipidemia; malaise and fatigue; hypertension; anxiety; intestinal issues; skin issues; high levels of glucose/cholesterol/BP; abnormal heart results; migraine and/or headache; GERD; sleep disorders; depression; abnormal organ tests | ≥30 days (n = 1,959,982) | Cancer (breast, colorectal, enometrial, leukemia and lymphoma, lung, prostate), chronic kidney disease, COPD, cycstic fibrosis, viral hepatitis A/B/C/D or E, HIV/AIDS, liver disease, spina bifida and other congenital anomalies of the nervous system, stroke | Case series | Diagnosed with COVID-19 | n/a | n/a |
| Frontera et al. [42] | July 2021 | US residents Prolific.co 148,000 US residents (online survey "Prevalence of Medical Conditions among Community Dwellers") | 999 survey respondents (50 US states); COVID-19 = 76; Prolonged symptoms = 19 | Anxiety; brain fog; headache; post-exertional brain fog; fatigue; depression; chest pain; joint pain; muscle aches and pains; difficulty sleeping; vision abnormalities; shortness of breath; dizziness/ lightheadedness; post-exertional malaise/fatigue; persistent loss taste/smell; wheezing; irregular heart beat; cough; fever | Median = 4 mo. (n = 999) | n/a | Cross-sectional | Diagnosed with COVID-19 by laboratory test or developed typical symptoms after being exposed to COVID-19 | n/a | n/a |
| García-Abellán et al. [43] | July 2021 | Patients hospitalized with COVID-19 (phone and clinic surveys, blood and nasopharyngeal samples) | 146 (Spain) | Fatigue; myalgia; dyspnea; cough; nasal congestion | 2 (n = 104) and 6 months (n = 116) | n/a | Prospective longitudinal | Positive PCR test | n/a | n/a |
| Garrigues et al. [11] | December 2020 | Hospitalized patients at Beaujon Hospital (phone survey) | 120 (France) | Fatigue; dyspnoea; memory loss; sleep disorder; attention disorder; hair loss; cough; anosmia; chest pain; aguesia | >100 days since onset (n = 120) | Deceased, unreachable, bedridden, demented, non-French speaking | Cross-sectional comparative | PCR positive or chest computed tomography diagnosis, hospitalized (ward group and ICU group) | n/a | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Goërtz et al. [12] | August 2020 | Two Facebook groups for COVID-19 patients with persistent symptoms, website panel registrants (online survey) | 2113 (The Netherlands, Belgium) | Fatigue; dyspnoea; chest tightness; headache; muscle pain; pain between shoulder blades; heart palpitations; cough; increased resting HR; dizziness; sore throat; pain/burning feeling in lungs; increased body temp; joint pain; burning feeling in trachea; nose cold; mucus; anosmia; hot flushes; nausea; sneezing; eye problems; aguesia; diarrhea; ear pain | >3 weeks (n = 2113) | Missing data, onset before 1 January 2020, symptoms for <3 weeks | Prospective observational | People who considered themselves to have long COVID | n/a | n/a |
| Halpin et al. [44] | July 2020 | Patients at Leeds Teaching Hospitals NHS Trust who were residents of Leeds Metropolitan District (phone survey) | 100 (UK) | Fatigue; breathlessness; worse usual activites; worse mobility; PTSD symptoms related to illness; worse anxiety/depression; new or worse concentration problem; voice change; worse pain/discomfort; new or worse short-term memory problem; laryngeal sensitivity; worse self-care; new bladder control problem; swallowing problem; appetite problem; communication difficulty; new bowel control problem | Mean = 48 days from discharge (n = 100) | No contact details, under 18, dementia, learning disability, or other cognitive or communication impairment | Screening tool evaluation | Positive PCR test during inpatient hospital admission, 4 weeks or more since discharge date, not currently inpatient | n/a | n/a |
| Heesakkers et al. [45] | January 2022 | Multicetner ICU patients (questionnaires, online or paper) | 301 (The Netherlands) | Weakened condition; joint stiffness; joint pain; muscle weakness; myalgia; dyspnea; tingling or numbness in limbs; lung disease; neuropathic pain; voice problems; dizziness or balance problems; hypotension or hypertension; sexual problems; skin problems; hair loss; loss of smell; loss of taste; headache; heart disease/chest pain; vision problems; loss of hearing; bowel problems; urinary problems; wound pain; pressure ulcers | 1 year (n = 246) | ICU admission <12 h, life expectancy <48 h, receiving pallative care | Exploratory prospective | Admitted to ICU with laboratory or clinical diagnosis of COVID-19 | n/a | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Horberg et al. [46] | October 2022 | Patients at Kaiser Permanente Mid-Atlantic States (EHR) | PCR positive = 28,118; PCR negative matched controls = 70,293 (USA) | Abdominal pain; gastrointestinal disease; nonspecific chest pain; conditions associated with dizziness or vertigo; genitourinary symptoms and ill-definited conditions; malaise and fatigue; anxiety disorders; other lower respiratory disease; mental health; cardiac dysrhymias; diabetes; other nervous system disorders; nausea and vomiting; other nutritional/endocrine/and metabolic disorders; fluid and electrolyte disorders; anosmia; respiratory failure/ insufficiency/arrest | Acute/Persistent: 0–30 days; Late: 30–120 days (n's unclear) | Patients not enrolled in KPMAS 120 days post-PCR test date | Case-control | PCR positive | PCR negative | 3:1 negative to positive by age, sex, testing month, service area |
| Horwitz et al. [47] | August 2021 | Patients discharged from hospital (survey) | 1 mo. = 152; 6 mo. = 126 (USA) | Fatigue; weakness; memory changes; muscle/body ache; brain fog; difficulty sleeping; joint pain; diarrhea; lightheadedness/dizziness; numbness/tingling; headache; dry mouth; burning or pins/needles sensation; chest pain; dry eyes; palpitations; altered/loss of smell; ringing in ears; altered/loss of taste; GI; tremors; rash; nausea; hair loss; vision changes | 1 (n = 152) and 6 mo. (n = 126) | Incomplete surveys | Prospective cohort | Hospitalized for COVID-19 at single health system who required minimum 6 1 of supplemental oxygen during admission, intact baseline functional status, discharged | n/a | n/a |
| Huang et al. [48] | January 2021 | Patients discharged from Jin Yin-tan Hospital (surveys, physical exams, blood, pulmonary function test, chest CT, ultrasonography) | 1733 (China) | Fatigue or muscle weakness; pain or discomfort; sleep difficulties; anxiety or depression; hair loss; smell disorder; palpitations; joint pain; decreased appetite; taste disorder; mobility problems; dizziness; diarrhea or vomiting; chest pain; sore throat or difficulty swallowing; skin rash; myalgia; headache; usual activity problems; personal care problems; low grade fever | Median 186 days (n = 1655) | Psychosis, dementia, hospital re-admission, serious mobility issues, could not be contacted, nursing/welfare home residents, live outside Wuhan, deceased | Cohort | Laboratory diagnosis of COVID-19 | n/a | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Huang et al. [21] | November 2022 | University of California COVID Research Data Set (EHR) | 1441 (USA) | Chest pain; dyspnea; anxiety; abdominal pain; cough; low back pain; fatigue; insomnia; diarrhea; joint pain; headache; nausea; tachycardia; muscle pain; alopecia; fever; heart palpitations; syncope; heartburn; dysgeusia; amnesia; skin lesions; tinnitus; sore throat or pain in throat; hypotension | 0–30 days (n = 1441) and 180+ days (n = 227) | Hospitalized | Cohort | Patients with at least 5 year history with UC system, positive PCR test, healthcare interaction after diagnosis | n/a | n/a |
| Jacobson et al. [49] | February 2021 | Patients with COVID-19 (surveys, walk test) | 118 (USA) | Fatigue; dyspnea; loss of taste/smell; myalgias; memory problems; chest pain; hair loss; cough; congestion/rhinorrhea; nausea/vomiting/diarrhea; headache; palpitations; sore throat; fever/chills | 3–4 mo. (n = 118) | n/a | Cohort | Positive PCR test | n/a | n/a |
| Kayaaslan et al. [50] | December 2021 | Patients with COVID-19 in Ankara City Hospital (questionnaire by phone or in clinic); 1092 invited | 1007 (Turkey) | Fatigue; dyspnea; hair loss; concentration or memory deficit; myalgia; insomnia; chest pain; headache; cough; wheezing; hypersomnia; loss of weight; loss of smell; loss of taste; new anxiety; new depression; rash; nightmare; genitourinary issues; abdominal pain; constipation; diarrhea | >12 weeks (n = 1007) | n/a | Prospective | Laboratory or imaging confirmation of COVID-19 | n/a | n/a |
| Kuodi et al. [51] | August 2022 | Patients at Ziv Medical Centre, Padeh-Poriya Medical Centre, Galilee Medical Centre (online survey): of 79,482 invitations to participate in the study, 3572 (4.5%) individuals > age 18 agreed to participate: 2447 who reported no previous SARS-CoV-2 infection and 1125 who did; excluded 174 infected individuals without vaccination status. | COVID-19 = 951; Control = 2447 (Israel) | Fatigue; headache; weakness in arms or legs; persistent muscle pain; loss of concentration; hair loss; problem sleeping; dizziness; persistent cough; shortness of breath; loss of taste; chest pains; pins and needles sensation; palpitations; depression and anxiety; abdominal pain; problems with balance; inability to control body movement; joint pain or swelling; loss of smell; loss of appetite; pain on breathing; nausea and vomiting; constipation; erectile dysfunction | Not specified beyond "not fully recovered" | Not reporting vaccination status | Cross-sectional nested in Prospective Longitudinal Cohort Study | Self-reported previous COVID-19 infection | Self-reported no COVID-19 infection | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Larsen et al. [52] | April 2022 | COVID support groups and social media (online survey) | Test-confirmed = 1249; Test-unconfirmed = 1065 (Global/34 countries) | Fatigue; Brain fog; headache; shortness of breath with exertion; body aches; palpitations; lightheadedness; tachycardia; difficulty sleeping; pre-syncope; loss of taste; loss of smell | Symptoms for >30 days, n = 1249 test-confirmed and 1065 test-unconfirmed | Incomplete, symptom duration < 30 days, onset before November 2019, age ≥ 65 | Cross-sectional | Adults with self-suspected, clinician-diagnosed or test-confirmed COVID-19 | n/a | n/a |
| LaVergne et al. [53] | July 2021 | Participants from community and hospital settings in Colorado (survey, saliva, blood, breast milk, stool) | 119 (USA) | Fatigue; forgetful/absent minded; difficulty concentrating; exercise intolerance; difficulty sleeping; loss of smell; joint pain; confusion; difficulty breathing; loss of taste; change in taste; rapid heartrate; depression | 25–89 days (n = 56), 90–174 (days n = 55), >175 days (n = 42) | n/a | Case-control, longitudinal | PCR positive | PCR Negative | n/a |
| Liang et al. [13] | December 2020 | Hospitalized patients at Wuhan Union Hospital (questionnaires, laboratory tests, physical exams) | 76 (China) | Chest tightness and palpitations; cough; fatigue; increased sputum; diarrhea; fever | 3 mo. (n = 76) | History of pulmonary resection, psychiatric or neurological disease | Prospective observational | PCR positive, discharged from hospital | n/a | n/a |
| Mandal et al. [54] | November 2020 | Patients discharged from three London hospitals (clinical assessment) | 384 (UK) | Fatigue; breathlessness; cough; depression | Median 54 days (n = 384) | Could not be reached, could not complete assessment | Cross-sectional | Tested positive for COVID-19 | n/a | n/a |
| Mizrahi et al. [22] | November 2022 | Nationwide healthcare services members with a PCR test for COVID-19 (EHR) | COVID+ = 299,870; COVID− = 299,870 (Israel) | Anosmia/dysgeusia; concentration/memory; weakness; dyspnea; convulsions; muscle atrophy; voice disorder; dizziness; sore throat; palpitations; arthralgia; myalgia; cough; chest pain; visual disturbances; bloody stool; tremor; headache; abdominal pain; rhinorrhea; menstruation abnormalities; skin rash; nausea/vomiting; insomnia; respiratory disorders | Single follow-up between 2nd-12th month after PCR test, n = 299,870 | Incomplete data, vaccinated >3 mo. before positive test, admitted to hospital with COVID 30 days after infection, patients with chronic outcomes that predated COVID infection (ever), patients with temporary outcomes that predated COVID infection (1 year) | Retrospective nationwide cohort | Positive PCR test in medical record | Negative PCR test/no previous positive PCR test | Age, sex, month of test, immune status (unvaccinated, partially vaccinated, second dose vaccine, booster) |
| Moreno-Perez et al. [55] | January 2021 | Patients at the Emergency Dept of Alicante General University Hospital (clinical exam, blood, chest x-ray, pulmonary function test, survey) | 277; 141 with Post-COVID syndrome (Spain) | Fatigue; persistent dyspnea; anosmia/dysgeusia; persistent cough; myalgias/arthralgias; headache; mnesic complaints; diarrhea; skin features; visual loss; fever | 77 days (follow-up n unclear) | "Severe comorbidity" | Prospective cohort | PCR or antibody positive | n/a | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Munblit et al. [56] | July 2021 | Hospitalized patients at Sechenov University Hospital network (phone interview with ISARIC questionnaire) | PCR+ = 1358; Clinical COVID = 1291 (Russia) | Chronic fatigue; respiratory; neurologic; mood and behavior changes; dermatologic | Median 218 days after discharge (PCR+ n = 1358, Clinical COVID+ n = 1291) | Death, no contact info, survey not collected | Longitudinal cohort | Confirmed or suspected COVID-19 | n/a | n/a |
| Naik et al. [57] | November 2021 | COVID patients discharged from hospital (phone or clinic questionnaire); 2243 invited, 1234 responded | 1234 (India) | Myalgia; dyspnea; fatigue; cough; insomnia; chest pain; anxiety; mood disturbance/ depression; anosmia | <1 mo. (140), 1–3 mo. (n = 398), 3–6 mo. (n = 264), >6 mo. (n = 276) | Under 18 | Longitudinal cohort | Laboratory-confirmed COVID 19 | n/a | n/a |
| Peghin et al. [58] | June 2021 | Patients attending Infectious Disease Department (phone interview) | 599 (Italy) | Fatigue; anosmia/dysgeusia; neurological disorders; rheumatological disorders; dyspnea; psychiatric disorders; hair loss; cutaneous lesions; URTI sympoms; headache; cough; GI disorders; chest pain; ocular symptoms | 6 mo. (n = 599) | Seronegative patients | Bidirectional prospective | Diagnosis of COVID-19 | n/a | n/a |
| Petersen et al. [59] | November 2020 | Patients diagnosed with COVID-19 (questionnaire, phone interview) | 180 (Faroe Islands) | Fatigue; loss of smell; loss of taste; arthralgia; rhinorrhea; dyspnea; myalgia; headache; cough with expectoration; chest tightness; chills; dry cough; nausea; diarrhea; rashes; anorexia; sore throat | ≥2 mo. (n = 179) | n/a | Longitudinal cohort | Positive PCR test | n/a | n/a |
| Reese et al. [60] | May 2022 | U.S. N3C patients (EHR)/RECOVER EHR PASC: cluster analysis | N3C N = 12,443,936, COVID N = 2,909,292, U09.9 (Long COVID) N = 5645, Included in analysis N = 2464 | Cough; pain; fatigue; hyperglycemia; chest pain; hypoxemia; fever; myalgia; headache; insomnia; hypocalcemia; lymphopenia; asthenia; nausea; abdominal pain; vertigo; nasal congestion; diarrhea; abnormal movement; elevated ASAT; elevated creatinine; elevated ALP; thrombocytopenia; hypotension; tachycardia | ≥4 weeks (n = 2464) | n/a | Retrospective observational | Patients with U09.9 (Long COVID) diagnosis | n/a | n/a |
| Roessler et al. [61] | November 2022 | Insured patients (Health insurance data); COVID patients matched 1:5 with non-COVID patients | 145,184 adults; 11,950 children/adolescents (Germany) | Fever; dyspnea; cough; respiratory insufficiency; throat/chest pain; hair loss; malaise/fatigue/exhaustion; dysphagia; headache | Mean = 254 days (n = 145,184) | COVID-19 diagnosis without PCR, patients not continuously insured | Retrospective matched cohort study | Documented COVID-19 diagnosis with PCR detection | No COVID-19 diagnosis | 1:5 by index date, age, sex and propensity score matching on preexisting medical conditions |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Romero-Duarte et al. [62] | May 2021 | Patients at four Spanish hospitals (primary care records) | 797 (Spain) | Dyspnea; fatigue; cough; musculoskeletal pain; diarrhea; pharyngeal symptoms; anosmia or dysgeusia; fever; anxiety symptoms; thoracic pain; abdominal pain; headache; sleep disturbances; opthalmological problems; rib pain; depressive symptoms; general malaise; UTI; muscle weakness; paraesthesia; movement disturbances; ICU-related polyneuropathy; thromboic manifestations; exanthema; arrythmia or palpitations | 6 mo. (n = 797) | Negative PCR | Retrospective observational | Confirmed positive PCR | n/a | n/a |
| Sarrafzadegan et al. [63] | August 2022 | Previously hospitalized patients in Isfahan urban and rural areas (questionnaires) | 819 (Iran) | Joint pain or myalgia; dry cough or dyspnea; hair loss; fatigue or muscle weakness; GI disorders; mental health problems; headache; palpitations; low grade fever; dizziness; ocular problems; chest pain; skin rash/pruritus; smell disorder; body tremor or tingling; renal disorders; decreased appetite; sore throat/difficulty swallowing/sputum productions; ear problems; taste disorders; sleep difficulties | 1 year (n = 819) | Patients hospitalized before 10 March 2020, no PCR test, negative PCR test | Multicenter prospective cohort | Positive PCR test | n/a | n/a |
| Sigfrid et al. [64] | August 2021 | Patients hospitalized with COVID-19 (questionnaire by mail, phone, or clinic) | 327 (UK) | Fatigue; breathlessness; problems sleeping; headache; limb weakness; persistent muscle pain; joint pain or swelling; dizziness/lightheadedness; problems with balance; swollen ankle; palpitations; vision problems; constipation; stomach pain; diarrhea; cough; chest pains; pain on breathing; loss of smell; persistent fevers; loss of taste; nausea/vomiting; loss of appetite; problems swallowing; skin rash | ≥3 mo. (n = 327) | No positive PCR test recorded | Longitudinal cohort | Patients admitted to hospital with confirmed or highly suspected COVID-19 | n/a | n/a |
| Søraas et al. [23] | August 2021 | Non-hospitalized patients (online surveys) | COVID+ = 794; COVID− = 7229 (Norway) | Fatigue; changed smell or taste; headache; nasal symptoms; dyspnea; cough; body ache/muscular pain; sore throat; abdominal pain/nausea/diarrhea; fever | 3–8 mo. (n = 672) | Hospitalized | Longitudinal cohort | Laboratory-confirmed COVID 19 | COVID 19 negative patients | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Suárez-Robles et al. [14] | December 2020 | Patients discharged from hospital (phone survey) | 134 (Spain) | Fatigue; dyspnea; loss of weight; loss of appetite; cough; anosmia; arthritis; headaches; palpitations; dysgeusia; general malaise; dysphonia; sensitivity disorders; sputum; walking disturbances; cutaneous manifestations | 90 days (n = 134) | n/a | Observational descriptive | Positive PCR test | n/a | n/a |
| Sudre et al. [65] | April 2021 | Participants using Zoe COVID Symptom Study App (survey) | 4182 cases/ 4182 controls (UK) | Fatigue; headache; palpitations/tachycardia; memory issues; tinnitus/ earache; peripheral neuropathy symptoms | ≥28 days (n = 558); ≥ 8 weeks (n = 189); ≥12 weeks (n = 95) | Admitted to ICU | Prospective observational cohort | Users of the COVID Symptom Study App | Symptomatic test-negative | Age, sex, BMI |
| Tabacof et al. [66] | January 2022 | Patients at Mount Sinai post-acute COVID-19 syndrome clinic (online survey) | 156 (USA) | Fatigue; brain fog; headache; sleep disturbance; dizziness; dyspnea; memory loss; palpitations; confusion; general weakness; chest pain; neuropathic pain; muscle pain; temperature dysregulation; indigestion; mood alteration; sweating; joint pain; tinnitus; nausea; tachypnoea; vision impairment; bloating; sore throat; hair loss | Median = 351 days (n = 156) | Incomplete survey | Cohort | PCR or antibody positive or diagnosis by medical doctor for COVID-19, diagnosis of PACS (>12 weeks of symptoms since onset) | n/a | n/a |
| Morin et al. [67] | April 2021 | Patients hospitalized in Bicêtre Hospital (telephone assessment) | COVID+ = 478 (France) | Fatigue; memory difficulties; dyspnea; persistent paresthesia; mental slowness; concentration problems; weight loss > baseline; chest discomfort/pain; anorexia; anosmia; headaches; cough | 4 months after discharge (n = 478) | Death, persistent hospitalization, end-stage cancer, dementia, nosocomial COVID-19 infection, incidental positive result during hospital stay for another condition | Cohort | Adults patients hospitalized for COVID-19 between March 1 and 29 May 2020 | n/a | n/a |
| Tleyjeh et al. [68] | December 2021 | Patients discharged from King Fahad Medical City Hospital (phone interview) | 222 (Saudi Arabia) | Shortness of breath; fatigue; cough; lasting muscle/body pain; difficult concentrating; headaches; joint pain; memory impairment; insomnia; loss of appetite; chest pain; abdominal pain; nausea/vomiting; constipation; diarrhea; loss of smell; sore throat; fever; loss of taste | Median 4 mo. (n = 222) | Death, still hospitalized, mental illness, did not respond | Prospective cohort | Positive PCR test | n/a | n/a |

**Table 1.** *Cont.*

| Study | Publication Date | Study Population | Sample Size/Location(s) | Top 25 Symptoms (Most to Least Common) | Time Since Infection or Discharge (n = Responders) | Exclusion Criteria | Design | Case Definition | Control | Matching |
|---|---|---|---|---|---|---|---|---|---|---|
| Venturelli et al. [69] | January 2021 | Patients discharged from Papa Giovanni XXIII Hospital (clinical assessment, blood tests, chest x-ray, electrocardiogram, full pulmonary function testing, psychological evaluation, assessment of rehabilitation needs) | 767 (Italy) | Asthenia; dyspnea; palpitations; myalgia; chest pain; confusion; cough; anosmia/dysguesia; lower GI problems; fever; headache; syncope; upper GI problems | Median 81 days (n = 767) | Pregnant and admitted for delivery, under 18, asymptomatic | Cohort | Admitted to or discharged from hosptial with any condition possibly related to COVID-19, then a double negative nasopharyngeal swab | n/a | n/a |
| Wang et al. [15] | September 2020 | Hospitalized patients at Tongji Hospital (hospital records, follow-up with patients/ method unspecified) | 131 (China) | Cough; dyspnea; pharyngeal pain; nausea; chest tightness | Follow-up at 1–2, 3–4 weeks (all n = 131) | Could not be contacted | Prospective cohort | Confirmed COVID-19 cases discharged from hospital | n/a | n/a |
| Wanga et al. [70] | September 2021 | US nationwide CDC sample of adults (online survey) | Self-reported positive test = 698; negative test = 2437 (USA) | Fatigue/tired/weakness; change in smell or taste; shortness of breath or breathlessness; cough; headache; problems sleeping; joint or muscle pain; cognitive dysfunction; chest pain or pressure; change in mood; post-exertional malaise; stomach pain; hair loss; diarrhea; sore throat; fever or chills; palpitations; nausea/vomiting | >4 weeks (n = 698) | n/a | Retrospective observational | Positive test result | n/a | n/a |
| Xiong et al. [71] | September 2020 | Hospitalized patients at Renmin Hospital of Wuhan University (phone survey) | COVID survivors = 538; residents of local area not hospitalized = 184 (China) | Alopecia; fatigue; sweating; postactivity polypnoea; somnipathy; chest distress; chest pain; resting heart rate increase; arthralgia; cough; anxiety; discontinuous flushing; nonmotor polypnoea; chills; myalgia; depression; throat pain; sputum; limb edema; dizziness; dysphoria; new hypertension; feelings of inferiority | >3 mo. (n = 538 COVID survivors) | Pregnant or breastfeeding, severe underlying disease, receiving invasive treatment | Longitudinal cohort | Inpatients 20–80 years old who were diagnosed with COVID-19 | Residents living in urban area at same time as outbreak | n/a |
| Zhao et al. [16] | August 2020 | Hospitalized patients at 3 tertiary hospitals in Henan Province (Physical and imaging tests) | 55 (China) | GI symptoms; headache; fatigue; exertional dyspnea; decreased sense of taste; cough and sputum | 3 mo. (n = 55) | Critical pneumonia | Retrospective cohort | Confirmed PCR positive, discharged from hospital | n/a | n/a |

"n/a" indicates no relevant data to report.

### *2.3. Long COVID Symptom Categories*

Symptoms were categorized into 25 different phenotypic bins in an a priori fashion based on symptoms assessed in the National Institutes of Health (NIH)–funded Researching COVID to Enhance Recovery (RECOVER) Adult Cohort (recovercovid.org (accessed on 21 September 2024)), grouped by CTCAE (Common Terminology Criteria for Adverse Events) for the symptoms [72]. Any symptom that fell into one of the following categories was added to the review table (Supplemental Figure S1): general symptoms included fatigue, fever, chills, sweats or flushing, post-exertional malaise; cardiac symptoms included general cardiac symptoms such as tachycardia and chest pain; respiratory symptoms included cough, shortness of breath, sleep problems; neurologic symptoms included problems thinking or concentrating, dizziness, headache, nerve problems (tremor, shaking, abnormal movements, numbness, tingling, burning, cannot move part of body, seizures), and loss of or changes in smell or taste; psychiatric symptoms include mental health concerns such as depression, and anxiety; musculoskeletal symptoms included joint or muscle pain, weakness in arms or legs; gastrointestinal (GI) symptoms included abdominal pain and/or feeling full or vomiting after eating, diarrhea, constipation weight loss, dry mouth; metabolic symptoms included excessive thirst; urinary problems included incontinence, trouble passing urine or emptying bladder); dermatologic symptoms included skin rash, hair loss; ear symptoms included hearing problems; eye symptoms included vision problems. Two symptoms, swelling of the legs and changes in skin coloration, were not reported in the top 25 symptoms of the 59 reviewed papers and were thus left out of further analyses. Two additional symptoms, dry mouth and excessive thirst, were reported in only one study. Therefore, this review used an end total of 21 phenotypic categories.

### *2.4. Long COVID Symptom Reporting*

The methods used to evaluate and measure Long COVID symptoms were heterogeneous across the 59 studies reviewed that reported individual symptoms as regards their prevalence (n = 59). To be exhaustive in our representation of symptom data, all methods with numerical values were included and similar data were grouped when possible (Table 2). The colors indicate a symptom's prevalence relative to all other reports, with green = lowest, yellow = lower, orange = highest, and red = highest across all studies.

**Table 2.** Long COVID symptom reports for all studies.

| Table 2. Prevalence of Post-COVID Symptoms | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Author/Year | Population/Methods/ Sample Summary | Fatigue | Fever, Chills, Sweats or Flushing † | Dizziness | Post-Exertional Malaise | Sleep Problems | Weakness in Arms or Legs | Headache | Joint/Muscle Pain † | Loss of or Change in Smell or Taste † | Shortness of Breath | Persistant Cough † | Cardiac Symptoms Including Chest Pain † | GI Symptoms Including Abdominal Pain † | Urinary Symptoms | Mental Health Concerns † | Nerve Problems, Seizures † | Problems Thinking or Concentrating | Skin Rash | Hair Loss | Vision Problems | Hearing Problems | Dry Mouth | Excessive Thirst |
| Anastacio et al., 2021 [27] | Previously hospitalized and non-hospitalized patients (pulmonary function test, 6MWT, survey), n = 379 | n/a | n/a | 2.4% | n/a | 4.2% | n/a | 5.3% | 13.7% | 10.3% | 42.7% | 6.1% | 6.1% | n/a | n/a | 8.2% | n/a | n/a | n/a | 3.2% | n/a | n/a | n/a | n/a |
| Arnold et al., 2020 [28] * | Previously hospitalized patients (radiographs, pulmonary function testing, blood, survey), n = 163 | 39.0% | 2.0% | n/a | n/a | 26.0% | n/a | 2.0% | 5.0% | 11.0% | 39.0% | 11.0% | 12.0% | 2.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Baruch et al., 2022 [29] | Previously hospitalized and non-hospitalized patients (survey), n = 2665 | 9.7% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 14.2% | 5.3% | n/a | n/a | n/a | 11.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Becker et al., 2021 [30] | Previously hospitalized patients (phone interview and surveys), n = 90 | 46.0% | 2.0% | n/a | 20.0% | 17.0% | n/a | 9.0% | 18.0% | 16.0% | 21.0% | 7.0% | 12.0% | 6.0% | n/a | 13.0% | 8.0% | 31.0% | n/a | n/a | n/a | n/a | n/a | n/a |
| Bellan et al., 2021 [31] | Previously hospitalized patients (phone interview, pulmonary function and physical performance tests, psychological inventory), n = 238 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 5.9% | 5.0% | 5.5% | 2.5% | 0.4% | 1.3% | n/a | n/a | 5.9% | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Bliddal et al., 2021 [20] * | Non-hospitalized patients in Danish Civil Registration System (online survey), n = 198 | 16.0% | 1.0% | n/a | n/a | n/a | n/a | 6.5% | 5.5% | 7.5% | 12.0% | 4.5% | n/a | 2.3% | n/a | n/a | n/a | 13.0% | n/a | n/a | n/a | n/a | n/a | n/a |
| Blomberg et al., 2021 [32] | Home isolated or hospitalized patients (clinic interview), n = 247 | 30.0% | 2.0% | 10.0% | n/a | 5.0% | n/a | 11.0% | n/a | 27.0% | 15.0% | 6.0% | 6.0% | 6.0% | n/a | n/a | 4.0% | 19.0% | n/a | n/a | n/a | n/a | n/a | n/a |
| Buttery et al., 2021 [33] | Respondents to UK national online post-COVID support survey, n = 3290 enrolled, n = 1865 at 12 weeks. | 84.1% | n/a | n/a | n/a | 47.6% | n/a | n/a | 52.8% | 26.2% | 91.5% | 40.3% | n/a | n/a | n/a | 45.1% | n/a | 50.9% | n/a | 13.3% | n/a | n/a | n/a | n/a |
| Carfi et al., 2020 [8] * | Previously hospitalized patients (survey), n = 143 | 55.0% | n/a | n/a | n/a | n/a | n/a | 9.0% | n/a | 15.0% | 42.0% | 17.0% | 21.0% | 2.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Carvalho-Schneider et al., 2020 [34] | Previously hospitalized and non-hospitalized patients (EHR, phone call), n = 150 enrolled, n = 130 at 2 months | n/a | 0.0% | n/a | n/a | n/a | n/a | n/a | 16.3% | 22.7% | 7.7% | n/a | 13.1% | 11.5% | n/a | n/a | n/a | n/a | 11.5% | n/a | n/a | n/a | n/a | n/a |
| Chopra et al., 2021 [35] | Previously hospitalized patients/MI-COVID 19 Initiative (EHR), n = 488 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 13.1% | 16.6% | 15.4% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Cirulli et al., 2020 [17] * | Participants in Healthy Nevada Project and Helix DNA Discovery Project (online survey); 21,359 respondents, COVID+ 357, COVID− 5497, 19,095 not tested, n = 21,359 | 4.0% | n/a | 5.0% | n/a | 4.0% | n/a | 5.0% | 5.0% | 10.0% | n/a | 10.0% | 6.0% | 4.0% | n/a | n/a | 4.0% | 8.0% | n/a | n/a | n/a | 3.0% | n/a | n/a |
| Daitch et al., 2022 [36] | Patients at COVID-19 recovery clinics (visit or survey), n = 2333 | 39.0% | n/a | n/a | n/a | n/a | n/a | 6.8% | n/a | 15.5% | 28.0% | 11.4% | 11.8% | n/a | n/a | n/a | n/a | 19.1% | n/a | 5.3% | n/a | n/a | n/a | n/a |
| Daher et al., 2020 [9] | Previously hospitalized patients (physical and laboratory tests, questionnaires), n = 33 | 45.0% | 3.0% | n/a | n/a | n/a | n/a | 15.0% | 15.0% | 12.0% | 33.0% | 33.0% | n/a | 9.0% | n/a | n/a | n/a | 18.0% | n/a | n/a | n/a | n/a | n/a | n/a |
| Danesh et al., 2022 [37] | Patients seeking COVID-19 recovery care clinic (medical assessments), n = 441 | n/a | n/a | 3.4% | n/a | 15.6% | n/a | 19.3% | n/a | 14.1% | 63.7% | 26.9% | 17.2% | 5.9% | n/a | 11.6% | 2.3% | 20.2% | n/a | n/a | 2.0% | 1.1% | n/a | n/a |
| Darcis et al., 2021 [38] | Previously hospitalized patients (survey, biological data, pulmonary function tests, CT scans of chest), n = 199 enrolled, n = 78 at 6 month follow-up | 32.0% | n/a | n/a | n/a | n/a | n/a | 1.0% | n/a | 1.0% | 1.0% | 9.0% | 5.0% | 1.0% | n/a | n/a | 1.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Davis 2021 [24] * | COVID-19 support groups, social media (online survey), n = 3762 | 97.0% | 56.0% | n/a | 88.0% | n/a | n/a | n/a | 70.0% | n/a | 77.0% | 66.0% | 67.0% | 60.0% | n/a | n/a | n/a | n/a | n/a | n/a | 36.0% | n/a | n/a | 36.0% |
| Dryden et al., 2022 [39] | Previously hospitalized patients (phone interview), 3 month follow-up, n = 2410 surveyed, n = 1873 responders at 3 months | 50.3% | 1.5% | 6.2% | n/a | n/a | n/a | 13.8% | 9.3% | 2.7% | 23.4% | 4.2% | 7.0% | 2.3% | n/a | n/a | n/a | 17.5% | 1.9% | n/a | 10.1% | n/a | n/a | n/a |
| Elkan et al., 2021 [40] * | Previously hospitalized patients (survey), n = 66 | 27.0% | n/a | n/a | n/a | 8.0% | n/a | 8.0% | n/a | n/a | 11.0% | n/a | n/a | n/a | n/a | 7.0% | n/a | n/a | n/a | 8.0% | n/a | n/a | n/a | n/a |
| FAIR Health White 2021 [41] * | Previously hospitalized and non-hospitalized patients in FAIR Health database (EHR), n = 1,959,982 | 2.9% | n/a | n/a | n/a | 1.3% | n/a | 1.6% | 5.1% | n/a | n/a | n/a | n/a | 2.2% | n/a | 2.3% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Frontera et al., 2021 [42] | US community research platform (online survey), n = 999 respondents; COVID-19 = 76; Prolonged symptoms = 19 | 42.0% | 11.0% | 26.0% | 26.0% | 32.0% | n/a | 47.0% | 37.0% | 21.0% | 26.0% | 16.0% | 37.0% | n/a | n/a | 53.0% | n/a | 47.0% | n/a | n/a | 26.0% | n/a | n/a | n/a |
| García-Abellán et al., 2021 [43] | Previously hospitalized patients (phone and clinic surveys, blood and nasopharyngeal samples), n = 146 | 10.3% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 4.3% | 4.3% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Garrigues et al., 2020 [11] | Previously hospitalized patients (phone survey), n = 120 | 55.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 13.3% | 41.7% | 16.7% | 10.8% | n/a | n/a | n/a | n/a | n/a | n/a | 20.0% | n/a | n/a | n/a | n/a |
| Goërtz et al., 2020 [12] | Two Facebook groups for COVID-19 patients with persistent symptoms, website panel registrants (online survey), n = 2113 | 87.0% | 22.0% | 27.0% | n/a | n/a | n/a | 38.0% | 66.7% | 13.0% | 71.0% | 29.0% | 32.0% | 41.1% | n/a | n/a | n/a | n/a | n/a | n/a | 25.7% | n/a | n/a | n/a |
| Halpin et al., 2020 [44] | Previously hospitalized patients (phone survey), n = 100 | 64.0% | n/a | n/a | n/a | n/a | n/a | n/a | 19.0% | n/a | 50.0% | n/a | n/a | n/a | n/a | 31.0% | n/a | 22.0% | n/a | n/a | n/a | n/a | n/a | n/a |
| Heesakkers et al., 2022 [45] | Previously hospitalized patients (questionnaires, online or paper), n = 301 surveyed, n = 246 responders at 1 year | n/a | n/a | 11.5% | n/a | n/a | n/a | 5.3% | 25.5% | 6.9% | 20.8% | n/a | 5.3% | 3.7% | 3.3% | n/a | 20.6% | n/a | n/a | 7.0% | 4.9% | 4.1% | n/a | n/a |
| Horberg et al., 2022 [46] | Previously hospitalized and non-hospitalized patients (EHR), PCR positive = 28,118; PCR negative matched controls = 70,293 | 1.4% | n/a | 1.7% | n/a | n/a | n/a | n/a | n/a | 0.3% | 1.1% | n/a | 1.7% | 1.8% | 1.5% | 1.1% | 1.8% | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Horwitz et al., 2021 [47] | Previously hospitalized patients (survey), 1 mo. n = 152, 6 mo. n = 126 | 85.0% | n/a | 29.0% | n/a | 35.0% | n/a | 26.0% | 33.0% | 15.0% | n/a | n/a | 21.0% | 33.0% | n/a | n/a | 28.0% | 37.0% | 9.0% | 7.0% | 3.0% | 12.0% | 25.0% | n/a |
| Huang et al., 2021 [48] | Previously hospitalized patients (surveys, physical exams, blood, pulmonary function test, chest CT, ultrasonography), n = 1733 | 63.0% | <1% | 6.0% | n/a | 26.0% | n/a | 2.0% | 9.0% | 11.0% | n/a | n/a | 9.0% | 5.0% | n/a | 23.0% | n/a | n/a | 3.0% | 22.0% | n/a | n/a | n/a | n/a |
| Huang et al., 2022 [21] * | Non-hospitalized patients (EHR), n = 1407 | 9.0% | 3.0% | n/a | n/a | 7.0% | n/a | 12.0% | 4.0% | n/a | 16.0% | 7.0% | 13.0% | 12.0% | n/a | 8.0% | 1.0% | n/a | n/a | 1.0% | 1.0% | 2.0% | n/a | n/a |
| Jacobson et al., 2021 [49] | Previously hospitalized and non-hospitalized patients (surveys, walk test), n = 118 | 30.8% | 0.9% | n/a | n/a | n/a | n/a | 6.0% | n/a | 21.4% | 26.5% | 8.5% | 13.7% | 6.8% | n/a | n/a | n/a | n/a | n/a | 12.0% | n/a | n/a | n/a | n/a |

**Table 2.** *Cont.*

| Table 2. Prevalence of Post-COVID Symptoms | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Author/Year | Population/Methods/ Sample Summary | Fatigue | Fever, Chills, Sweats or Flushing † | Dizziness | Post-Exertional Malaise | Sleep Problems | Weakness in Arms or Legs | Headache | Joint/Muscle Pain † | Loss of or Change in Smell or Taste † | Shortness of Breath | Persistant Cough † | Cardiac Symptoms Including Chest Pain † | GI Symptoms Including Abdominal Pain † | Urinary Symptoms | Mental Health Concerns † | Nerve Problems, Seizures † | Problems Thinking or Concentrating | Skin Rash | Hair Loss | Vision Problems | Hearing Problems | Dry Mouth | Excessive Thirst |
| Kayaaslan et al., 2021 [50] | Previously hospitalized and non-hospitalized patients (questionnaire by phone or in clinic); 1092 invited, n = 1007 | 24.3% | n/a | n/a | n/a | n/a | n/a | 5.7% | n/a | 3.1% | 20.5% | 4.5% | 5.8% | 0.4% | 0.8% | 1.5% | n/a | 16.2% | 1.0% | 16.5% | n/a | n/a | n/a | n/a |
| Kuodi et al., 2022 [51] | Previously hospitalized and non-hospitalized patients (online survey), COVID-19 = 951; Control = 2447 | 21.9% | n/a | 7.8% | n/a | 8.9% | 13.5% | 20.0% | 10.3% | 6.6% | 7.2% | 7.4% | 6.4% | 6.0% | n/a | 5.8% | 6.3% | 9.5% | n/a | 9.3% | n/a | n/a | n/a | n/a |
| Larsen et al., 2022 [52] | COVID support groups and social media (online survey), Test-confirmed = 1249; Test-unconfirmed = 1065 | 89.4% | n/a | 68.6% | n/a | 65.4% | n/a | 77.9% | n/a | 61.3% | n/a | n/a | 65.0% | n/a | n/a | n/a | n/a | 81.3% | n/a | n/a | n/a | n/a | n/a | n/a |
| LaVergne et al., 2021 [53] * | Previously hospitalized and non-hospitalized patients (survey, saliva, blood, breast milk, stool), n = 119 | 23.0% | n/a | n/a | n/a | 18.0% | n/a | n/a | 18.0% | 17.0% | n/a | n/a | 5.0% | n/a | n/a | 18.0% | n/a | 18.0% | n/a | n/a | n/a | n/a | n/a | n/a |
| Liang et al., 2020 [13] | Previously hospitalized patients (questionnaires, laboratory tests, physical exams), n = 76 | 60.0% | 20.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 60.0% | 62.0% | 26.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Mandal et al., 2020 [54] | Previously hospitalized patients (clinical assessment), n = 384 | 69.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 53.0% | 34.0% | n/a | n/a | n/a | 15.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Mizrahi et al., 2022 [22] | Non-hospitalized patients (EHR), n = 299,870 | n/a | n/a | 0.9% | n/a | 0.02% | 2.5% | 2.1% | 0.9% | 0.3% | 2.0% | 2.9% | 2% | 3.4% | n/a | 0.5% | 0.5% | 0.3% | 0.8% | 0.7% | 0.3% | 0.4% | n/a | n/a |
| Moreno-Perez et al., 2021 [55] | Previously hospitalized and non-hospitalized patients (clinical exam, blood, chest x-ray, pulmonary function test, survey), n = 277 | 34.8% | <1% | n/a | n/a | n/a | n/a | 17.8% | n/a | 21.4% | 34.4% | 21.3% | n/a | 10.5% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Munblit et al., 2021 [56] | Previously hospitalized patients (phone interview with ISARIC questionnaire), PCR+ = 1358; Clinical COVID = 1291 | 21.2% | n/a | n/a | n/a | 7.0% | n/a | n/a | n/a | n/a | 14.5% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 7.6% | 7.1% | n/a | n/a |
| Naik et al., 2021 [57] | Previously hospitalized and non-hospitalized patients (phone or clinic questionnaire); n = 1234 | 5.5% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.2% | 6.1% | 2.1% | 1.2% | n/a | n/a | 0.6% | n/a | 1.2% | n/a | n/a | n/a | n/a | n/a | n/a |
| Peghin et al., 2021 [58] | Previously hospitalized and non-hospitalized patients (phone interview), n = 599 in study, n = 596 | 13.1% | n/a | n/a | n/a | n/a | n/a | 2.7% | n/a | 10.4% | 6.0% | 2.0% | 0.8% | 1.5% | n/a | n/a | n/a | n/a | n/a | 3.7% | n/a | n/a | n/a | n/a |
| Petersen et al., 2020 [59] * | Non-hospitalized patients (questionnaire, phone interview), n = 180 | 23.0% | 4.0% | n/a | n/a | n/a | n/a | 7.0% | n/a | 23.0% | 9.0% | 5.0% | n/a | 3.0% | n/a | n/a | n/a | n/a | 2.0% | n/a | n/a | n/a | n/a | n/a |
| Reese et al., 2022 [60] | Previously hospitalized and non-hospitalized patients (EHR)/RECOVER PASC N3C N = 12,443,936, COVID N = 2,909292, U09.9 (Long COVID) N = 5645, Included in analysis N = 2464 | 30.9% | 12.3% | 3.7% | n/a | 5.6% | n/a | 8.3% | 43.9% | n/a | 28.0% | 61.8% | 3.1% | 3.7% | n/a | n/a | 1.3% | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Roessler et al., 2022 [61] | Previously hospitalized and non-hospitalized patients (Health insurance data); COVID patients matched 1:5 with non-COVID patients, 145,184 adults | 4.3% | 1.2% | n/a | n/a | n/a | n/a | 4.1% | n/a | 1.2% | 4.4% | 3.0% | 3.5% | n/a | n/a | n/a | n/a | n/a | n/a | 1.4% | n/a | n/a | n/a | n/a |
| Romero-Duarte et al., 2021 [62] | Previously hospitalized patients (EHR, phone), n = 797 | 22.1% | 7.0% | n/a | n/a | 4.9% | n/a | 5.3% | 15.3% | 7.2% | n/a | 19.2% | 3.1% | 10.3% | n/a | 6.8% | 3.4% | n/a | 3.1% | n/a | 4.6% | n/a | n/a | n/a |
| Sarrafzadegan et al., 2022 [63] | Previously hospitalized patients (questionnaires), n = 819 | 11.7% | 3.7% | 3.2% | n/a | 0.2% | n/a | 5.7% | 19.7% | 1.3% | 18.7% | 18.7% | 5.1% | 7.1% | n/a | n/a | 1.3% | n/a | 2.2% | 14.7% | 2.7% | 1.1% | n/a | n/a |
| Sigfrid et al., 2021 [64] * | Previously hospitalized patients (questionnaire by mail, phone, or clinic), n = 327 | 83.0% | 15.0% | 36.0% | n/a | 42.0% | 37.0% | 38.0% | 36.0% | 16.0% | 54.0% | 17.0% | 25.0% | 20.0% | n/a | n/a | n/a | n/a | 14.0% | n/a | 20.0% | n/a | n/a | n/a |
| Søraas et al., 2021 [23] | Non-hospitalized patients (online surveys), COVID+ = 794, n = 676 at 3 months; COVID− = 7229 | 23.0% | 3.0% | n/a | n/a | n/a | n/a | 13.0% | 8.0% | 14.0% | 10.0% | 8.0% | n/a | 6.0% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Suárez-Robles et al., 2020 [14] | Previously hospitalized patients (phone survey), n = 134 | 54.5% | n/a | n/a | n/a | n/a | n/a | 24.6% | n/a | 26.1% | 40.3% | 26.1% | 21.6% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sudre et al., 2020 [65] | Participants using Zoe COVID Symptom Study App (survey): 4182 COVID cases, 4182 matched non-COVID controls | 97.7% | n/a | n/a | n/a | n/a | n/a | 91.2% | n/a | n/a | n/a | n/a | 6.1% | n/a | n/a | n/a | 2.0% | n/a | n/a | n/a | n/a | 3.6% | n/a | n/a |
| Tabacof et al., 2022 [66] * | Patients at COVID-19 syndrome clinic (online survey), n = 156 | 82.0% | 29.0% | 54.0% | n/a | 59.0% | n/a | 60.0% | 33.0% | n/a | 53.0% | n/a | 44.0% | n/a | n/a | 30.0% | n/a | 67.0% | n/a | 19.0% | 25.0% | 27.0% | n/a | n/a |
| Morin et al., 2021 [67] | Previously hospitalized patients (telephone assessment), n = 478 | 31.1% | n/a | n/a | n/a | n/a | n/a | 5.5% | 8.1% | 6.0% | 16.3% | 5.0% | n/a | n/a | n/a | n/a | 12.1% | 10.0% | n/a | n/a | n/a | n/a | n/a | n/a |
| Tleyjeh et al., 2021 [68] * | Previously hospitalized patients (phone interview), n = 222 | 30.0% | 2.0% | n/a | n/a | 5.0% | n/a | 8.0% | 8.0% | 2.0% | 40.0% | 27.5% | 4.0% | 3.0% | n/a | n/a | n/a | 8.0% | n/a | n/a | n/a | n/a | n/a | n/a |
| Venturelli et al., 2021 [69] | Previously hospitalized patients (clinical assessment, blood tests, chest x-ray, electrocardiogram, full pulmonary function testing, psychological evaluation, assessment of rehabilitation needs), n = 767 | n/a | 0.5% | 0.1% | n/a | n/a | n/a | 0.5% | n/a | 3.4% | 22.6% | 3.0% | 3.9% | 0.7% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Wang et al., 2020 [15] | Previously hospitalized patients (hospital records, follow-up with patients/method unspecified), n = 131 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 1.5% | 9.2% | n/a | 0.8% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Wanga et al., 2021 [70] | Previously hospitalized and non-hospitalized (online survey), Self-reported positive test = 698; negative test = 2437 | 34.2% | 7.5% | n/a | n/a | 18.1% | n/a | 20.9% | 16.9% | 26.2% | 23.6% | 22.0% | 11.0% | 8.0% | n/a | 10.1% | n/a | 15.5% | n/a | 8.5% | n/a | n/a | n/a | n/a |
| Xiong et al., 2020 [71] | Previously hospitalized patients (phone survey), COVID survivors = 538; residents of local area not hospitalized = 184 | 28.3% | 23.8% | 2.6% | n/a | 17.7% | n/a | n/a | n/a | n/a | n/a | 7.1% | 12.3% | n/a | n/a | 6.5% | n/a | n/a | n/a | 28.6% | n/a | n/a | n/a | n/a |
| Zhao et al., 2020 [16] | Previously hospitalized (Physical and imaging tests), n = 55 | 16.4% | n/a | n/a | n/a | n/a | n/a | 18.2% | n/a | 4.0% | n/a | 1.8% | n/a | 30.9% | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

* Colors indicate a symptom's prevalence relative to all other reports, with green = lowest, yellow = lower, orange = highest, and red = highest across all studies.

### 2.5. Risk of Bias Assessment

The included studies were assessed for risk of bias using Hoy et al.'s [73] critical appraisal tool for prevalence studies. The critical appraisal checklist for studies reporting prevalence consists of nine topics: (a) target population representativeness, (b) sample frame suitability, (c) sampling method appropriateness, (d) likelihood of non-response bias, (e) direct data collection from subjects, (f) usage of valid methods for identification of the condition, (g) use of valid, reliable study instrument to measure parameter of interest, (h) same mode of data collection for all subjects, and (i) adequate response rate. Each study was assessed across each of these areas, with results reported as Yes, No, or Unclear. The studies were assigned an overall score, reflecting the number of questions with a Yes response.

### 2.6. Statistical Methods

Sample sizes and populations in each paper are summarized in Table 1. Frequencies were summarized across studies using random effects meta-analyses. Specifically, a generalized linear mixed modelplogit with a logit transformation was performed in R. Where available, the exact number of events and total number of respondents for each symptom were included in the meta-analyses. For studies that only reported proportions, the number of events was estimated by multiplying number of respondents by proportion with the event and rounding up. The studies were grouped in three ways, by type of study (EHR, survey, Long COVID), risk of bias (low, medium, high), and hospitalization of respondents (hospitalized only versus non-hospitalized and mixed). Comparisons of proportion within each symptom category were carried out using a fixed-effects model using the "metafor" package in R (Supplemental Figure S2) [74]. All analyses were performed using R.

## 3. Results

### 3.1. Population Characteristics

The global population was surveyed owing in part to the authors' efforts to include COVID-19 support groups and social media groups for Long COVID in an online survey across 34 countries [52]. Study populations were reported from around the world, including the USA, the UK, Italy, Malta, South Africa, The Netherlands, Belgium, China, Turkey, Switzerland, Denmark, Norway, France, Israel, Spain, Germany, Belgium, Russia, India, Faroe Islands, Iran, and Saudi Arabia. Twenty-one of the studies included had a COVID-19 patient sample size > 950, with the largest sample at nearly 2 million [41]. The most common reasons for patients to be excluded from analyses were incomplete follow-up data, cognitive or neuropsychiatric conditions that prevented participation, death, current COVID-19 infection, and chronic or severe illness unrelated to/predating the COVID-19 infection (Table 1).

### 3.2. Definitions of Long COVID

Definitions varied for Long COVID in terms of length of time necessary for symptoms to persist or emerge. The lower ends of post-infection follow-up times started at just over 3 weeks [12,15]. The remaining studies investigated symptoms from 30+ days onward, even up to 1 year after the initial COVID-19 infection, hospital admission, or hospital discharge (Table 1). Several studies also utilized multiple time points for comparison [15,20,21,30,32,33,38,43,46,47,53,57,65]. Definitions of symptom-based phenotypes were also diverse across studies. Most included symptom checklists without assessment of Long COVID symptom severity.

### 3.3. Study Designs and COVID-19 Case Definitions

Study designs varied in the reviewed papers and included cohort (prospective, retrospective, and longitudinal), COVID-19 case–uninfected control, cross-sectional, case series, and diverse combinations thereof. Many studies required clinical diagnosis via laboratory confirmation of a past SARS-CoV-2 infection such as a positive PCR test. However, we also

included survey studies that relied on self-reports of COVID-19 infection. Control groups were not commonly present (n = 8/59 or 14% of reviewed studies included controls) but usually identified patients as COVID-19-negative via formal laboratory testing, although self-reports of negative infection status were sometimes used for inclusion (Table 1).

### 3.4. Most Common Symptoms Reported across 59 Studies

Due to the focus on utility in this review, article symptom lists were capped at 25, with priority given to the most common symptoms [26]. Of note, a handful of studies reported highly comprehensive lists of Long COVID symptoms at 39 [41], 58 [37], 68 [53], and 203 [24]. The general symptoms that patients experienced most often, and that were reported by at least two of the studies reviewed, were as follows: respiratory problems such as shortness of breath, fatigue, pain of various kinds, cognitive problems such as brain fog, changes in or loss of smell or taste, weakness mental health issues such as anxiety and depression, cardiac symptoms such as palpitations or chest pain, hair loss, fever/chills, sleep problems, gastrointestinal symptoms, and flu-like symptoms. Symptoms reported by patients but not captured in multiple studies included hyperlipidemia, post-exertional malaise, worse performance at usual activities, neurological disorders and unintentional weight loss (Supplemental Figure S3).

### 3.5. Data Collection Methods

Three studies utilized electronic health records (EHR) to create comprehensive data sets of COVID-19 cases and uninfected controls [22,46,61]. Three used EHR data on COVID-19 cases only [21,35,41]. Four studies conducted national or community surveys among self-reported COVID-19 test positive cases and COVID-19 test negative controls [17,33,42,70]. One study utilized a COVID-19 Symptom Study app, for which 4,223,955 adults registered from the UK (88.2%), the USA (7.3%), and Sweden (4.5%); in this study, a small subset (<0.1%) reported prospective data on symptoms after 28 days [65]. Studies that focused on populations of reporting symptoms after SARS-CoV2 infection rather than being focused on anyone infected in a population included four studies that conducted surveys using social media and online outreach to support groups for individuals with post-COVID-19 symptoms [12,24,33,52]; two studies that surveyed patients visiting local clinics for Long COVID symptoms [37,66]; and one study that relied on EHR data and used the Long COVID International Classifications of Disease, 10th Edition (ICD-10) code to identify the cohort [60].

Davis and colleagues from the Patient-Led Research Collaborative conducted an online survey that was distributed via COVID-19 support groups and social media to patients from 56 countries with symptoms lasting >28 days and onset prior to June 2020 [24]. They estimated the prevalence of 203 symptoms among 3762 respondents. The most common symptoms were fatigue, post-exertional malaise, and cognitive dysfunction, with 85.9% of participants experiencing relapses triggered by physical or mental activity, and stress. Buttery et al. studied survey responses from a UK online post-COVID-19 support and information hub, completed ≥4 weeks after onset of symptoms [33]. Goertz et al. studied 21,113 members of Facebook groups for COVID-19 patients with persistent symptoms in The Netherlands and Belgium [12]. Larsen et al. studied an online survey of 2314 adults with Long COVID recruited through Long COVID support groups and social media channels between October 2020 and August 2021 for 53 symptoms, including autonomic symptoms assessed with the Composite Autonomic Symptom Score-31 (COMPASS-31) [52]. Tabacof et al. conducted a survey of 156 patients attending Mount Sinai's Long COVID clinic [66]. Danesh et al. conducted interviews of 441 patients from an integrated health system multispecialty telemedicine-based consultation service for post-COVID-19 patients [37].

Multiple studies conducted post-discharge surveys by telephone or email with COVID-19-infected inpatients who were recently hospitalized [8,9,11,13–16,20,23,27–32,38–40,43–45,47–51,53–59,63,64,66–69,71]. Five of these studies also included either follow-up sur-

veys [57,58] or EHR data [46,60,61] from hospitalized and non-hospitalized COVID-19 patients, while three studies focused only on non-hospitalized COVID-19 patients using surveys [23,59] or EHR data [22]. For this review and meta-analysis, we limited the data extracted from manuscripts to Long COVID symptoms.

We classified study design into three categories: (1) "EHR" studies that included data on COVID-19 cases and/or uninfected controls; (2) "Survey" studies of general population groups, COVID-19 patients post-hospitalization/or post-outpatient infections; and (3) "Long COVID" survey studies of patients attending Long COVID clinics or that used social media and outreach to survey Long COVID support groups, or EHR data on COVID-19 cases specifically using Long COVID ICD-10 codes.

The denominator for calculating frequency varied and was based on the specific population studied. For example, the population included for symptom frequency in Long COVID studies was limited to people with Long COVID symptoms, patients seen in Long-COVID clinics, or patients with Long COVID ICD-10 codes in EHR, [12,24,33,52,60,66], whereas studies classified as "Survey" aimed to assess frequency among general populations that included people with no Long COVID symptoms at all. For the 59 studies that reported prevalence, averaged Long COVID symptom frequencies for 21 of the phenotypic symptom categories are presented in Figure 2, stratified into Long COVID, Survey, and EHR groups. Two symptoms, dry mouth and excessive thirst, were reported in one study each and were excluded from the meta-analyses; thus, 21 symptoms were included in the final meta-analyses. Marked differences were observed in symptom prevalence across the three different study design groups (Long COVID (n = 7), EHR (n = 6), Survey (n = 46) (Figure 2), where the highest frequencies were observed in studies that only included respondents with Long COVID symptoms [12,24,33,52], patients seen at Long COVID clinics [37,66], or with EHR Codes for Long COVID [60]. Across studies stratified by risk of bias (Figure 3), eleven categories were reported across all groups (fatigue, fever/sweats, dizziness, sleep problems, headache, joint/muscle pain, loss of or change in smell or taste, shortness of breath, persistent cough, cardiac symptoms, gastrointestinal symptoms, mental health concerns, nerve problems, problems thinking or concentrating, hair loss, hearing problems). These symptoms were among the most commonly reported across studies, as noted in Supplemental Figure S3.

### 3.6. Risk of Bias Comparisons

Using the Hoy [73] critical appraisal tool, 25 studies were classified as high risk of bias, 19 as moderate risk of bias, 15 as low risk of bias. Comparing symptom prevalence across three risk of bias categories demonstrated differences in results across high-risk-of-bias studies (largest difference seen for fatigue, post exertional malaise, cardiac symptoms including chest pain, persistent cough, problems thinking or concentrating, dizziness, headache, mental health concerns, joint or muscle pain), with less variation comparing moderate-risk-of-bias studies to low-risk-of-bias studies. The highest variation between studies was seen in the high-risk-of-bias studies (Figure 3). High-risk-of-bias studies included those with a small sample size that did not reflect the general population characteristics in a country, studies with low response rates suggesting selection bias, and studies without general population data on symptom prevalence. Since the primary goal of this meta-analysis was to summarize the prevalence of Long COVID symptoms among the general population, all Long COVID studies were classified as high risk of bias due to data collection being limited to those with symptoms and not the general population.




**Figure 2.** Long COVID symptom frequencies (n = 59 studies) according to three study design groups: Long COVID, Survey and EHR studies. Bars around the means indicate 95% CI.

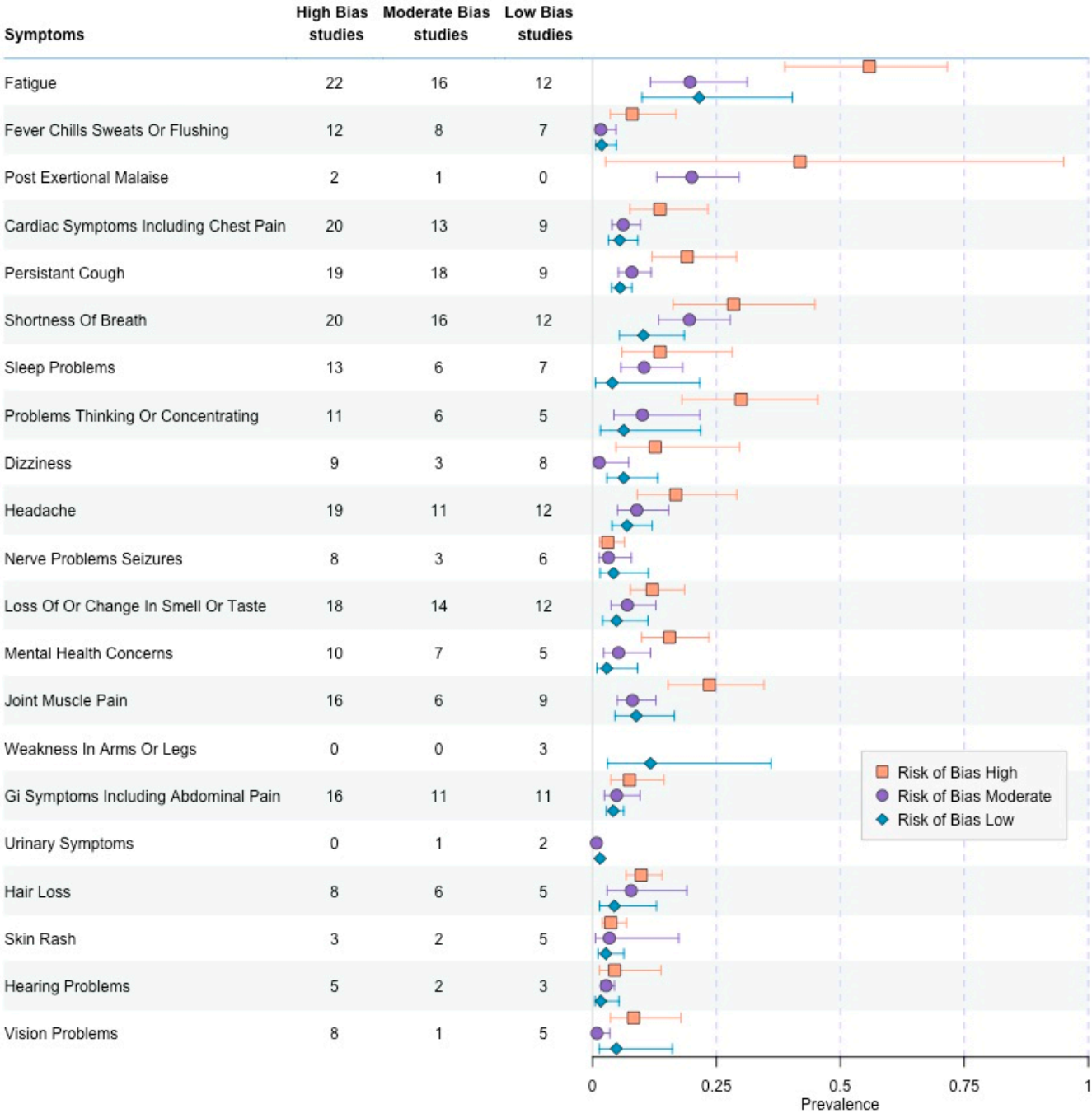



**Figure 3.** Long COVID symptom frequency across high-, moderate-, low-risk-of-bias groups. Bars around the means indicate 95% CI.

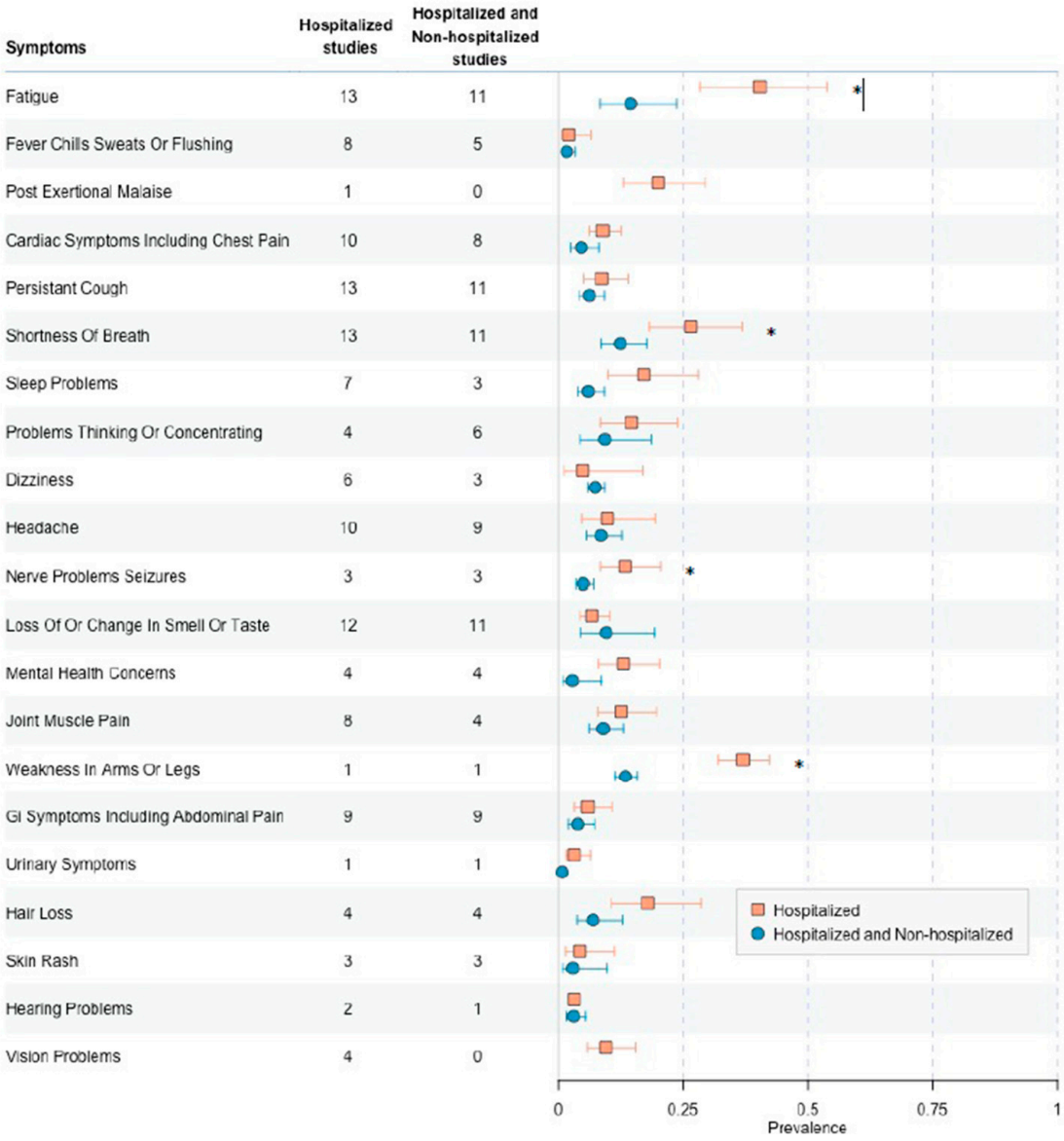
### *3.7. Low-to-Moderate Risk of Bias, EHR Versus Survey Collection*

Among the low- and moderate-risk-of-bias studies, Long COVID symptoms were compared between the EHR and survey studies (Figure 4a). Twenty-seven studies were classified as surveys, while five were classified as EHR studies. A higher prevalence was recorded across 20 of 21 symptoms when evaluated with the survey compared to that of the EHR. Eight of those symptoms were found to have a statistically significant difference, including fatigue, problems thinking of concentrating, and weakness in the arms or legs. The prevalence across the two study designs was relatively similar for certain symptoms, including cardiac/chest pain, GI/abdominal pain, and persistent cough.




**(a)**

**Figure 4.** *Cont.*




(**b**)

**Figure 4.** (**a**) Long COVID symptom prevalence limited to moderate- or low-risk-of-bias studies stratified by EHR or survey data. Bars around the means indicate 95% CI. An asterisk indicates a statistically significant comparison of proportion for a given symptom category after multiple hypothesis correction ($p < 0.0024$) (**b**). Long COVID symptom prevalence in moderate- or low-risk-of-bias studies stratified by hospitalized or mixed studies with hospitalized and non-hospitalized survey data. Bars around the means indicate 95% CI. An asterisk indicates a statistically significant comparison of proportion for a given symptom category after multiple hypothesis correction ($p < 0.0024$). An asterisk indicates a statistically significant comparison of proportion for a given symptom category after multiple hypothesis correction ($p < 0.0024$).

### *3.8. Low-to-Moderate Risk of Bias, Hospitalized Versus Hospitalized and Non-Hospitalized among Survey Studies*

Among the low- and moderate-risk-of-bias survey studies, Long COVID symptoms were then compared between studies including patients who were hospitalized at the time of the incident COVID-19 event versus studies from non-hospitalized patients, and mixed studies of hospitalized and non-hospitalized patients. Sixteen studies were from

patients exclusively hospitalized with COVID-19, while eleven studies focused on a non-hospitalized and mixed patients. In total, 20 of 21 Long COVID symptoms had a higher prevalence among the hospitalized group. Only dizziness had a higher prevalence among the non-hospitalized and mixed studies (Figure 4b). Four of the symptoms were found to have a statistically significant difference. See Supplemental Figure S4 for a visual summary of meta-analysis groupings.

## 4. Discussion

In 59 studies of symptoms lasting more than 3 weeks after acute COVID-19 infection, we found wide ranges of symptom frequencies, variable categories of symptoms included, and marked variation in study design. Most studies to date have focused largely on individual symptom prevalence but are limited by lack of controls and retrospective data. The current review examined the most prevalent Long COVID symptoms in 59 scientific articles as fitted to a 21-symptom phenotype grid. Individual symptom prevalence varied widely depending on study design, with lower prevalence in studies based on EHR compared to moderate prevalence in surveys conducted by outreach to general population samples, infected inpatients after hospital discharge, or mixed studies of hospitalized and non-hospitalized outpatients, and highest symptom prevalence reported from surveys on recorded in the EHR of individuals with suspected Long COVID. After excluding studies with high risk of bias, meta-analysis of symptom prevalence for 21 symptom categories ranged widely from 2.6–28.7% in studies based on surveys to 0.3–7.1% in studies based on EHRs. The challenges with varied study design include potential biases, resulting in under-ascertainment of symptoms in EHR studies, including symptom frequencies only among individuals with suspected Long COVID that do not reflect general population prevalence.

EHR studies demonstrated the lowest prevalence rates for Long COVID symptoms, shortness of breath, fatigue, pain, cognitive problems, changes in smell and/or taste compared to other methods with some symptoms not available in EHR data. The challenges in survey design include ensuring a representative sample of the general population. Many of the studies that surveyed hospitalized patients or mixed hospitalized and non-hospitalized outpatients used smaller populations and were classified as having a high risk of bias. Some large studies that surveyed general population samples with low response rates, thus raising the issue of representativeness of responders, were also rated as having a high risk of bias. For studies that assessed symptoms only among individuals with suspected Long COVID (Long COVID clinics, diagnosis code, Long COVID support groups/social media), prevalence data demonstrate much higher symptom rates. The most striking of these are post-exertional malaise (88%) and fatigue (80%), followed by shortness of breath (55%), cognitive problems (53%), changes in smell and/or taste (26%), joint/muscle pain (42%), and fever/chills/sweats (36%), illustrating the burden of symptoms among people with Long COVID symptoms.

Differences in data collection methods across the studies can affect how prevalence is reported. Potential biases in symptom assessment in EHR data include absence of diagnosis codes for many symptoms, incomplete symptom assessment or documentation by providers, potential limited access to care by vulnerable patients, and lack of full data on individuals who receive care outside the EHR system. Many of these limitations could result in underestimates of symptom prevalence. This may contribute to the lower frequencies reported in EHR studies. Conversely, survey studies could be impacted by response bias, whereby symptomatic individuals are more likely to respond than asymptomatic individuals. Surveys among individuals seeking resources for Long COVID, such as in specialty clinics or social media support groups, are most likely to exhibit selection bias. Nevertheless, symptom prevalence data amongst the moderate- and low-risk-of-bias studies support a substantial prevalence of symptoms across a wide array of organ systems and suggest that Long COVID is a multi-system disorder.

While EHR and survey studies can have their own biases, this meta-analysis identifies which of the Long COVID symptoms have similar measurements between study designs. For example, chest pain, gastrointestinal pain, and persistent cough were all detected with similar prevalence in the EHR and survey studies. This would suggest that future Long COVID studies that use EHR should expect the prevalence of these specific symptoms to be more accurate. However, the prevalence of fatigue, post-exertional malaise, and weakness in arms and legs was significantly different between the EHR and the survey studies. Therefore, these symptoms may not be as reliably measured. Given that collecting prospective or retrospective data from EHRs can be easier and less expensive than setting up a survey study, future Long COVID studies could rely on the EHR to track symptoms such as chest pain and gastrointestinal discomfort in Long COVID. However, they should consider alternative ways to measure symptoms like fatigue and post-exertional malaise.

In addition, it has already been observed that a longer recovery course is expected in patients requiring hospitalization or prolonged stays in the hospital [8,19,44]. While this meta-analysis validates increased prevalence of Long COVID among hospitalized patients, it provides further insight into exactly how these differences manifest across the various Long COVID symptoms. Interestingly, for certain symptoms such as headaches, nerve problems/seizures, and changes in smell, no statistically significant difference was observed between the two cohorts. While these data suggest the severity of the acute COVID-19 episode may directly lead to increased prevalence of fatigue, weakness, and shortness of breath in the subsequent recovery phase, an alternative mechanism (auto-immune response, persistent viral reservoir, spike protein persistence) may explain why that difference is not as significant for Long COVID symptoms like headache and changes in smell. These findings may also prepare healthcare providers for what to expect with patients depending on their acute COVID-19 level of severity.

Other limitations to the published studies include incomplete symptom lists in some studies and lack of control groups to assess frequency of symptoms in a representative uninfected group. Many of these Long COVID symptoms, taken individually, are non-specific, prevalent in the population, vary widely, and overlap with many other conditions. The heterogeneity of symptoms suggests that Long COVID is a set of syndromes with variable etiologies [6,7]. Because of the substantial short- and long-term effects of Long COVID, including impacts on quality of life, healthcare costs, and economic productivity [75], it is imperative to better characterize Long COVID, and Long COVID sub-phenotypes in a prospective design with uniform data collection from a diverse group of uninfected and infected participants as the RECOVER Initiative intends to do.

One of the strengths of this analysis is the inclusion of diverse studies from around the world. However, studies from Africa and South America are notably missing from this analysis. Unfortunately, there are fewer published studies from these regions to draw from. As these data become available, it will be important to update such meta-analyses to reflect these diverse environments to better understand the complications in various environments.

Over time, there have likely been changes in important variables that may affect symptom presentation, including the introduction of vaccinations and variants of the SARs-CoV-2 virus. However, the studies included in our cohort primarily described the first two years of the pandemic and primarily reflect the effects of the initial strain and relatively lower vaccination rates in the population. Future studies should consider how these changing factors may affect the symptomology of the population.

We acknowledge that Long COVID symptoms—especially considering the introduction of vaccinations, virus variants, and pre-existing conditions—are difficult to fully capture and describe. A comprehensive overview of symptom phenotypes was attempted in this review; however, 200+ symptoms have been reported post-COVID-19. Knowledge of Long COVID is still evolving. Another challenge in this review was the reliability of self-reports compared to EHR, for example, and wide variation in the quality of symptom reporting. Occasionally, values had to be visually estimated from graphs and figures when

exact numbers were not provided. We have attempted to summarize extant research in a way that is helpful for clinicians, the patient community, and researchers alike while keeping these caveats in mind.

The striking variability in symptom prevalence across studies of Long COVID illustrates the challenge with defining criteria for this novel, multi-system condition. Studies to date have focused largely on individual symptom prevalence but some are limited by lack of controls, small sample size, and potentially biased study designs. Symptom prevalence ranges widely, with the lowest prevalence in EHR studies and highest prevalence in survey studies, as illustrated by a range of 1–8% in EHR studies versus 2–28% in survey studies in the low- to moderate-risk-of-bias studies. When limiting the study population to only participants who report Long COVID, the prevalence is much higher, reflecting a change in the denominator for prevalence calculations and a different study question, namely, "what is the prevalence of symptoms among participants who have any long-term symptoms after SARS-CoV-2 infection?". Our study question was "what is the prevalence among a population infected with SARS-CoV-2?" The challenges are that many of these symptoms, taken individually, can be common in the population regardless of COVID-19 infection. Long COVID symptoms are also heterogeneous and overlap with many other conditions. Major questions remain about the effect of vaccination status, the role of viral variants, the role of COVID-19 therapies, comorbidities, social determinants of health, and clinical risk factors on the development of Long COVID. Further research into Long COVID phenotypes is needed to effectively cluster symptoms in meaningful ways that enable focused pathobiology studies and clinical trials.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/covid4100106/s1, Figure S1: Symptom categories, Figure S2: Meta analysis, Figure S3: Top 3 most prevalent symptoms (n = 59 studies), Figure S4: Meta-analysis categories.

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