

SYSTEMATIC REVIEW

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Work ability and return-to-work of patients with post-COVID-19: a systematic review and meta-analysis

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Abstract

Background In addition to several sequelae of post-COVID-19, individuals also experience significant limitations in work ability, resulting in negative consequences for the return-to-work (RTW) process. This systematic review and meta-analysis were conducted to assess the impact of post-COVID-19 on work ability and RTW of individuals previously infected with SARS-CoV-2.

Methods Studies on the work ability and RTW of patients with post-COVID-19 (more than 12 weeks after an acute SARS-CoV-2 infection) were regarded eligible for inclusion. Systematic search of literature was performed up to March 2023 using five databases (MEDLINE, EMBASE, CINAHL, CENTRAL and WHO COVID 19). Study selection followed the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) Statement. A meta-analysis estimated the overall success rate of RTW. The risk of bias of the included studies was evaluated with the Newcastle Ottawa Scale (NOS).

Results 19 relevant studies, published between 2021 and 2023, were included in the systematic review, involving 21,155 patients from 14 different countries. The findings indicate that a significant proportion of individuals with post-COVID-19 experience persistent symptoms and functional impairments, with fatigue being the most prominent symptom. These persistent symptoms can have a considerable (negative) impact on individuals' physical and psychological capacity to participate in work-related activities, leading to lower work ability and increased absenteeism. The RTW for post-COVID-19 patients is complex, with approximately 60.9% of patients successfully returning to work after 12 or more weeks following SARS-CoV-2 infection. Among those who successfully returning to work, a considerable number need modifications in their work duties or hours to cope with residual impairments. Factors such as workplace accommodations, supportive policies, and occupational rehabilitation programs play a crucial role in facilitating successful RTW.

Conclusions The systematic review underscores the substantial impact of post-COVID-19 on work-related outcomes. The implications of this research highlight the need for healthcare providers, employers, and policymakers to collaborate in creating inclusive work environments and implementing tailored rehabilitation programs to support individuals recovering from post-COVID-19. Further research should focus on long-term follow-up studies with mixed

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methods to gain a more comprehensive understanding of the long-term consequences of post-COVID-19 on work ability and RTW outcomes.

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Keywords Post-COVID-19, Work ability, Return-to-work, Sick leave, Occupational status

Background

Workplaces were generally a high-risk setting for virus transmission of SARS-CoV-2 due to interpersonal contacts with colleagues, clients or patients [1, 2]. Reuter et al. [3] conducted a study involving more than 100,000 workers across diverse occupational segments such as medical healthcare, as well as business management, and observed an incidence rate of 3.7 infections per 1,000 workers. SARS-CoV-2 infections were higher in essential (180 infections among 33,458 workers) workers compared with workers in non-essential (224 infections among 75,502 workers) occupations (incidence rate ratio 1.95) [3]. Particularly, healthcare workers were more likely to be affected by COVID-19 (coronavirus disease 2019), compared with other professions [4–6]. In Germany until October 2023, 350,045 cases of COVID-19 were recognized as occupational diseases (BK) with BK-No. 3101. Furthermore, 26,698 recognized cases of COVID-19 were recorded as work-related accidents (according to the German Social Accident Insurance) [7]. Acute infection with SARS-CoV-2 can lead to several persistent symptoms [8–10]. According to the NICE (National Institute for Health and Care Excellence) guideline, persistent signs and symptoms after an acute SARS-CoV-2 infection, which continue for more than 12 weeks and cannot be explained by an alternative diagnosis, are classified as post-COVID-19 [11].

In population-based cohort studies, the prevalence of ongoing post-COVID-19 symptoms was estimated to be around 6% depending on, for example, virus variants, study design and study population [12–14]. A pooled analysis of data from 22 countries defined three main post-COVID-19 symptom clusters: persistent fatigue, cognitive problems and ongoing respiratory problems [12]. This study showed, that 6.2% of over one million individuals, who had symptomatic SARS-CoV-2 infection, experienced at least 1 of the 3 symptom clusters [12]. In a systematic review, including 70 studies of working age adults, the most frequently reported long-/post-COVID-19 symptoms were fatigue (92%), shortness of breath (82%), muscle pain (44%), and joint pain (35%) [15]. Moreover, findings from systematic reviews and meta-analyses indicated, that the prevalence of post-COVID-19 symptoms in adults, who were hospitalized due to COVID-19, was substantially higher, than in cases with mild or asymptomatic courses of the disease [16, 17]. Studies revealed that both physical as well

as neuropsychological limitations can persist for several months (4–24 months) after acute SARS-CoV-2 infection [18–22]. Especially in the case of post-infectious fatigue, a symptom that affected a large number of post-COVID-19 patients, results on long-term courses of other viral and non-viral infectious diseases (e.g., SARS virus, Q-fever, Lyme disease) indicated the risk of chronicity [23].

Patients also reported severe limitations in their ability to work with negative consequences on the RTW process. A systematic review concluded that long- and post-COVID-19 symptoms are increasing problems in occupational medicine, because they influence the RTW-process and quality of life of workers previously hospitalized with SARS-CoV-2 [24]. Even a mild SARS-CoV-2 infection can result in a significant reduction in work capacity [25]. Work ability is a multidimensional concept of various factors that enable employees to successfully complete the work tasks [26]. The interaction of both personal resources (health, psychophysical performance, professional competence, values and attitudes) as well as work requirements (e.g., work conditions) for maintaining individual work ability takes place in the concept of the “House of Workability” [27]. Previous research showed that a variety of factors influence the work ability of people with long-term diseases, such as work demands, age, gender, comorbidities and somatic complaints [28]. In addition, poor work ability was also associated with early retirement [29], a factor that had significant consequences for both the labor market (fewer skilled workers) and the economy (low productivity) [30]. As we delved into the concept of RTW, this comprehensive understanding became crucial. Importantly, the RTW process hinged on the restoration of work ability, emphasizing the need for employees to recover their physical and mental capacity to work before entering the occupational reintegration phase. Previous studies showed that improved work ability influenced the RTW positively [31, 32]. This relation emphasized the interdependence of work ability and the subsequent RTW, which refers to the process of reintegration into the workforce after an extended period of absence, whether due to illness, injury, or other reasons. Accordingly, various factors both at individual (e.g., socioeconomic status, expectations, psychological resources) as well organizational level (e.g., workplace factors, RTW coordination) can determine successful RTW after an injury or

illness [33]. In the case of post-COVID-19 patients, the RTW process might be complicated by a range of factors, such as ongoing symptoms, and long-term effects of the disease [34]. Aben et al. [35] observed variations in the RTW duration influenced by different virus variants. The duration was found to be longest when the alpha variant was predominant and became progressively shorter with the emergence of the delta and omicron variants [35]. As highlighted by the meta-analysis of Kamdar et al. [36], conducted before the COVID-19 pandemic, RTW after critical illness is often delayed (36% at 1–3 months, 60% at 12 months) and accompanied by worsening employment status and performance (e.g., fewer work hours).

While the long-term physical and psychological effects of COVID-19 are meanwhile well documented, the potential occupational impact remains to be explored. Understanding the work ability and RTW of patients with post-COVID-19 is crucial for healthcare professionals, occupational health professionals, employers, and policymakers in adapting or developing strategies and interventions to support the recovery and reintegration of these patients into the workforce and to ensure their social participation. It is particularly pivotal for mitigating potential increases in occupational disability and early retirements, thereby playing an essential role in minimizing broader impacts on the labor market and the economy. However, there is currently limited research available on this topic. A systematic review of the available evidence on work ability and RTW of patients with post-COVID-19 is therefore needed to provide a comprehensive analysis of the existing literature and to identify gaps in knowledge and research needs that guide future research. The aim of this systematic review and meta-analysis is to synthesize the evidence on work ability and RTW of patients with post-COVID-19. Specifically, the review will address the following research question:

What is the impact of post-COVID-19 on work ability and the RTW process of patients previously infected with SARS-CoV-2?

By addressing and bridging the gaps in knowledge and synthesizing the available evidence, this systematic review will contribute to systematize the growing body of literature on the post-COVID-19 population and support efforts to mitigate the long-term effects of the pandemic on the global workforce.

Methods

This systematic review of the literature was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement [37]. To ensure transparency and reproducibility, the review adheres to the PRISMA checklist, which can be found in Appendix 1 in the supplementary materials. The protocol was registered in the International Prospective Register

for Systematic Reviews (PROSPERO) database (Registration number: CRD42023385436).

Search strategy

The PRISMA Statement suggest performing the search across multiple databases; therefore, we have chosen five databases due to their relevance in the medical field. A comprehensive search in MEDLINE (via EBSCO), EMBASE (via Ovid), CINAHL (via EBSCO), Cochrane Central Register of Controlled Trials (CENTRAL) and WHO COVID 19 was conducted from January 2020 until December 2022 to encompass the period since the onset of the COVID-19 pandemic. The search in the five databases was repeated in March 2023 to identify further studies with longer analysis periods. The literature search strategy used MeSH terms (Medical Subject Headings) and text words associated with post-COVID-19 and work ability or RTW. MeSH terms used to perform the search in MEDLINE, were the following:

“coronavirus” OR “covid-19” OR “sars-cov-2” OR “coronavirus infections” OR “betacoronavirus”) AND (“workplace” OR “return to work” OR “absenteeism” OR “occupational health” OR “work performance” OR “work capacity evaluation” OR “sick leave”).

SIGN search filters were used to identify randomized trials and observational studies in the MEDLINE, CINAHL and EMBASE databases [38]. In addition, secondary searches in other sources, such as Google Scholar and medRxiv were also carried out, to retrieve relevant publications that were not found with the database search. To ensure that the literature was comprehensive, the reference lists of the included studies or relevant reviews identified through the search, were scanned. Furthermore, a search was carried out in the German Register for Clinical Studies (DRKS) and the International Clinical Trials Registry Platform (ICTRP) search portal of the WHO to identify ongoing, discontinued and completed studies. The full search strategy is presented in Appendix 2. The literature search was conducted independently by two reviewers.

Eligibility criteria

Studies on the work ability and RTW of patients with post-COVID-19 were regarded eligible for inclusion if the following criteria were fulfilled: (1) population: patients with persistent signs and symptoms more than 12 weeks after an acute SARS-CoV-2 infection; (2) intervention: SARS-CoV-2 infection (diagnosed by RT-PCR, suspected, self-report). Comparison was not applicable due to the aim of the performed review; (3) outcomes: the primary outcome measures of the systematic review were work ability and RTW of patients with post-COVID-19. Since work ability and RTW can be measured in different ways, several methods for outcome collection were

accepted for this review, including for example interviews; and (4) following types of studies: interventional studies (e.g., randomised clinical trials) and observational studies (e.g., prospective cohort studies).

The exclusion criteria were as follows: (1) studies involving subjects without SARS-CoV-2 infection; (2) case series, case reports, pilot studies, unpublished data, editorials, news articles, commentaries, studies not involving humans and systematic reviews; and (3) studies published before 2020. This review was restricted to articles written in English or German language.

Study selection

The screening of articles was carried out in two stages [39]. After duplicates were removed, two persons independently screened the titles and abstracts of references retrieved from the searches and categorized them as relevant, not relevant, or possibly relevant. Studies that clearly did not align with the research objectives, such as those unrelated to COVID-19 work outcomes, were excluded. Studies that were categorized as relevant or potentially relevant by at least one reviewer underwent a full-text-screening. In this second stage the full-text versions of eligible articles were evaluated by both reviewers regarding the inclusion criteria independently. Articles were included if they met the predefined criteria. Any disagreement for inclusion was resolved through discussion between the reviewers and, if necessary, via

consultation of the supervising researcher. The screening process was facilitated using Rayyan [40], which allowed blinding in each step of the process. The selection process is documented in the PRISMA flowchart (Fig. 1).

Data extraction

At the end of the filtering, the extracted features were recorded using a pre-designed data table in Excel. The review authors extracted data from each eligible study. The study team extracted bibliographic data (author, title, year, location and study design), population (age, gender distribution, occupation, comorbidities/risk factors, acute COVID-19 severity), sample size, duration of follow-up, outcome measurements, main results, post-COVID-19 symptoms and results on RTW/ work ability.

Statistical analysis

A random effects proportional meta-analysis [41] was used to compute a pooled estimate of the RTW rate and respective 95% confidence intervals (CIs). When conducting a meta-analysis on prevalence and encountering heterogeneity in prevalence estimates across studies, it is recommended to employ a random effects model [42]. This is because a fixed effects model may yield misleading outcomes when significant heterogeneity is present, which is the case in current study. The analysis was performed using the DerSimonian and Laird random-effect [43]. The statistical heterogeneity between the studies

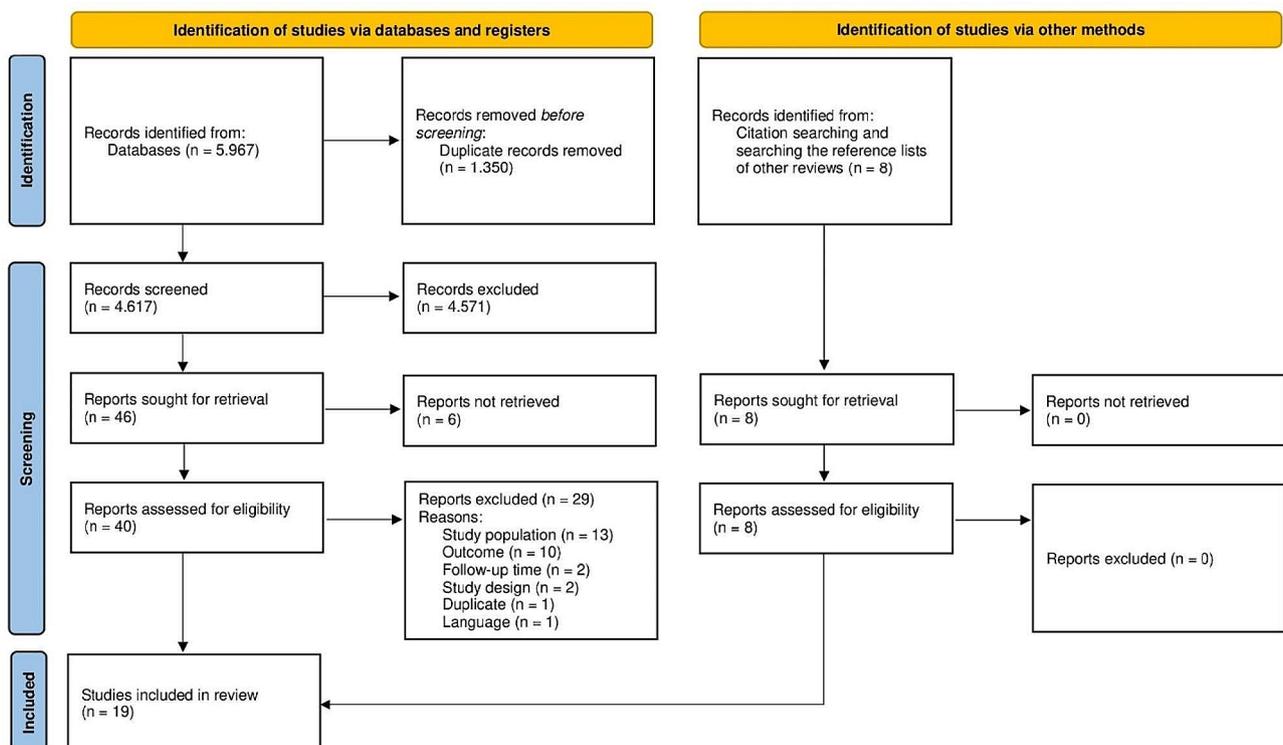


Fig. 1 PRISMA flowchart of the article selection process

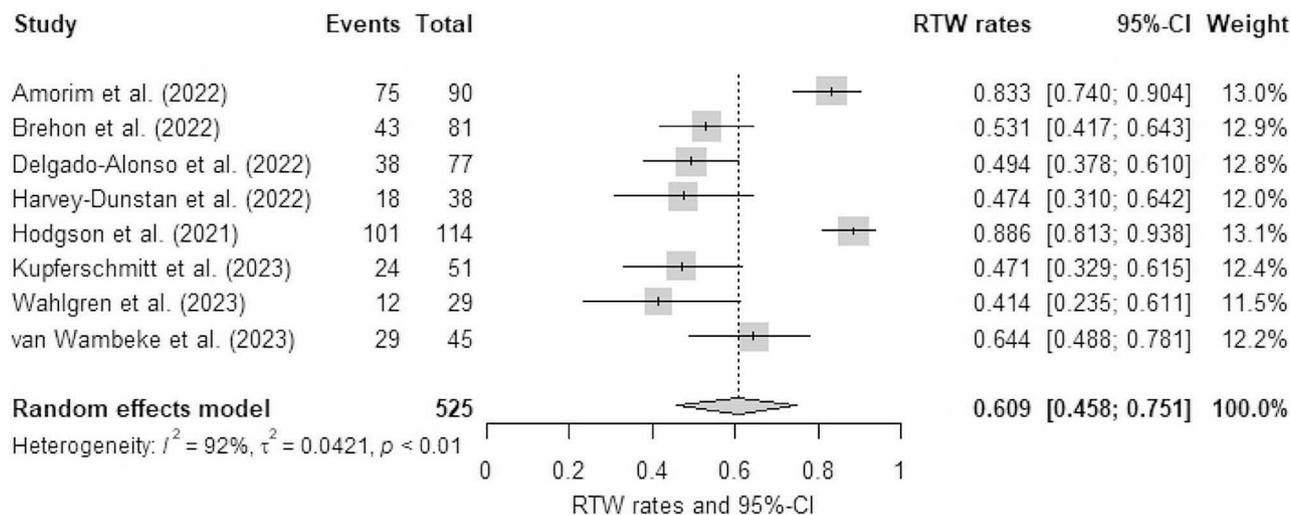


Fig. 2 Meta-analysis of RTW of post-COVID-19 patients

was determined by the τ^2 and I^2 . I^2 indexes of 25%, 50%, and 75% indicated low, moderate, and high heterogeneity, respectively [44]. Also, the corresponding sample sizes were considered. *Events* classified the number of individuals who successfully achieved RTW, while *Total* represented the overall number of individuals, from which RTW rates could be derived. Publication bias was evaluated through a visual inspection of funnel plots. Statistical analysis was conducted using R [45] and RStudio (version 4.3.0) [46] and statistical significance was set at $p < 0.05$. The forest plot was generated using the “tidyverse” [47], “meta” [48], and “metafor” [49] packages in R. When conducting the meta-analysis, studies that did not provide data for analysing RTW rates were excluded from the analysis. This ensured that only studies with comprehensive RTW rates were included in the meta-analysis. No subgroup meta-analysis could be performed due to the limited number of studies providing data on RTW. A narrative, qualitative summary of the work ability of patients with post-COVID-19 was carried out and is presented in text and table form to summarise and explain the characteristics and findings of the included studies.

Risk of bias in individual studies

The risk of bias of the included cohort studies was evaluated with the Newcastle Ottawa Scale (NOS) [63], modified for cohort and cross-sectional studies [22]. The NOS’s utilizes a star system. The cohort tool assigns a maximum of 9 stars in 3 domains: (1) selection of study groups (max. 4 stars), (2) comparability (max. 2 stars), and (3) ascertainment of outcome (max. 3 stars). In the cross-sectional tool a maximum of 9 stars for quality assessment across the same 3 domains can be attained: (1) selection of study groups (max. 5 stars), (2)

comparability (max. 2 stars), and (3) ascertainment of outcome (max. 2 stars). A higher score indicates a higher quality of the study. The total score could be categorized into three groups: low quality (0–4 stars), moderate quality (5–6 stars), high quality (7–9 stars). The risk of bias was assessed independently by two review authors and results were corroborated, with discrepancies resolved through discussion. Modified NOS’s (see Appendix 4) and methodological quality rankings for each study type are provided.

Results

Search results and study selection

The comprehensive search identified a total of 5.967 articles across the five databases (MEDLINE, EMBASE, CINAHL, CENTRAL and WHO COVID 19) and 8 additional records through other sources (see Fig. 1). After duplicates were removed, 4.625 references remained for the initial screening by title and abstract. This screening resulted in a total of 4.571 excluded articles. The remaining 54 articles were screened by full text, of which 35 did not meet the inclusion criteria with following reasons: wrong study population ($n=13$), wrong outcome ($n=10$), no full-text available ($n=6$), wrong follow-up time ($n=2$), wrong study design ($n=2$), duplicate ($n=1$) and wrong language ($n=1$). 19 studies met the inclusion criteria and were included in the systematic review [18, 25, 50-62, 64-67].

Study characteristics

The characteristics of the 19 studies included are reported in Table 2. The studies were published between 2021 and 2023. Regarding study design, 12 studies corresponded to cohort studies and 7 to cross-sectional studies. The overall population included 21.155 patients

Table 1 Impact of post-COVID-19 on work ability

| Study | Sam- ple size (n) | Follow-up time | Work status | Work ability | Limitations to work duties/ hours |
|---------------------------------|----------------------------|-------------------|---|--|---|
| Kupferschmitt et al. 2023 [50] | 51 | at least 3 months | <ul style="list-style-type: none"> • 28/51 (54.9%) unable to work on admission • sick leave before admission: 43.1% >6 months, 13.7% 3–6 months, 41% <3 months • 18/51 (35.3%) ability to work (at least 6 h/day) at discharge | N/A | <ul style="list-style-type: none"> • 6/51 (11.8%) gradual reintegration |
| Westerlind et al. 2021 [51] | 11,955 | 4 months | <ul style="list-style-type: none"> • 1,592/11,955 (13.3%) sick leave for at least 12 weeks | N/A | N/A |
| Rutsch et al. 2023 [52] | 178 | 5 months | <ul style="list-style-type: none"> • 88/178 (49%) sick leave (M: 21 weeks) • 32% restoration of their work ability after rehabilitation | <ul style="list-style-type: none"> • WAS (0–10) pre reha: M: 4 | N/A |
| Kedor et al. 2022 [53] | 42 | 6 months | N/A | <ul style="list-style-type: none"> • Bell disability score (0–100) Mdn.: 40 and 50 of 100 at the time of the survey | N/A |
| Davis et al. 2021 [25] | 3,505 | 3–7 months | <ul style="list-style-type: none"> • 957/3,505 (27.3%) working same hours as before • 817/3,505 (23.3%) not working | N/A | <ul style="list-style-type: none"> • 1,598/3,505 (49.3%) working reduced hours |
| Nielsen et al. 2022 [54] | 401 | 246 days | <ul style="list-style-type: none"> • 158/401 (39.4%) working same hours as before • 215/401 (53.6%) sick leave | N/A | N/A |
| Buonsenso et al. 2022 [55] | 155 | 12 months | <ul style="list-style-type: none"> • 132/154 (85.7%) patients same occupational status as before COVID-19 • 22/154 (14.3%) changed status • 7 sick leave | N/A | <ul style="list-style-type: none"> • 3 patients shortening of working hours |
| Kiesel et al. 2022 [56] | 336 | 12 months | <ul style="list-style-type: none"> • 55/158 (35%) sick leave during the follow-up period (M: 8.1 weeks, SD: 6.5) | <ul style="list-style-type: none"> • Work ability had decreased in patients with persistent symptoms at the 12-month follow-up | N/A |
| Diern et al. 2022 [57] | 268 | 13 months | <ul style="list-style-type: none"> • 168/268 (62.7%) inability to work • sick leave M: 26.6 weeks (95%CI 23.5–29.6) | <ul style="list-style-type: none"> • people with reported inability to work δ more commonly fatigue ($p < 0.001$), pain ($p = 0.008$), sleep disturbances ($p = 0.030$) | N/A |
| Müller et al. 2023 [58] | 127 | 408.81 days | <ul style="list-style-type: none"> • inability to work: 86/127 (67.7%) pre reha; 90/124 (72.5%) after reha • 69.8% of the patients reported poor, 29.3% moderate, and 0.9% good work ability | <ul style="list-style-type: none"> • WAI (7–49): total score pre reha: Mdn.: 24.75 (IQR: 21–28); post reha: Mdn.: 24.75 (IQR: 21–28) | N/A |
| Peters et al. 2022 [59] | 1,406 | 3–15 months | N/A | <ul style="list-style-type: none"> • WAS (0–10): before COVID-19: M: 9.3 (SD: 1.2); at the time of the survey: M: 6.8 (SD: 2.2) | N/A |
| Sansone et al. 2022 [60] | 247 | 15 months | N/A | <ul style="list-style-type: none"> • adopted WAI (1–6): Group A (symptoms < 200 days): M: 5.18 (SD: 1.08) at the time of the survey; Group B (200 + days): M: 4.5 (SD: 1.44); Group A significantly higher ($p < 0.001$) | N/A |
| Delgado-Alonso et al. 2022 [61] | 77 | 20.71 months | <ul style="list-style-type: none"> • 38 (49.4%) patients were working • 36 (46.8%) sick leave M: 12.07, SD: 8.07 months | <ul style="list-style-type: none"> • not working associated with higher levels of fatigue (U = 372.50; $p < 0.001$) and lower cognitive performance (U = 488.50; $p = 0.010$) | <ul style="list-style-type: none"> • 12/77 (16%) reduced working hours • 18/77 (23%) job adaptation |

Table 1 (continued)

| Study | Sam- ple size (n) | Follow-up time | Work status | Work ability | Limitations to work duties/ hours |
|------------------------------|----------------------------|-------------------|---|--------------|---|
| Van Wambeke et al. 2023 [62] | 45 | 22 months | • 18 (40%) working full-time; 16 (36%) no return-to-work | N/A | • 8 (18%) working half-time; 3 (6%) working 60-70% of the time N/A |
| Wahlgren et al. 2023 [18] | 94 | 24 months | • 4 months: 65/94 (69.1%) working; 22/94 (23.4%) sick leave • 24 months: 66/94 (70.2%) working, 15/94 (16%) sick leave | N/A | N/A |

N/A = not available; M = mean; Mdn = Median; SD = standard deviation; IQR = interquartile range; U = Mann-Whitney U test

(65.3% female; 34.7% male). Study sample sizes ranged from 42 to 11,955 patients with post-COVID-19 (mean: 1.113). Most studies included middle aged participants (on average 49.15 years of age). The mean follow-up time was 11 months (range 3 months – 24 months). In all, 14 studies included patients treated in the hospital (range: 6.5 – 100%), 8 studies patients treated in intensive care units (ICU) (range: 1.2 – 28.5%) during acute SARS-CoV-2 infection, 3 studies included only non-hospitalized patients and 2 studies did not provide information. The studies were conducted in 14 different countries, of which 5 were implemented in Germany, 3 in Sweden, 2 each in Italy and the United Kingdom and 1 each in Brazil, Canada, Spain, Switzerland, Australia, Denmark and France.

Impact of post-COVID-19 on work ability

Out of the 19 studies included in the review, 15 of them providing data on the impact of post-COVID-19 on work ability. The following analysis summarizes the key findings from each study regarding work status, sick leave, work ability, and limitations in work duties/hours and taking into account different follow-up periods (see Table 1).

Follow-up less than 12 months

Many post-COVID-19 patients experienced a prolonged recovery period after COVID-19, leading to temporary or long-term work limitations. Five studies had a follow-up time less than 12 months after the acute SARS-CoV-2 infection. The studies revealed that even individuals with mild or moderate acute SARS-CoV-2 infection required an extended period to recover their pre-illness work capacity. In the study by Davis et al. [25] 957 (27.3%) participants were able to maintain the same working hours as before the onset of infection. 817 (23.3%) patients were not working 3–7 months after the SARS-CoV-2 infection. Additionally, 1,598 (49.3%) participants were working reduced hours, suggesting some limitations in their work capacity. The cross-sectional study conducted by Nielsen et al. [54] with a follow-up of approximately 8 months reported a higher percentage of participants working the same hours as before the SARS-CoV-2 infection. Specifically, 39.4% of the participants in the study were able to continue working to the same extent as they did prior to the infection, while 215 out of 401 (53.6%) were on sick leave (84/215 full-time sick leave; 131/215 part-time sick leave). The national registry-based study by Westerlind et al. [51] involved 11,955 patients (follow-up: 4 months) and reported that 1,592 (13.3%) were on full-time sick leave for post-COVID-19. Kedor et al. [53] consisted a cross-sectional study of 42 post-COVID-19 patients with a follow-up of 6 months and highlighted that participants had a median Bell disability score of 40 (post-COVID/

Table 2 Characteristics of the study population

| Study | Country | Study design | Sample size (N) | Sex (% female) | Mean (M) age (SD) or Median (Mdn) age (IQR) | Follow-up time | Acute COVID-19 severity |
|---------------------------------|----------------|-----------------------|-----------------|----------------|---|-----------------------------|---|
| Amorim et al. 2022 [64] | Brazil | cohort study | 780 | 317 (40.6%) | M: 48 (12) | 3 months | 352 (45.1%) hospitalized; 131 (16.8%) intensive care unit (ICU) |
| Brehon et al. 2022 [65] | Canada | cohort study | 81 | 52 (64.2%) | M: 48.9 (10.5) | 165.2 days | N/A |
| Buonsenso et al. 2022 [55] | Italy | cohort study | 155 | 79 (50.9%) | M: 46.48 (7.3) | 12 months | 18 (11.6%) hospitalized |
| Davis et al. 2021 [25] | United Kingdom | cross-sectional study | 3,762 | 2,961 (78.9%) | N/A | 6 months | 317 (8.4%) hospitalized |
| Delgado-Alonso et al. 2022 [61] | Spain | cross-sectional study | 77 | 67 (87.0%) | M: 46.31 (7.97) | 20.71 months | 15 (19.5%) hospitalized; 3 (3.9%) ICU |
| Diem et al. 2022 [57] | Switzerland | cross-sectional study | 309 | 249 (80.6%) | M: 44.6; range: 19–83 years | 13.0 months | 33 (10.7%) hospitalized; 14 (4.5%) ICU |
| Harvey-Dunstan et al. 2022 [66] | United Kingdom | cohort study | 42 | 28 (66.7%) | M: 49 (10) | 44 weeks | non-hospitalized patients |
| Hodgson et al. 2021 [67] | Australia | cohort study | 160 | 63 (39.4%) | Mdn: 62 (55–71) | 6 months | all patients were hospitalized |
| Kedor et al. 2022 [53] | Germany | cross-sectional study | 42 | 28 (69.0%) | Mdn: 36.5; range: 22–57 | 6 months | 3 (7.1%) hospitalized |
| Kisiel et al. 2022 [56] | Sweden | cross-sectional study | 336 | 253 (75.3%) | M: 43.1 (13.4) | 12 months | non-hospitalized patients |
| Kupferschmitt et al. 2023 [50] | Germany | cohort study | 150 | 39 (76.5%) | M: 52.32 (9.16) | at least 3 months | N/A |
| Müller et al. 2023 [58] | Germany | cohort study | 127 | 97 (76.4%) | M: 50.62 (10.74) | 408.81 days | 33 (25.9%) hospitalized; 10 (7.9%) ICU |
| Nielsen et al. 2022 [54] | Denmark | cross-sectional study | 448 | 325 (72.5%) | M: 46.8 (12.6) | 246 days | 63 (14.1%) hospitalized |
| Peters et al. 2022 [59] | Germany | cross-sectional study | 2,053 | 1,677 (81.7%) | Mdn: 51 | 3–15 months | 133 (6.5%) hospitalized; 35 (1.7%) ICU |
| Rutsch et al. 2023 [52] | Germany | cohort study | 221 | 145 (65.6%) | M: 52.4 (9.0) | 5 months | 82 (37%) hospitalized; 18 (8.1%) ICU |
| Sansone et al. 2022 [60] | Italy | cohort study | 247 | 159 (64.4%) | M: 48.1 (10.5) | 15 months | 108 (43.7%) hospitalized; 3 (1.2%) ICU |
| van Wambeke et al. 2023 [62] | France | cohort study | 45 | 28 (62.2%) | M: 49.6 (11.2) | 15.1 months and 22.6 months | non-hospitalized patients |
| Wahlgren et al. 2023 [18] | Sweden | cohort study | 165 | 61 (37.0%) | M: 61 (13) | 24 months | 100% hospitalized; 47 (28.5%) ICU |
| Westerlind et al. 2021 [51] | Sweden | cohort study | 11,955 | 7,129 (59.6%) | M: 48 (11.3) | 4 months | 2,960 (24.8%) hospitalized |

N/A = not available; M = mean; Mdn = Median; SD = standard deviation; IQR = interquartile range

ME/CFS-group) and 50 (post-COVID/non-ME/CFS-group) indicating limited work ability (reduced working hours or inability to work). Kupferschmitt et al. [50] and Rutsch et al. [52] are two studies that evaluated work ability following rehabilitation. Kupferschmitt et al. [50] examined a sub-sample of 51 post-COVID-19 patients. Out of the 51 individuals assessed, 28 (54.9%) were unable to work on admission. At the time of discharge, 18 participants (35.3%) showed an ability to work at least 6 h per day. Additionally, 6 patients (11.8%) underwent gradual reintegration. Prior to admission, a significant proportion of participants (43.1%) were on sick leave for over 6 months, 13.7% for 3–6 months, and 41% for less than 3 months. 2.0% were not employable. In the study conducted by Rutsch et al. [52], the rehabilitation took place 5 months after SARS-CoV-2 infection. The study reported that 32% of participants experienced restoration of their work ability after rehabilitation. The mean Work Ability Score (WAS) of the Work Ability Index (WAI) was 4 on a scale of 0–10, indicating some limitations in work capacity. 41% perceive their work ability as permanently at risk. Among the participants, 88 out of 178 (49%) were on sick leave, with an average duration of 21 weeks.

Follow-up between 12 months and 18 months

In 15 studies that provided data on the impact of post-COVID-19 on work ability, there were 6 studies with a follow-up period between 12 months and 18 months. In the study of Buonsenso et al. [55] with a sample size of 154 participants, the majority (85.7%) maintained the same occupational status as before COVID-19. However, 22 patients (14.3%) experienced a change in their work status with following reasons: sick leave ($n=7$), loss of job due to ill health ($n=3$), shortening of working hours ($n=3$), fired ($n=1$), different reasons ($n=7$). Kisiel et al. [56] included 158 post-COVID-19 patients followed up for 12 months. Among the 158 participants, 35% were on sick leave during the follow-up period, with an average duration of 8.1 weeks. Patients with persistent symptoms at the 12-month follow-up reported a decrease in work ability. With a follow-up of 13 months, Diem et al. [57] highlighted that 168 patients (62.7%) were unable to work, and the average sick leave duration was 26.6 weeks. There was a significant association between inability to work and symptoms such as fatigue, pain, and sleep disturbances. Müller et al. [58] performed a study on a total of 127 patients, and had a median time between SARS-CoV-2 infection and beginning of rehabilitation of 408.81 days. Among the participants, 90 (72.5%) were unable to work after rehabilitation. The majority of patients reported poor (69.8%), 29.3% moderate, and only 0.9% good work ability measured by the WAI. WAI-scores (scale 7–49) before (Median (Mdn): 24.75) and

after (Mdn: 24.75) rehabilitation did not show significant changes. The study by Peters et al. [59] involved a large sample of 1,406 post-COVID-19 patients. The WAS-scores (scale 0–10) decreased from 9.3 before COVID-19 to 6.8 at the time of the survey, indicating a decline in work ability over time. The authors showed that the work ability was significantly different between patients with symptoms > 3 months and patients without symptoms. Sansone et al. [60] conducted a study with 247 participants who were followed up for 15 months. The findings reveal that participants with symptoms lasting 200 or more days (Mean (M): 4.5 ± 1.44) had significantly lower mean work ability-scores (scale 1–6) compared to those with symptoms lasting less than 200 days (M: 5.18 ± 1.08 ; $p < 0.001$).

Follow-up more than 18 months

Some individuals experienced a prolonged recovery period after COVID-19, leading to long-term work limitations. Three studies had a follow-up time of 15 months and longer. Delgado-Alonso et al. [61] involved 77 participants who were followed up for an average of 20.71 months. Out of the participants, 38 (49.4%) were working, while 39 (50.6%) were not working. Among those who were currently not working, 36 (92.3%) were on sick leave. A portion of the participants (16%) reported reduced working hours, and 23% required job adaptation (e.g., more breaks, telework, cognitive aids, or a position change). Factors contributing to work disability include higher levels of fatigue, and lower cognitive performance. The cohort study by van Wambeke et al. [62] included 45 participants who were followed up for 22 months. Among these participants, 18 (40%) patients were working full-time, 3 (6%) working 60–70% of the time, 8 (18%) working half-time and the remaining individuals (36%) did not RTW. Among the mentioned studies, Wahlgren et al. [18] conducted the longest follow-up period with 24 months. At the 4-month follow-up, the majority (69.1%) of the participants were working, while a smaller proportion (23.4%) were on sick leave. At the 24-month follow-up, a similar percentage (66 out of 94 patients) were working, and a smaller proportion (16 out of 94 patients; 16%) were on sick leave.

Impact of post-COVID-19 on return-to-work

The meta-analysis included eight studies that examined the RTW outcomes of patients previously infected with SARS-CoV-2 (Fig. 2). The random-effects meta-analysis estimated a pooled proportion of 0.609 (95% CI: 0.458–0.751), indicating that approximately 60.9% of post-COVID-19 patients were able to successfully RTW 12 or more weeks following the SARS-CoV-2 infection. In the Forest Plot, the dashed line represents the aggregated average RTW rate across all studies. Studies to

the right of this line tend to indicate higher RTW rates, while those to the left suggest lower rates. Among the individual studies, Hodgson et al. [67] had the highest weight (13.1%) and reported a proportion of 0.886 (95% CI: 0.813–0.938), suggesting a high likelihood of successful RTW. The remaining studies had weights ranging from 11.5 to 13.0% and reported proportions ranging from 0.414 to 0.833. Heterogeneity analysis yielded an I^2 index of 92% and a τ^2 of 0.042 with $p < 0.01$, indicating substantial variability and inconsistency. Visual inspection of funnel plot asymmetry for the RTW meta-analysis did not suggest the presence of publication bias (Appendix 5), and the Peters' regression test (intercept=1.111; standard error (SE)=0.147; $p=0.146$) was not statistically significant.

Factors influencing the work ability and return-to-work of post-COVID-19 patients

Based on the information provided from various studies, several influencing factors for work ability and RTW of post-COVID-19 patients could be identified. The duration between symptom onset and the beginning of rehabilitation or treatment influences the likelihood of returning to work [65]. Early intervention and rehabilitation improve the chances of returning to work. Job adaptations and modified duties, such as reduced working hours, tasks with lower physical or mental strain, telework or flextime can positively affect work ability and facilitate the RTW [25, 65]. Economic factors and financial needs can force post-COVID-19 patients to continue working or RTW sooner despite ongoing symptoms [25]. An individuals' work ability can be significantly impacted by various psychological factors, among which include high levels of fatigue, depressive symptoms, and reduced cognitive performance. These factors are closely linked with diminished work capacity and overall effectiveness in the workplace [61]. In addition, Diem et al. [57] reported, that inability to work is commonly reported alongside symptoms such as fatigue, sleep disturbances, and pain. These symptoms act as significant barriers for post-COVID-19 patients, impeding their ability to engage in work-related activities and having a negative impact on overall performance and productivity. The presence of fatigue is also associated with a lower likelihood of returning to previous work hours [66]. Additionally, certain demographic and health-related factors have been associated with higher odds of not returning to work after SARS-CoV-2 infection. According to the study conducted by Westerlind et al. [51], factors such as older age, being male, having a history of sick leave before contracting COVID-19, and having received inpatient care are all associated with an increased probability of not returning to work. Overall, the influencing factors for work ability and RTW of post-COVID-19 patients are

diverse and can vary between individuals, interacting in complex ways to determine work outcomes.

Post-COVID-19 symptoms

Studies [61–66] have underscored the impact of post-COVID-19 symptoms on an individual's work ability and RTW. Therefore, it is crucial to outline the prevalent post-COVID-19 symptoms reported in the included studies. 13 studies investigated self-reported post-COVID-19 symptoms in COVID-19 patients 12 or more weeks following diagnosis. The studies reported on a wide range of post-COVID-19 symptoms experienced by patients. Appendix 3 presents the five most commonly reported symptoms in the included studies, along with their respective prevalence rates. The prevalence of post-COVID-19 symptoms varied across studies, with estimates ranging from 12.2 to 100% of individuals who had recovered from the acute phase of the illness. Fatigue was the most commonly reported symptom, with prevalence rates exceeding 80% in many studies (mean prevalence: 72.9%). Other frequently reported symptoms included neurocognitive disorders such as concentration impairment, dizziness or memory problems. Estimates of neurocognitive symptoms prevalence ranged from 14 to 92% (mean prevalence: 59.5%). Most of the studies also reported physical ailments such as weakness, muscle pain or exercise intolerance with prevalence rates between 13% and 100% (mean prevalence: 56.2%). Other frequently reported symptoms included shortness of breath, headache, and sleep disturbances. Long-term follow-up studies indicated that patients with post-COVID-19 continued to experience symptoms for up to two years after the initial infection [18, 60–62]. For a comprehensive understanding of the full range of post-COVID-19 symptoms, it is recommended to refer to the original studies included in this systematic review.

Risk of bias

Of the 19 studies, more than half were assessed to be of moderate quality ($n=10$). Five studies were considered to be of high quality, and the remaining studies ($n=4$) were considered to be of poor quality. Taken together, the NOS rating of the component studies was moderate, evidenced by mean scores of 6.2 for cohort studies and 4.8 for cross-sectional studies. The NOS quality assessment results for cohort studies are summarized in Table 3, and quality assessment results for cross-sectional studies are summarized in Table 4.

Selection

Within the cohort studies ($n=12$), nearly all studies scoring a star for being either truly or somewhat representative of the average target population. Common methodological limitations were the failure to include a

Table 3 Newcastle-Ottawa Quality Assessment Scale criteria for cohort studies

| Study | Selection (max. ★★★) | | | Comparability (max. ★★) | | Outcome (max. ★★★) | | Total | Quality score |
|---------------------------------|--|-------------------------------------|---------------------------|---------------------------------------|---|-----------------------|---|-------|---------------|
| | Representativeness of the exposed cohort | Selection of the non-exposed cohort | Ascertainment of exposure | Outcome not present at start of study | Comparability of cohorts on the basis of the design or analysis | Assessment of outcome | Follow-up long enough for outcomes to occur | | |
| Amorim et al. 2022 [64] | 0 | 0 | ★ | ★ | ★ | ★ | ★ | 6★ | moderate |
| Brehon et al. 2022 [65] | ★ | 0 | ★ | ★ | ★ | ★ | ★ | 6★ | moderate |
| Buonsenso et al. 2022 [55] | ★ | 0 | 0 | ★ | ★ | ★ | ★ | 5★ | moderate |
| Harvey-Dunstan et al. 2022 [66] | 0 | 0 | ★ | 0 | ★ | ★ | ★ | 4★ | low |
| Hodgson et al. 2021 [67] | ★ | 0 | ★ | ★ | ★ | ★ | ★ | 7★ | high |
| Kupferschmitt et al. 2023 [50] | ★ | ★ | ★ | ★ | ★ | ★ | ★ | 8★ | high |
| Müller et al. 2023 [58] | ★ | 0 | ★ | ★ | ★★ | ★ | ★ | 8★ | high |
| Rutsch et al. 2023 [52] | ★ | 0 | ★ | 0 | 0 | ★ | ★ | 5★ | moderate |
| Sansone et al. 2022 [60] | ★ | 0 | ★ | 0 | ★★ | ★ | ★ | 7★ | high |
| van Wambeke et al. 2023 [62] | ★ | 0 | ★ | ★ | ★ | ★ | ★ | 7★ | high |
| Wahlgren et al. 2023 [18] | ★ | 0 | ★ | ★ | ★ | ★ | ★ | 7★ | high |
| Westerlind et al. 2021 [51] | ★ | 0 | 0 | 0 | ★ | ★ | ★ | 5★ | moderate |
| Westerlind et al. 2021 [51] | ★ | 0 | ★ | 0 | ★ | ★ | ★ | 6★ | moderate |

Quality score: high=9–7★, moderate=6–5★, low=4 or fewer★

non-exposed group in cohort studies, and to ascertain whether outcomes were present prior to SARS-CoV-2 infection. The exposure (COVID-19) was usually measured using either objective measurement (e.g., polymerase chain reaction (PCR) test) or clinical judgment. Within cross-sectional studies ($n=7$), all but two studies had somewhat representative or truly representative samples (with selection bias). However, nonresponse characteristics (with non-response/self-selection bias); and a sample size justification were not provided or poorly described in all of the cross-sectional studies. 5 out of 7 studies used validated measurement tools.

Comparability

Cohort studies controlled for confounders in 12 of the 13 studies. However, only two studies controlled for age, sex, and an additional factor required to score two stars. One study scored zero stars, as it used unadjusted analyses. In the cross-sectional studies, 5 studies used adjusted analyses.

Outcome

Within the cohort studies, all studies used a validated objective assessment tool (e.g., WAI) or a structured/systematic interview conducted by a trained healthcare/research professional and were followed up after a sufficient duration (3 months). The follow-up cohort rate was inadequate in 3 studies, as no description of differences in responders and non-responders was provided, or less than 80% responded. Within the cross-sectional studies, 3 studies used a validated objective assessment tool or a structured/systematic interview conducted by a trained healthcare/research professional; therefore, they scored a star. 3 studies scored zero stars, as they used self-reported work ability measurements. All of the cross-sectional studies were considered to have used appropriate and clearly described statistical tests.

Discussion

The present systematic review aimed to assess the impact of post-COVID-19 on work ability and the RTW of patients previously infected with SARS-CoV-2. Through a comprehensive analysis of the available literature, we have identified several key findings that shed light on the long-term consequences of COVID-19 on individuals' ability to work and their journey back to the workforce. The comprehensive search and rigorous study selection process resulted in the inclusion of 19 relevant studies published between 2021 and 2023, involving a diverse population of 21,155 patients from 14 different countries.

Work ability and return-to-work

An essential determinant of a sustainable RTW is the perceived work ability, which is more independent of

Table 4 Newcastle-Ottawa Quality Assessment Scale criteria for cross-sectional studies

| Study | Selection (max. ★★ ★) | | Ascertainment of the exposure (risk factor) | Comparability (max. ★★ ★) | Outcome (max. ★★ ★) | Statistical test | Total | Quality score |
|---------------------------------|--|-----------------|---|---------------------------|---------------------|------------------|-------|---------------|
| | Representativeness of the exposed cohort | Non-respondents | | | | | | |
| Davis et al. 2021 [25] | ★ | 0 | 0 | 0 | 0 | ★ | 2★ | low |
| Delgado-Alonso et al. 2022 [61] | ★ | 0 | ★★ | ★ | ★ | ★ | 6★ | moderate |
| Diem et al. 2022 [57] | ★ | 0 | 0 | ★★ | 0 | ★ | 4★ | low |
| Kedor et al. 2022 [53] | 0 | 0 | ★★ | ★★ | ★ | ★ | 6★ | moderate |
| Kisiel et al. 2022 [56] | ★ | 0 | ★★ | ★★ | 0 | ★ | 6★ | moderate |
| Nielsen et al. 2022 [54] | 0 | 0 | ★★ | 0 | ★ | ★ | 4★ | low |
| Peters et al. 2022 [59] | ★ | 0 | ★★ | ★ | ★ | ★ | 6★ | moderate |

Quality score: high = 9–7 ★, moderate = 6–5 ★, low = 4 or fewer ★

the patient’s specific context compared to the aspects of returning to work [68, 69]. The impact of post-COVID-19 on work ability was assessed in 15 of the 19 included studies. The findings varied depending on the follow-up period. In studies with a follow-up period of less than 12 months, it was found that many post-COVID-19 patients experienced a prolonged recovery period, resulting in temporary or long-term work limitations. A significant proportion of patients were not working or were working reduced hours (range between 13.3% and 54.9%). Even those with mild or moderate acute SARS-CoV-2 infection required extended periods to regain their pre-illness work capacity [25]. This indicates that a significant proportion of patients face challenges in resuming their work responsibilities. However, some participants were able to maintain their pre-illness work capacity. Also, in studies with a follow-up period between 12 months and 18 months, a decline in work ability over time was observed. The percentage of patients unable to work or on sick leave was relatively high in these studies (14.3–67.7%). Work ability scores decreased compared to pre-COVID-19 levels, indicating limitations in work capacity. For studies with a follow-up period of more than 18 months, some individuals experienced long-term work limitations. The percentage of patients working varied across studies, with a range of 40.0–70.2%. However, it is important to note that these patients may also experience a decline in work ability, resulting in reduced work productivity. Lemhöfer et al. [70] demonstrated that more than half of the post-COVID-19 patients who were able to work experienced impairments in the physical sum score of Health-Related Quality of Life (HRQoL), resulting in reduced productivity. In this context, the concept of presenteeism gains relevance.

Presenteeism involves individuals continuing to work despite being unwell, and exerting extra efforts to manage job demands, which can exacerbate health problems [71]. The estimated costs of having a sick employee could potentially be higher than the costs of their actual absence, due to lower productivity and if illnesses become worse and chronic as a result which is associated with longer periods of absence from work [30, 72]. This becomes especially notable as a substantial proportion of participants in this systematic review remained on sick leave or needed job adaptation for 15 months or longer after the SARS-CoV-2 infection.

Fatigue remained a prevalent symptom even in the long term, which could significantly impact an individual’s ability to perform daily work tasks and maintain productivity. Especially in the case of post-infectious fatigue, a symptom that affects a considerable number of post-COVID-19 patients, results concerning the long-term course of other infectious diseases (e.g., SARS virus, Q-fever, Lyme disease) indicate the risk of chronicity

[23]. Other frequently reported symptoms, such as neurocognitive disorders, physical ailments, and sleep disturbances also contributed to work limitations and challenges in returning to work [57, 61]. Delgado-Alonso et al. [61] confirmed, that there was a wide variability of influencing post-COVID-19 symptoms on work ability among the participants. Similarly, results from Pauwels et al. [34] and Sanchez-Ramirez et al. [20] indicated, that the impact on work ability and RTW for patients with long- and post-COVID-19 is complex and varies due to the different symptomatology, disease severity during the acute infection and age. Rehabilitation can play a central role in restoring the ability to work after a SARS-CoV-2 infection [73]. According to national [74, 75] and international guidelines [76], a specific post-COVID-19 rehabilitation program is recommended to contribute to the preservation and restoration of biopsychosocial health and work ability. Positive rehabilitation effects have been demonstrated for both physical and mental health in patients with post-COVID-19 [77, 78]. After regaining work ability through rehabilitation and ongoing aftercare, the process of occupational reintegration is essential.

The RTW of post-COVID-19 patients is complex and multifaceted. The meta-analysis estimated that approximately 60.9% of post-COVID-19 patients were able to successfully RTW 12 or more weeks following the SARS-CoV-2 infection. This finding highlights the importance of understanding the long-term impacts of COVID-19 on individuals' ability to return to their pre-infection work status. However, there was substantial heterogeneity among the studies. This suggests that differences in methodologies such as study populations, follow-up durations, and other factors might have contributed to the variability in RTW outcomes observed across the studies.

Moreover, it is crucial to recognize that this prevalence figure represents just the endpoint of a much more complex process of RTW. RTW is not a straightforward, linear process. It often involves multiple stages, including gradual reintegration, adaptations, and even job changes [34]. The coexistence of comorbidities alongside post-COVID-19 can increase the complexity of the RTW process [51]. Additionally, psychosocial factors like anxiety, depression and stress can have a significant impact, leading to delays, problems, or even making it necessary to change jobs [79]. Individual differences in resilience, coping strategies and self-efficacy are key factors in how they handle the disease and navigate the RTW process [80, 81]. Some may adapt more effectively, while others may face challenges.

The findings in this systematic review reveal that environmental and organisational factors such as the availability of workplace accommodations, supportive policies, and occupational rehabilitation programs play

a crucial role in facilitating successful RTW. Workplaces that offer flexible work arrangements, including modified duties, reduced working hours and remote work options were positively related with the reintegration process [25, 65]. This is particularly relevant for healthcare workers who face high work demands and workplace stress [82]. Therefore, the possibilities for adjusting workplace conditions within the company should be given more emphasis, especially to facilitate RTW for post-COVID-19 patients with extended periods of work disability. Moreover, collaboration between healthcare providers, employers, and employees was emphasized as crucial in developing personalized RTW plans tailored to individuals' specific needs and capabilities [83]. In order to facilitate the RTW of patients with post-COVID-19, it is necessary to develop a long-term strategy [83]. Strategies for returning to work after SARS-CoV-2 infection may be similar to programs already developed for chronic diseases [84–86]. It is important to recognize that the RTW for COVID-19 survivors may be influenced by a multitude of factors, including the severity of the infection, the presence of long-term symptoms, individual resources such as resilience or self-efficacy, the socio-economic context and the nature of their occupation. Therefore, a comprehensive understanding of these factors is necessary to facilitate the successful reintegration of COVID-19 survivors into the workforce. This is in line with results by Pauwels et al. [34] indicated, that the impact on return to the workplace for patients with long-COVID and post-COVID-19 is complex and varies due to the different symptomatology. Economic aspects such as continued wage payment during illness must also be taken into consideration. The financial losses resulting from extended absences are not sustainable for some patients in the long term and can lead to psychological disorders, e.g., depression disruption of financial wellbeing up to existential fears [87]. The risk of not achieving a successful RTW increases significantly with the duration of absence. Approximately 50% of individuals are unable to RTW after a sick leave of six months [88]. In the study by Wahlgren et al. [18], it was also found that out of the 22 patients who were on sick leave four months after the SARS-CoV-2 infection, only 11 patients managed to achieve a RTW after 24 months. The process of returning to work itself can contribute significantly to the recovery from SARS-CoV-2 infection. When individuals successfully adapt the requirements of their workplace to accommodate their existing limitations, employment can serve as an effective way to improve overall performance and reduce mental stress [89, 90]. It's important to mention that aftercare and support or self-help groups also play an important role in assisting individuals during their RTW process. They take care of the medical, emotional as well

as mental and social aspects of the individuals and can create a sense of togetherness and social inclusion.

Post-COVID-19 symptoms

The systematic review highlights that a significant proportion of individuals who have recovered from COVID-19 experience persistent symptoms and functional impairments that can impact their work ability. Identifying and presenting these symptoms not only provided a clear insight into the challenges individuals face but also contributes to developing interventions and support measures to reduce the long-term effects of COVID-19 on work ability. Neurocognitive disorders (e.g., concentration impairment or dizziness), physical ailments (e.g., weakness or exercise intolerance), shortness of breath, headache, and sleep disturbances were commonly reported symptoms among these individuals. Fatigue emerged as the most prominent symptom, with prevalence rates exceeding 80% in many studies. The occurrence of fatigue is consistent with systematic reviews on post-COVID-19 [8, 22], indicating that persistent fatigue is a common and debilitating symptom for many individuals recovering from SARS-CoV-2 infection. According to a previous study, 40% of SARS survivors experienced chronic fatigue for an average duration of 41 months following the infection [91].

Persistent symptoms can have a significant impact on the physical and psychological capacity of post-COVID-19 patients to participate in work-related activities, resulting in lower work ability and increased sick leave. Residual impairments lasting months after the acute SARS-CoV-2 infection could also explain why some of the people returning to work required modifications in their work duties or hours. This is supported by Böckermann et al. [92], who demonstrated that poor health status is linked with a higher rate of unemployment. Lemhöfer et al. [70] already revealed, that 38% of the patients were unable to work and showed impairments in physical and mental health 3–12 months after the SARS-CoV-2 infection. Especially cognitive and physical limitations, as well as existing fatigue symptoms, were associated with reduced work capacity [93, 94]. Similar associations were also demonstrated in studies included in this systematic review [57, 61].

It's important to note that these findings are based on the available studies, and individual experiences may vary. Additionally, the long-term effects of COVID-19 on work ability are still being researched, and further studies may provide additional insights.

Implications

The results of this systematic review and meta-analysis generate a lot of implications for healthcare providers, occupational health professionals, employers, and

policymakers. It highlights the need for a comprehensive understanding of the post-COVID-19 symptoms and their impact on work ability. Healthcare professionals should be aware of the potential long-term consequences of COVID-19 and consider appropriate rehabilitation as well as aftercare and support services to help individuals RTW. Early identification of post-COVID-19 symptoms and timely interventions may significantly improve the work ability, overall well-being of patients and the successful reintegration into the workplace. Brehon et al. [65] showed, that patients with a shorter time between the onset of SARS-CoV-2 infection and admission to a rehabilitation program had a higher likelihood of RTW. It is important to note that the long-term effects of COVID-19 on work ability and the RTW process are not limited to physical symptoms alone. The systematic review highlights the significant impact of neurocognitive health challenges, such as concentration impairment, dizziness or memory problems, on individuals' ability to work and return to the workforce. Therefore, comprehensive support systems encompassing both physical as well as neurocognitive health interventions under consideration of individual load limitations are crucial for optimizing work outcomes in post-COVID-19 patients. Rehabilitation plays a central role in restoring workability and reintegrating into the professional routine after SARS-CoV-2 infection [73]. In accordance with national [74, 75] and international guidelines [76], a specifically designed post-COVID-19 rehabilitation aims to contribute to the preservation and recovery of biopsychosocial health and work capability within the rehabilitation management of long-/post-COVID-19 patients.

Employers may need to implement flexible work arrangements, offering support services and provide reasonable accommodations for employees recovering from SARS-CoV-2 infection to facilitate their RTW and foster a more supportive and inclusive work environment. The possibilities of adapting working conditions within the company should be given more attention, especially to enable an optimal reintegration into the profession and achieve a RTW for post-COVID-19 patients with prolonged work disability periods [65, 83]. Employers should also be educated about the potential challenges faced by post-COVID-19 patients and the importance of providing appropriate resources and support to aid in their recovery and successful RTW. Policy initiatives could focus on ensuring that post-COVID-19 patients have access to necessary healthcare and rehabilitation services, and protections against discrimination in the workplace due to COVID-19 related symptoms. Furthermore, continuous monitoring of the potential increase in the number of people opting for early retirement due to post-COVID-19 is crucial in the upcoming years, as reduced work ability serves as a predictor for such decisions [29].

Limitations

While the systematic review provides valuable insights into the impact of post-COVID-19 on work ability and the RTW process, there are some limitations to consider. The available literature is still evolving, and the studies included in this review vary in their methodologies, leading to heterogeneity, and thus, difficulties of comparison. Additionally, there is a scarcity of long-term follow-up studies, making it challenging to ascertain the impact of post-COVID-19 on work ability and RTW. Future research should focus on longer follow-up periods to better understand how post-COVID-19 symptoms change over time and affect people's ability to work. Large and long-term cohort studies incorporating mixed methods, encompassing both qualitative as well as quantitative approaches, are essential for gaining comprehensive insights into the long-term consequences of COVID-19. These studies allow a more differentiated understanding of the multifaceted impacts of the disease on individuals' work ability and RTW and should aim for diverse representation in terms of age, gender, severity of acute COVID, occupation, and geographical locations. Supplementing quantitative approaches with qualitative research can offer a better understanding of the lived experiences and challenges faced by individuals recovering from post-COVID-19. Previous research has descriptively analysed work ability and RTW as a secondary parameter over mostly short periods of time. No articles were found that analysed the impact of post-COVID-19 on work ability and RTW as their primary objective. Data about work ability and RTW was collected from different questionnaires (Bell Disability Scale, World Health Organization Disability Assessment Schedule, Work ability index), open questions, online surveys or work ability scales. The studies primarily relied on self-reported work ability, which may introduce biases and problems such as social desirability. Moreover, there were no articles found describing a validated screening tool for post-COVID-19. Employing standardized assessment tools for work ability and RTW outcomes will enhance the reliability and comparability of findings across studies.

There is heterogeneity across the studies with respect to the selection of participants, the assessment of outcomes, follow-up periods and sample sizes in almost all the studies which may influence the generalizability of the results of this study. Despite these limitations, the authors maintain that this systematic review significantly addresses the knowledge gap regarding the impact of post-COVID-19 on work ability and RTW.

The risk of bias assessment indicated that more than half of the included studies were of moderate quality. Common limitations included the failure to include a non-exposed group in cohort studies and inadequate control for confounders. In cross-sectional studies,

nonresponse characteristics and sample size justifications were often poorly described. The Quality Assessment of the included studies using the Newcastle-Ottawa Scale has revealed certain consistency problems and its reliability relies on the expertise of the operator [95, 96]. Consequently, if conducted by a different research group, the quality assessment might have yielded varying results.

Another notable constraint of this systematic review is the restriction to articles published only in English or German. This might result in the exclusion of relevant studies published in other languages, limiting the reviews' overall comprehensiveness.

The majority of studies included hospitalized patients, potentially impacting the generalizability of our findings to the broader population of individuals with post-COVID-19. This focus might introduce bias due to the higher prevalence of comorbidities among hospitalized patients [97]. However, previous studies demonstrated that individuals, even with mild SARS-CoV-2 infections, developed post-COVID-19 symptoms [98, 99], underscoring the importance of considering varying disease severities. To improve our understanding, future studies should include more non-hospitalized individuals, providing a more balanced perspective on the post-COVID-19 landscape.

In addition to the previously mentioned limitations, one crucial aspect that most of the included studies overlooked is the consideration of the specific COVID-19 variants by which the patients were infected. This oversight prevents us from comprehensively understanding the potential differential effects of various variants on individuals' ability to RTW after recovering from SARS-CoV-2 infection. Notably, most studies with a large sample size were conducted in the early stages of the pandemic when the alpha and delta variants were predominant. However, the study by Aben et al. [35] provided the insight that later virus variants (e.g., Omicron) demonstrated a shorter duration between infection and RTW. This crucial finding does not receive adequate attention within the context of this systematic review.

Unanswered questions

In addition to detailing a number of methodological considerations, this review has also highlighted gaps in the literature. The following unanswered questions will help focus future research:

- How does the individual recovery of employees' ability to work with post-COVID-19 look like?
- How do processes of occupational reintegration post-COVID-19 employees look like, and which (promoting and hindering) factors are relevant?
- What problems arise during the recovery process to the ability to work, and how do employees deal

with such problems? What coping strategies do they develop and apply?

- What influence do physical and psychological resources have on the ability to work of employees with post-COVID-19?
- What role does the social as well as the workplace environment (considering the broader context of the International Classification of Functioning, Disability, and Health) play in the recovery of employees' ability to work?
- How do demographic factors impact the ability to work of individuals with post-COVID-19, and what tailored interventions can be developed to address specific needs based on demographic diversity?
- What are the different subtypes of post-COVID-19, and how can a deeper understanding of the various clinical manifestations post-COVID-19 enhance the effectiveness of RTW interventions?
- To what extent do specific interventions such as rehabilitation programmes, aftercare and support services for employees with post-COVID-19 result in improvements of ability to work and faster RTW?

Conclusions

This systematic review and meta-analysis provide valuable insights into the impact of post-COVID-19 on work ability and the RTW. The findings underscore the need for comprehensive support for individuals recovering from SARS-CoV-2 infection to improve their work capacity and overall quality of life. However, the influence of post-COVID-19 on the working-age population seems to be substantial, and it is expected to result in enduring strains on economic and healthcare systems. Policymakers, healthcare providers, occupational health professionals and employers need to collaborate to create inclusive work environments and implement tailored rehabilitation and aftercare programs that improve the work ability of post-COVID-19 patients in long-term. Future research should focus on long-term follow-up studies with mixed methods (qualitative and quantitative) to gain a more comprehensive understanding of the trajectory of post-COVID-19 symptoms and their impact on work outcomes and to identify effective interventions to facilitate the RTW for affected individuals.

Abbreviations

| | |
|----------|--|
| 6MWD | Six-minute walking distance 6MWD |
| CI | Confidence intervals |
| COVID-19 | Coronavirus disease 2019 |
| DRKS | German Register for Clinical Studies |
| HRQoL | Health-Related Quality of Life |
| ICTRP | International Clinical Trials Registry Platform |
| ICU | Intensive care units |
| IQR | Interquartile range |
| PRISMA | Preferred Reporting Items for Systematic Reviews and Meta-Analyses |

| | |
|----------|---|
| PROSPERO | International Prospective Register for Systematic Reviews |
| RTW | Return-to-work |
| PCR | Polymerase chain reaction |
| M | Mean |
| Mdn | Median |
| MeSH | Medical Subject Headings |
| NICE | National Institute for Health and Care Excellence |
| NOS | Newcastle Ottawa Scale |
| SD | Standard deviation |
| SE | Standard error |
| WAI | Work ability index |
| WAS | Work ability score |

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-024-19328-6>.

Supplementary Material 1

Author contributions

Concept and design: K.M. and M.O. Search strategy: M.O., I.P. and K.M. Screening of titles/abstracts and full texts: M.O., I.P. and N.S. Critical review of screening process: I.P. and K.M. Acquisition of data: M.O., I.P., N.S. and K.M. Assessing risk of bias: M.O., N.S. Statistical analysis and interpretation of data: M.O., I.P. and K.M. Drafting of the manuscript: M.O., I.P. and K.M. Critical revision of the manuscript: M.O., I.P., N.S., T.S. and K.M. Supervision: K.M. All authors read and approved the final manuscript.

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Data availability

All data generated or analysed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate

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Competing interests

The authors declare no competing interests.

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