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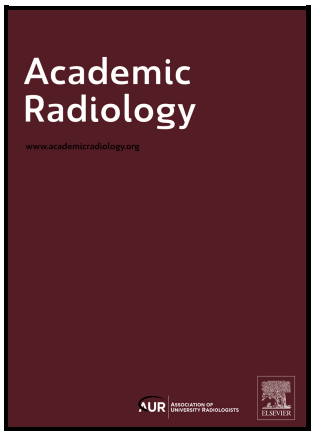

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Radiological Findings as Predictors of COVID-19 Lung Sequelae: A Systematic Review and Meta-Analysis

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Abstract

Background: This systematic review and meta-analysis aimed to investigate the radiological predictors of post- coronavirus disease 19 (COVID-19) pulmonary fibrosis and incomplete absorption of pulmonary lesions.

Method: We systematically searched PubMed, EMBASE, and Web of Science for studies reporting the predictive value of radiological findings in patients with post-COVID-19 lung residuals published through November 11, 2022. The pooled odds ratios with a 95% confidence interval (CI) were assessed. The random-effects model was used due to the heterogeneity of the true effect sizes.

Results: We included 11 studies. There were 1777 COVID-19-positive patients, and 1014 (57 %) were male. All studies used chest computed tomography (CT) as a radiologic tool. Moreover, chest X-ray (CXR) and lung ultrasound were used in two studies, along with a CT scan. CT severity score, Radiographic Assessment of Lung Edema score (RALE), interstitial score, lung ultrasound score (LUS), patchy opacities, abnormal CXR, pleural traction, and subpleural abnormalities were found to be predictors of post-COVID-19 sequels. CT severity score (CTSS) and consolidations were the most common predictors among included studies. Pooled analysis revealed that pulmonary residuals in patients with initial consolidation are about four times more likely than in patients without this finding (OR: 3.830; 95% CI: 1.811-8.102, I2: 4.640).

Conclusion: Radiological findings can predict the long-term pulmonary sequelae of COVID-19 patients. CTSS is an important predictor of lung fibrosis and COVID-19 mortality. Lung fibrosis can be diagnosed and tracked using the LUS. Changes in RALE score during hospitalization can be used as an independent predictor of mortality.

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Keywords: SARS-CoV-2; coronavirus disease 2019; high-resolution computed tomography; pulmonary fibrosis; pulmonary sequelae

Introduction

The pandemic of coronavirus disease 19 (COVID-19) was caused by a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and spread rapidly over the world. It caused an interruption in healthcare systems with more than 6 million death worldwide [1]. As the number of recovered people grows about 10% of the patients may experience long-term sequelae of COVID-19 known as “Long COVID-19” or “post-COVID conditions” or “post-acute sequelae of SARS CoV-2 infection (PASC)” [2-4].

Respiratory symptoms are among the most common ranging from mild symptoms to acute respiratory distress syndrome or severe pneumonia [5]. Chest computed tomography (CT) and chest X-ray (CXR) play important roles in the detection of infection and follow-up of COVID-19 patients from the beginning. approximately half of the recovered patients had CT residual abnormality 90 days after infection and the most common findings were ground glass opacity in 44.1% and parenchymal band or fibrous stripe in 33.9% of them. [6] Fibrotic alterations have been detected in one-third of patients with severe pneumonia [7].

Our study aims to explore the radiological predictors of post-COVID-19 pulmonary fibrosis and incomplete absorption of pulmonary lesions.

Materials and Methods

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This study was performed and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [8] 2020 statement [9]. The study was registered in the Systematic Review Registration: PROSPERO (registration ID: CRD42023393459).

Search strategy

We searched PubMed/Medline, Embase, and Web of Science for studies reporting the predictive value of radiological findings in patients with post-COVID-19 lung residuals published through November 11, 2022. Cohort and analytical cross-sectional studies written in English were selected. We used the following MeSH terms: "'COVID-19', 'SARS-CoV-2', 'Bronchiectasis', and 'pulmonary fibrosis'". Keyword searches were done with combinations of the terms "COVID-19 complication", "post covid-19 complication", "pulmonary residual", "architectural distortion", "Fibrosing organizing pneumonia", "Septal thickening" and "Pleural Thickening". Backward and forward citation searching was performed.

Study Selection

The records found through database searching were merged, and the duplicates were removed using EndNote X8 (Thomson Reuters, Toronto, ON, Canada). Two reviewers separately screened the records by title/abstract and full text to exclude those unrelated to the study purposes. The lead investigators resolved any disagreements. Included studies met the following criteria: (i) patients with a definite diagnosis of COVID-19 according to WHO criteria (ii) patients were divided into residual+ and residual- groups after follow-up, and (iii) comparison of the radiological findings of initial lung imaging in each group. Studies that did not report and analyze radiological findings as predictors for post-COVID-19 sequels, editorials, reviews, conference abstracts, and non-English publications were excluded.

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Data extraction

Three reviewers designed a data extraction form. Reviewers collected data from all relevant studies, and consensus settled disagreements. The following data were extracted: first author name; year of publication; study design and duration; countries where the research was conducted; demographics (i.e., age, sex); COVID-19 detection test; COVID-19 severity, radiologic tool, outcome, and time of follow-up imaging, predictor definition and the total number of patients along with the number of residual+ and residual- groups.

Quality assessment

Three reviewers assessed the quality of the studies using the (Joanna Briggs Institute) JBI's critical appraisal tools for cohort and analytical cross-sectional studies [10]. If there were any discrepancies, another reviewer was consulted. Items such as study population, the measure of exposures, confounding factors, the extent of outcomes, follow-up data, and statistical analysis were evaluated.

Statistical analysis

The pooled odds ratios [11] with a 95% confidence interval (CI) were assessed. The random-effects model was used because of the estimated heterogeneity of the true effect sizes. The between-study heterogeneity was evaluated by Cochran's Q and the I^2 statistic. I^2 values of more than 50% were considered high heterogeneity [12]. Publication bias was assessed statistically by using Begg's test ($p < 0.05$ was considered indicative of statistically significant publication bias) [13]. All analyses were conducted using "Comprehensive Meta-Analysis" software, Version 3.7 (Biostat, Englewood, NJ).

Results

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Search results

Figure 1 shows the flow diagram of the study selection based on PRISMA. We identified 4371 papers through databases (PubMed, EMBASE, and Web of Science) and screened 2914 papers after removing duplicates. First, we ruled out 2842 papers by title and abstract since their subject or outcome was irrelevant to our study. We assessed 72 studies by full-text review. Finally, three cohorts [11, 14, 15], and eight analytical cross-sectional studies [16-23] were included.

Study characteristics

Six studies were conducted in China [15, 22], Egypt [16, 23], Italy [17, 18], and others in Iran [19], Mexico [14], the United Kingdom [11], Turkey [20], and Spain [21]. Follow-up time ranged from 41.5 days to 12 months. The duration of studies, detection test of COVID-19, and other study characteristics are shown in **Table 1**.

Quality of the included studies

The lists for observational studies [14] revealed that the included analytical cross-sectional and cohort studies had a low risk of bias (**Tables 2, 3**) except for Stewart et al. [11] and Vural et al. [20], which had an intermediate risk of bias for dealing with confounding factors.

Patient characteristics

There were 1777 COVID-19-positive patients, and 1014 (57 %) were male. The severity of COVID-19 was classified into three groups based on WHO criteria.

- Mild COVID-19: COVID-19 patients with no clinical signs of pneumonia or hypoxia.

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- Moderate COVID-19: patients presented with clinical signs of pneumonia including fever, cough, dyspnea, and tachypnea but without signs of severe pneumonia and also with oxygen saturation ≥ 90% on room air.
- Severe COVID-19: patients presented with clinical signs of pneumonia and respiratory rate >30 breaths/min or severe respiratory distress, or oxygen saturation < 90% on room air [24].

Seven of the 11 included studies reported the severity of patients based on WHO criteria: mild (n=244), moderate (n=420), and severe (n=556) [11, 15-19, 21]. Age, gender, and severity of cases are presented in **Table 1**.

Radiologic tools and findings

All studies used chest CT as a radiologic tool. In three studies, CXR and lung ultrasound were used along with CT scan [11, 18, 21]. The main outcome of these studies was identifying the predictors of residual absorption of pulmonary lesions, including opacifications (e.g. consolidations and ground glass opacities (GOO)) [15, 16] or fibrotic-like changes such as parenchymal bands, irregular interfaces (broncho-vascular, pleural, or mediastinal), coarse reticular pattern, and traction bronchiectasis after COVID-19 infection [14, 17-23].

CT severity score (CTSS) [19, 20, 22, 23], Radiographic Assessment of Lung Edema (RALE) score [21], interstitial score [17], lung ultrasound score (LUS) [25] [18], patchy opacities [16, 17], abnormal CXR [11], pneumonia [14], and pleural traction and subpleural abnormalities [15] were found to be predictors of post-COVID-19 sequelae.

CTSS is a semi-quantitative CT score and was calculated based on the lung area involved in each of the five lobes: score 0: no involvement, score 1: < 5%, score 2: 5%-25%, score 3: 26%-49%,

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score 4: 50%- 75%, and score 5: > 75%. Summing of the individual lobar scores (possible scores range from 0 to 25) was used to calculate the total CTSS [20].

LUS was derived from 12 areas, different lung areas were scored as follows:

- Score 0: the existence of horizontal artifacts (A-line pattern); < 3 B lines can be existed.
- Score 1: the existence of at least 3 B lines in at least one scan of the region, the B lines are well disjointed and do not merge one in the other; small subpleural consolidations ≤ 1 cm diameter and irregular pleural line might be existed.
- Score 2: multiple, converging B-lines, determining white lung in at least one scan of the region; small subpleural consolidations ≤ 1 cm diameter and irregular pleural lines might be existed.
- Score 3: at least one consolidation with a major axis > 1 cm in at least one the region scans [18].

RALE score presents extent and severity of parenchymal abnormalities in the CXR [4]. The RALE score has been revealed to have high diagnostic accuracy for acute respiratory distress syndrome [11] [25]. For the RALE score, the chest was separated into four quadrants by a vertical line over the spine and a horizontal line at the level of the first branch of the left main bronchus; then each quadrant was scored for the extent of alveolar opacities (consolidation score, from 0 to 4), and the corresponding density of alveolar opacities (density score, from 1 to 3), and the final score was calculated with the sum of the product of the consolidation and density scores for each quadrant. The RALE score ranged from 0 (no abnormalities) to 48 (maximum abnormalities) [26]. The severity score for the consolidation and crazy paving was calculated for each lobe with the same criteria (0– 4 scores), and the sum of individual lobes was used to

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calculate the total score for the lungs (0– 20 scores) [23]. Radiological tools, outcomes, and predictors values are presented in **Table 4**.

Predictive value of initial radiologic findings for post-COVID-19 lung residuals

CT severity score

CTSS was the most common predictor among these studies. Three studies [19, 20, 22] have evaluated the CTSS in categorical form, and CTSS>= 18 (OR=4.2, 95%CI: 1.2-14), CTSS>=19 (OR=2.15, 95%CI: 1.17-3.95), and CTSS>=15 (OR=2.2, 95%CI: 13.5-18) were the predictors among included studies. Yasin et al. [23] and Nabahati et al. [19] have assessed the predicting role of CTSS in continuous form. They revealed that CTSS (OR=2.38, 95%CI: 1.18-4.41; OR=1.1, CI 95%: 1.03-1.18) was a predictor for post-COVID-19 pulmonary fibrosis. In all these studies which analyzed and reported CTSS, Greater values of CTSS were observed in the initial CT among the fibrotic group compared with the non-fibrotic group during hospitalization. Moreover, Yasin et al. showed Chest CTSS demonstrates 86.1% sensitivity, 78% specifity, and 81.9% accuracy at a cutoff point of 10.5 [23].

Consolidation

Consolidations and patchy opacities were other common predictors in four studies [16, 17, 19, 23]. Three studies (Abdel-Hamid et al., Nabahati et al., and Cocconcelli et al.) assessed the presence of consolidation in initial CT scan as an independent predictor for pulmonary residuals (OR=4.98, 95%CI:1.195-20.791; OR=, 95%CI: 1.2-6.73; OR=20.6, 95%CI: 1.4-301.2; respectively) [16, 17, 19]. Three studies [16, 17, 19] had reported adjusted OR for the predictive value of consolidation in post COVID-19 lung residuals. The meta-analysis of these studies showed that pulmonary residuals in patients with initial consolidation are about four times more than in patients without

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this finding. (OR: 3.830; 95% CI: 1.811-8.102, I2: 4.640) (Figure 2). There was no evidence of publication bias (p > 0.05; Begg: 0.296).

Moreover, Cocconcelli et al. reported the consolidation >=0.8% and interstitial score >=1.4% were predictors of pulmonary fibrosis (OR=20.6, 95%CI: 1.4-301.2; OR=23, 95%CI: 1.4-377.2; respectively) and alveolar score >= 7% as a protective factor (OR=0.74, 95%CI: 0.09-5.99). Moreover, Yasin et al. reported that consolidation/crazy paving signs can be a predictor for pulmonary fibrosis (OR=1.91, 95%CI: 0.63-4.35) [23].

Chest x-ray

Stewart et al. have reported that abnormal CXR was a predictor for residual lung abnormalities (RR= 1.4, 95% CI: 1.22-1.61) [11].

Pleural and sub pleural abnormality

Three cohort studies have reported the hazard ratio (n=2) and relative risk (n=1) of pleural and sub-pleural abnormalities in chest CT, pneumonia, and abnormal CXR, as predictors for residual lung abnormalities [11, 14, 15]. Zhao et al. has found that the presence of diffuse lesions (HR = 0.28; 95% CI, 0.09–0.92), sub-pleural distribution of lesions (HR = 2.15; 95% CI, 1.17–3.92), the morphology of residuals (linear lesion: HR = 4.58, 95% CI, 1.22–17.11; nodular lesion: HR = 33.07, 95% CI, 3.58–305.74), and pleural traction (HR = 0.41; 95% CI, 0.22–0.78) before discharge were independent factors to predict the absorption status of COVID-19-related pulmonary abnormalities after discharge. In their study, the total absorption was set as the endpoint of the Cox Regression model, therefore, features with HR value over 1.0 (sub-pleural distribution of lesions, and lesions with liner and nodular shape in CT images) were regarded as the protective factors [15].

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Pneumonia

Fernández-Plata et al. showed that pneumonia was an imaging finding predictor (HR= 2.4; 95%CI: 1.51-3.82) of developing pulmonary fibrosis post-COVID-19, after several months of initial infection [14].

Lung Ultrasound Score

Two other studies investigated the role of LUS as another promising radiologic tool for the revealing of fibrotic-like patterns after COVID-19 recovery [18, 21]. Russo et al. found that lung ultrasound done after 6 months after severe COVID-19 can be a promising tool for pulmonary fibrotic sequelae identification and follow up [18].

Radiographic Assessment of Lung Edema

Tarraso et al. indicated that the RALE score at admission was an independent predictor of lung diffusion impairment at 12 months [21].

DISCUSSION

There is rising concern regarding the increased prevalence of COVID-19-recovered patients for ongoing pulmonary sequelae and fibrosis. This is the first meta-analysis investigating radiographic determinants of COVID-19 long-term pulmonary effects. The initial CTSS, consolidation, and pneumonia all predicted pulmonary fibrosis. Initial consolidation, abnormal CXR, and pleural and subpleural abnormalities are revealed to be predictive of persistent lung abnormalities. Our Meta-analysis revealed that pulmonary residuals are approximately four times more prevalent in patients with early consolidation than in those without this finding.

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Pulmonary fibrosis includes parenchymal bands, traction bronchiectasis, irregular interfaces, and honeycombing [27]. Older age [28] [29], male sex, hypertension, diabetes, and increased inflammatory markers have all been linked to the development of pulmonary fibrosis in COVID-19 patients [30]. Imaging predictors are critical for the early detection and management of individuals with pulmonary sequelae [28, 29, 31]. Watanabe et al. [32] discovered that even after a year of follow-up, fibrotic changes showed little improvement, indicating the need for a low-cost modality that does not expose patients to ionizing

radiation, and Russo et al. [18] recommend the LUS to diagnose and follow up on patients with pulmonary fibrosis six months after recovery. A greater LUS is related to more severe COVID-19 condition and mortality as well as has a positive correlation with CTSS [30].

Increased blood C- reactive protein (CRP), D-dimer, ferritin levels, lymphopenia [33], and fibrosis [34] are associated with an initial high CTSS. Adults over the age of 63 had approximately three times the probability of developing abnormalities on CT scans at 12 months [35]. Furthermore, fibrotic changes appear to be more common in patients requiring intensive care unit (ICU) recovery, staying in the hospital for longer periods of time, and/or having a higher inflammatory load [36, 37]. Six-month follow-up CTs revealed the presence of fibrosis in the same zones affected by the initial infection phase abnormalities [37]. It could be linked to a reduction in cell-mediated immunity and the augmented humoral immune response in the affected zone [38].

In a one-year follow-up, Watanabe et al. [32] found that 32.6% of recovered patients had residual abnormalities, with GGO being the most common finding in 21.2% of recovered people. According to Pan et al. report, after a one-year follow-up of COVID-19 diagnosis, chest CT showed aberrant findings in 25% of patients with subpleural and reticular/cystic lesions in 13% of

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them [36]. These pleural complications might result in increased mortality, morbidity, interventional procedures, and patient expenses in COVID-19 pneumonia cases [31].

The RALE score is an independent predictor of lung diffusion impairment at 12 months. Decreased lung diffusion was observed in 39.8% of COVID-19 patients with no association with their disease severity [21]. According to Watanabe etal. [32], diffusing capacity of the lungs for carbon monoxide (DLCO) was found to be less than 80% of the expected value in 30.5% of patients one year following recovery. An international multicenter trial showed that Change in RALE score after 14 days of mechanical ventilation was independently related to the highr rate of mortality. However, this association was not observed with baseline CXR RALE score [39].

There are some limitations to this study; First, we did not review the articles related to children, which might be different from what was evaluated in adults. Second, the presence of different equipment and the experience of interpreting radiologists might cause some variability. Third, the data is from the newest studies, and a more updated systematic review in the future is recommended.

In conclusion, consolidation is a strong imaging predictor of long-term sequelae of COVID-19 patients. CTSS is an important measure for predicting lung fibrosis and COVID-19 mortality. The LUS can be used to diagnose and follow patients with lung fibrosis. RALE score changes in COVID-19 hospitalization can be utilized as an independent predictor of mortality. This review will contribute to a better understanding of the potential long-term pulmonary sequelae of COVID-19 and help with the early detection and intervention to prevent or attenuate the advancement of lung fibrosis. However, Further research to better understand the underlying mechanisms of pulmonary fibrosis development in COVID-19 patients is warranted.

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Conflicts of interest: None

Source of funding: None

Figure1. Flow chart of study selection for inclusion in the systematic review and meta-analysis.

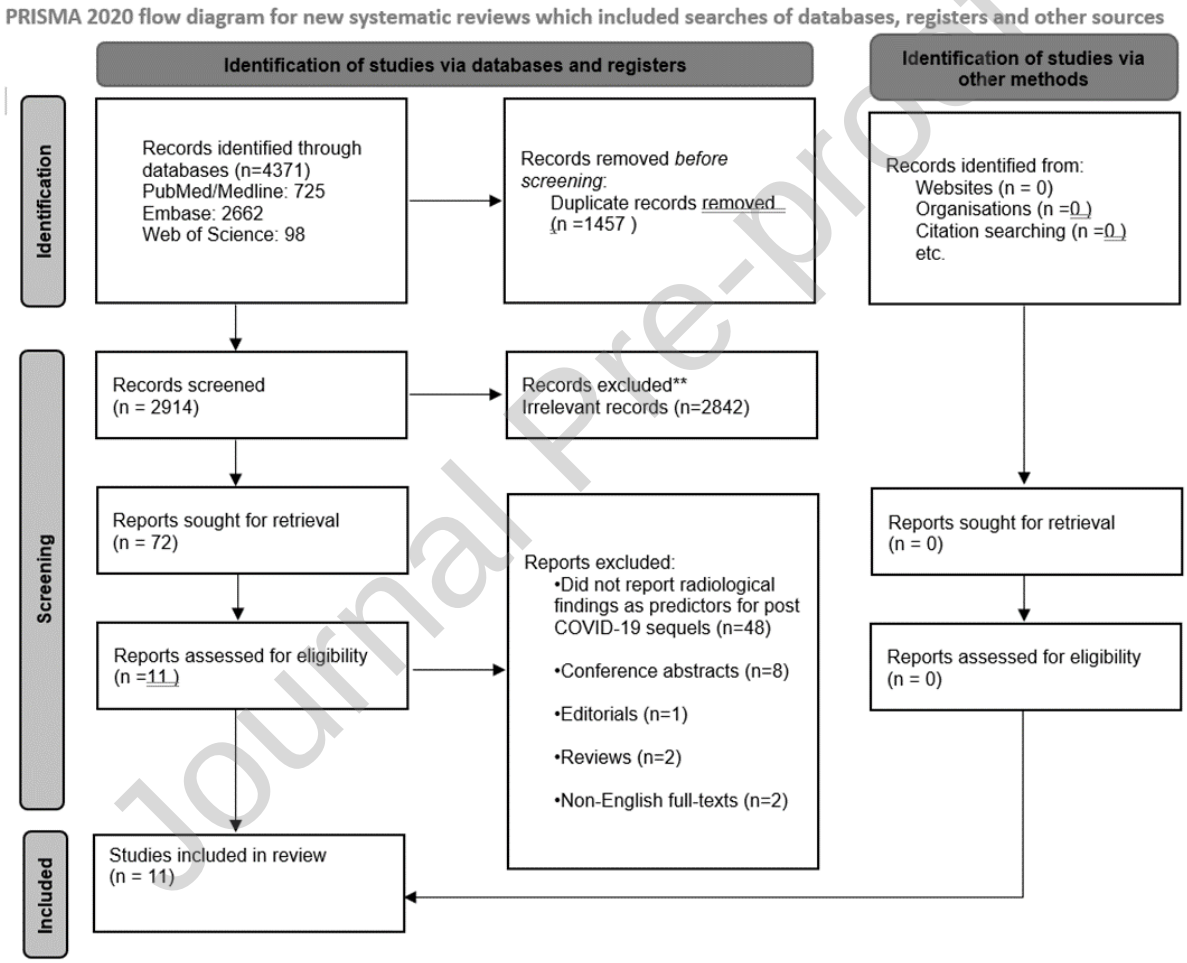

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Table 1. Summary of included studies

First author	Study design	Publication year	Country	Study duration	Detection test for COVID-19	Follow-up duration	Number (M/F)	Age	COVID-19 severity based on WHO criteria
Han et al. [22]	Prospective cross-sectional	2021	China	December 25, 2019 to February 20, 2020	RT-PCR on Throat swab	3 months	114 (80/34)	Mean (SD): 54 ± 12	NM
Zhao et al. [15]	Retrospective cohort	2021	China	January 21, 2020 to March 20, 2020	laboratory-confirmed COVID-19 infection by NAAT	3 months	175 (102/73)	Mean (SD): 44.75 ± 13.65	Moderate: 132 Severe: 43
Abdel-Hamid et al. [16]	Prospective cross-sectional	2021	Egypt	June 1, 2020 to July 1, 2020	RT-PCR on nasopharyngeal swab	3 weeks	85 (48/37)	Median (IQR): 52(37.5-59.5)	Moderate 74: Severe: 11
Yasin et al. [23]	Prospective cross-sectional	2021	Egypt	August 1, to December, 1 2020	RT-PCR on nasopharyngeal swab	41.5 days	210 (149/61)	Mean (SD): 53.85 ± 14.84	NM
Cocconcelli et al. [17]	Prospective cross-sectional	2022	Italy	February to December 2020	RT-PCR on nasopharyngeal swab	3 months	220 (115/105)	Median (range): 59 (19–84)	Severe: 220
Russo et al. [18]	Prospective cross-sectional	2022	Italy	February 21, to May 30, 2022	CT scan and lung ultrasound	6 months	74 (54/20)	Mean (IQR): 65 (56.25–73)	Severe: 74
Stewart et a. [11]	prospective longitudinal cohort	2022	United Kingdom	End of March to October 2021	Not mentioned	140 days	209 (143/66)	Median (range): 58 (52-67)	Mild:35 Moderate: 111 Severe: 63
Fernández-Plata et al. [14]	Prospective cohort	2022	Mexico	April 6, 2021 to December 14, 2021	RT-PCR	6 months	149 (58/91)	Median (IQR): 35 (29, 45)	NM

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Nabahati et al. [19]	Prospective cross-sectional	2021	Iran	During March 2020	RT-PCR on nasopharyngeal swab	3 months	173 (57/116)	Mean (SD): 53.62 ± 13.67	Moderate: 80 Severe: 93
Vural et al. [20]	Retrospective cross-sectional	2021	Turkey	April 1, 2020 to August 31, 2020	RT-PCR	3-6 months	84 (51/33)	Mean (SD): 67.3 ± 15.2	NM
Tarraso et al. [21]	Prospective cross-sectional	2022	Spain	May 1, 2020 to July 31, 2020	RT-PCR	12 months	284 (157/127)	Mean (SD): 60.5 ± 11.9	Mild: 209 Moderate: 23 Severe: 52

Abbreviations: COVID-19: Coronavirus disease, CT scan: computerized tomography scan, F: female, IQR: interquartile, M: male, NM: not mentioned, SD: standard deviation, WHO: world health organization, RT-PCR: reverse transcription polymerase chain reaction

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Table 2. Quality assessment of analytical cross-sectional studies.

Author	1	2	3	4	5	6	7	8
Han et al. [22]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Abdel-Hamid et al[16]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yasin et al. [23]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cocconcelli et al. [17]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Russo et al. [18]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nabahati et al. [19]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Vural et al. [20]	Yes	Yes	Yes	Yes	Unclear	Unclear	Unclear	yes
Tarraso et al. [21]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

1. Were the criteria for inclusion in the sample clearly defined?

2. Were the study subjects and the setting described in detail?

3. Was the exposure measured in a valid and reliable way?

4. Were objective, standard criteria used for measurement of the condition?

5. Were confounding factors identified?

6. Were strategies to deal with confounding factors stated?

7. Were the outcomes measured in a valid and reliable way?

8. Was appropriate statistical analysis used?

Table 3. Quality assessment of cohort studies.

Author	1	2	3	4	5	6	7	8	9	10	11
Zhao et al. [15]	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	NA	Yes
Stewart et al. [11]	Yes	Yes	Yes	No	No	Unclear	Yes	Yes	Yes	NA	Yes
Fernández-Plata et al. [14]	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes

1. Were the two groups similar and recruited from the same population?
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?
3. Was the exposure measured in a valid and reliable way?
4. Were confounding factors identified?
5. Were strategies to deal with confounding factors stated?
6. Were the groups/participants free of the outcome at the start of the study?
7. Were the outcomes measured in a valid and reliable way?
8. Was the follow-up time reported and sufficient to be long enough for outcomes to occur?
9. Was follow-up complete, and, if not, were the reasons to loss to follow-up described and explored?
10. Were strategies to address incomplete follow-up utilized?
11. Was appropriate statistical analysis used?

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Table 4. Radiological findings.

First Author	Radiologic tool	Outcomes	Radiological predictors value

Han et al. [22]	Chest CT	fibrotic-like changes	CT score>=18 OR: 4.2 (95%CI: 1.2-14)
Zhao et al. [15]	Chest CT	incomplete absorption of pulmonary lesions	diffuse distribution HR: 0.28 (95%CI: 0.09-0.92) sub pleural abnormalities HR: 2.15 (95%CI: 1.17-3.92) linear lesions HR: 4.58 (95%CI: 1.22-17.11) nodular lesions HR: 33.07 (95%CI: 3.58-305.74) the existence of pleural traction HR: 0.41 (95%CI: 0.22-0.78)
Abdel-Hamid et al. [16]	Chest CT	pulmonary residuals	patchy opacity OR: 4.984 (95%CI: 1.195-20.791)
Yasin et al. [23]	Chest CT	lung fibrosis	CT Severity score (continuous) OR: 2.38 (95%CI: 1.18-4.41) Consolidation/crazy-paving sign (continuous)

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			OR: 1.91 (95%CI: 0.63-4.35)
Cocconcelli et al. [17]	Chest CT	pulmonary fibrosis	consolidations>=0.8% OR: 20.6 (95%CI: 1.4-301.2) interstitial score>=1.4% OR: 23 (95%CI: 1.4-377.2) Alveolar score>=7% OR: 0.74 (95%CI: 0.09-5.99)
Russo et al. [18]	CT scan and lung ultrasound	fibrotic-like pattern	LUS Score OR: 1.35 (95%CI: 1.14-1.59)
Stewart et al. [11]	Chest CT, chest X-ray	residual lung abnormalities	abnormal CXR RR: 1.4 (95%CI: 1.22-1.61)
Fernández-Plata et al. [14]	Chest CT	pulmonary fibrosis	pneumonia HR: 2.41 (95%CI: 1.51-3.82)
Nabahati et al. [19]	Chest CT	Pulmonary fibrosis	consolidation OR: 2.84 (95%CI: 1.2-6.73) CT severity score (continuous) OR: 1.1 (95%CI: 1.03-1.18) CT severity score ≥ 19

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			OR: 2.15 (95%CI: 1.17-3.95)
Vural et al. [20]	Chest CT	predict fibrotic-like changes	CT severity score >=15 OR: 2.2 (95%CI: 13.5-18)
Tarraso et al. [21]	Chest CT	Lung fibrotic-like impairment	radiological involvement (RALE score) OR: 1.55 (95%CI: 0.98-0.99)

CI: confidence interval, CT scan: computerized tomography scan, CXR: chest x-ray, HR: hazard ratio, OR: odds ratio, RR: relative risk, RALE: Radiographic Assessment of Lung Edema

Figure 2. Meta-analysis of consolidation predictive value.

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Consolidation

Author	Year	Odds ratio	Lower limit	Upper limit	p-Value	Relative weight
Abdel-Hamid	2021	4.984	1.195	20.789	0.028	26.17
Nabahati	2021	2.840	1.199	6.726	0.018	66.16
Cocconcelli	2022	20.600	1.404	302.156	0.027	7.67
		3.830	1.811	8.102	0.000	

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Declaration of Competing Interest

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: