Lung imaging features in COVID-19 cases: a systematic review and meta-analysis

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Abstract

Background and aim: the purpose of present study was evaluate Lung imaging features in COVID-19 cases.

Method: Current study following the PRISMA guidelines, all articles published in international databases such as PubMed, Scopus, Science Direct, Embase between January 2019 and March 2022 included. 95% confidence interval on effect size were done with random effect model and Restricted maximum-likelihood method. Data analysis was performed using STATA.V16 software.

Result: In the initial search, 759 studies were identified; full text of 207 articles was reviewed; finally 17 articles entered the analysis. Effect size of Abnormal chest CT of adult and pediatric COVID-19 patients was 2.55 (ES; 95 CI (2.18, 2.92)) and CI (0.53, 0.93)), respectively. According to test of group differences, abnormal chest CT findings are more evident in adults. Ground Glass Opacity and Consolidation: Effect size of Ground Glass Opacity and Consolidation in pediatric COVID-19 patients was 0.47 (ES; 95 CI (-0.42, 1.36)) and Ground-glass opacity was 48 (ES; 95 CI (0.30, 0.66)).

Conclusion: Abnormal CT imaging was lower in the pediatric population than in adults with Covid-19. Ground Glass Opacity was more pronounced in both age groups. Further studies are needed to provide stronger evidence, especially in other parts of the world.

Key words: COVID-19, Computed tomography, Lung imaging features, Imaging manifestations, CT scan

Introduction

COVID-19 infection is a viral disease caused by a virus called SARS-CoV-2 infection(1). COVID-19 is now a pandemic (worldwide) and has caused infection and death in many countries (2). Most people infected with Covid-19 virus experience mild to moderate respiratory illness and recover without special treatment (3). The target of the Covid-19 virus is the human respiratory tract, so that the Covid-19 virus gradually enters the upper respiratory tract and then the lower respiratory tract, the lungs, causing involvement with the lungs(4). When the Covid-19 virus particle attaches to the respiratory cell by cellular receptors, at this point, the infection begins in the body(5). The outbreak of the new coronavirus is more widespread in humans than previous coronaviruses, indicating the highly contagious power of the virus(6). In general, the presence of Covid-19 virus can be very dangerous if a person has a chronic illness or has inflamed lungs and respiratory diseases such as asthma, or a person with a weakened immune system(7). According to the World Health Organization (WHO), the elderly and people with major medical problems or underlying diseases such as cardiovascular disease, diabetes, chronic respiratory disease and cancer are more likely to develop Covid-19 (8). Significant symptoms of the virus in humans include fever, cough, and shortness of breath, shortness of breath, sore throat (9). Other symptoms of Covid-19 virus include chills, body aches, sore throats, headaches, diarrhea, nausea and vomiting(10). In the process of diagnosing people with Covid-19 infection, the method of imaging by CT scan devices of the chest of people, has higher accuracy and sensitivity than diagnostic kits(11). Chest CT scans show high quality images of lung tissue, and the radiologist can quickly determine if the lungs are involved in the disease(12). Chest CT scan reveals common radiological features in patients with Covid-19(13). These features include ground-glass opacity, multifocal patchy consolidation, and interstitial changes with peripheral distribution(14). In a study of 81 Covid-19 patients, majority of patients had abnormal pneumonia on chest CT scans(15). In another study, abnormalities on chest CT images showed that all samples had significant ground-glass opacities in the peripheral parts of the lungs(16). Many review studies have been performed in adults and children, however, due to the course of the disease and changes in its strains, as well as the need for further studies in this area, the present study was conducted to review lung imaging features in COVID-19 cases.

Method

Search strategy

Current study following the PRISMA guidelines (17), all articles published in international databases such as PubMed, Scopus, Science Direct, Embase between January 2019 and March 2022 included. Google Scholar search engine was used.

The following keywords were used to search:

((((((("Tomography, X-Ray Computed"[Mesh]) OR "Ventilation-Perfusion Scan/methods"[Mesh]) OR "Ventilation-Perfusion Scan"[Mesh]) OR "Reversed halo sign"

[Supplementary Concept]) AND "COVID-19"[Mesh]) OR ("COVID-19/complications"[Mesh] OR "COVID-19/diagnosis"[Mesh])) OR ("SARS-CoV-2"[Mesh] OR "SARS-CoV-2 variants" [Supplementary Concept]).

Inclusion criteria

The selection criteria were RCT studies, cohort studies, case reports, and case-control studies that full text of the article was available. Studies other than these study design were excluded; only articles published in English were selected.

Table1. PECO strategy

PECO strategy	**Description**
P	Population: COVID-19 patients
E	Exposure: SARS -CoV-2
C	Comparison: Survival vs. death
O	Outcome: survival rate

Statistical analysis

Data analysis was performed using STATA.V16 software. I^2 index test was used to evaluate the level of heterogeneity (I^2< 50% = low levels, 50<I^2< 75% = moderate and I^2>75% = high levels). 95% confidence interval on effect size were done with random effect model and Restricted maximum-likelihood (REML) method.

Result

First search for articles in databases, 759 articles were identified. After importing all articles into EndNote.X8 software, duplicate articles were deleted (n=63). 696 article entered and examined in second stage. At this stage, while reviewing the titles and abstracts of articles, 489 unrelated articles were excluded from the study. In the third stage, the full text of 207 articles was reviewed. Finally 17 articles that were published between January 2019 and March 2022 and met the inclusion criteria, entered the analysis.

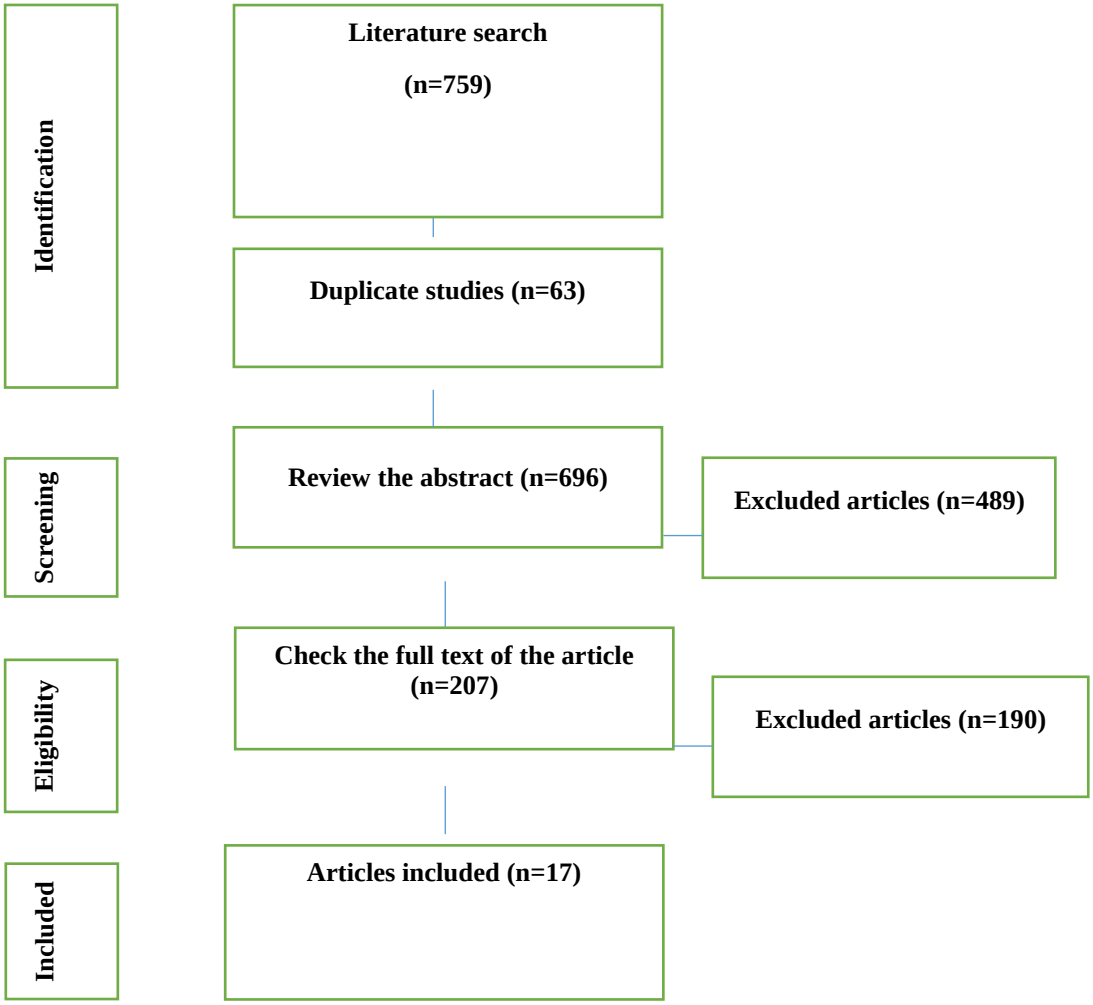

Figure 1. PRISMA flowcharts

Characteristics

Ten studies included in adult with COVID-19 population; the number of male and female patients were 455 and 411, respectively and a total 866 with 48.52 years old (Table1). Seven studies included in pediatric with COVID-19 population; the number of boys and girls patients were 92 and 77, respectively and a total 169 with 7.54 years old (Table1).

Abnormal CT imaging of COVID-19 pneumonia

Adult: Effect size of Abnormal chest CT of adult COVID-19 patients was 2.55 (ES; 95 CI (2.18, 2.92)) (I^2=67.30%; p=0.00). (Figure2). Based on findings, 94.32% of adult COVID-19 patients had Abnormal CT imaging.

Pediatric: Effect size of Abnormal chest CT of pediatric COVID-19 patients was 0.73 (ES; 95 CI (0.53, 0.93)) (I^2=25.28%; p=0.44). (Figure2). Based on findings, 77%% of pediatric COVID-19 patients had Abnormal CT imaging.

Overall: Effect size of Abnormal chest CT in all age groups was 1.61 (ES; 95 CI (0.1.09, 2.14)) (I^2=94.02%; p=0.00). (Figure2). According to test of group differences, there was a difference

between pediatric and adults COVID-19 patients in terms of abnormal chest CT (p=0.00); Abnormal chest CT findings are more evident in adults.

Table1. Characteristics of selected studies

n	Study. Years	population	Number of patients		Mean of age
			female	male	
1	Bai et al., 2020 (18)	adults	100	119	44.8
2	Inui et al., 2020 (19)	adults	53	59	60
3	Zhang et al., 2020 (20)	adults	4	5	35.3
4	Song et al., 2020 (21)	adults	26	25	49.6
5	Bernheim et al., 2020 (22)	adults	60	61	45.1
6	Shi et al., 2020 (15)	adults	39	42	50
7	Pan et al., 2020 (23)	adults	30	33	44
8	Xu et al., 2020 (24)	adults	21	29	43
9	Zhang et al., 2002 (25)	adults	71	69	57.4
10	Ng et al., 2020 (23)	adults	7	13	56
11	Chen et al., 2020 (26)	pediatric	6	6	14.5
12	Li et al., 2020 (27)	pediatric	10	12	8
13	Ma et al., 2020 (28)	pediatric	34	42	2.5
14	Song et al., 2020 (29)	pediatric	6	10	8.5
15	Zhu et al., 2020 (30)	pediatric	5	5	9.2
16	Xia et al., 2020 (31)	pediatric	7	13	2.1
17	Tan et al.,2020 (32)	pediatric	9	4	8

Imaging manifestations of COVID-19 pneumonia

Adult:

Overall Effect size of Imaging manifestations was 0.99 (ES; 95 CI (0.58, 1.40)) (I^2 = 86.74%; P =0.00) (Figure3).

Subgroup meta-analysis

Ground Glass Opacity and Consolidation: Effect size was 1.20 (ES; 95 CI (0.62, 1.78)) (I^2 = 45.76%; P =0.12) (Figure3).

Ground-glass opacity: Effect size was 1.39 (ES; 95 CI (0.55, 2.22)) (I^2 = 72.13%; P =0.00) (Figure3).

Consolidation: Effect size was 0.48 (ES; 95 CI (-0.06, 1.02)) (I^2 = 89.51%; P =0.02) (Figure3).

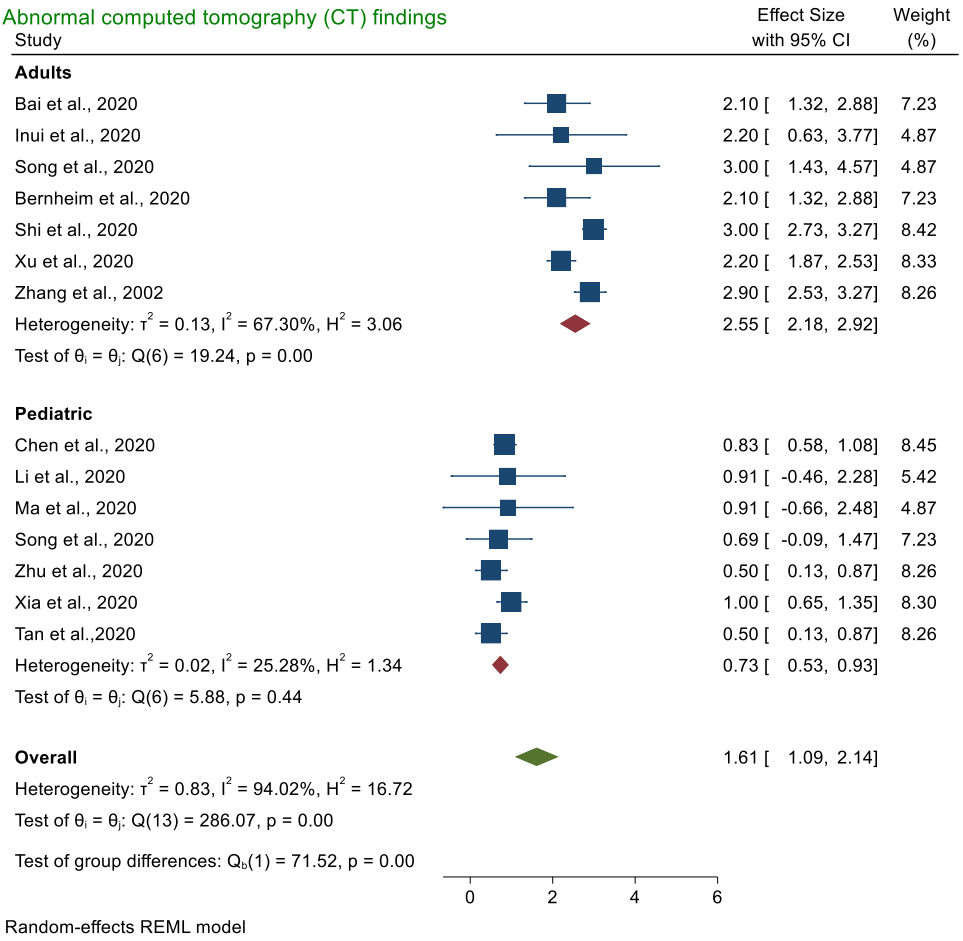

Figure2. Forest plot showed abnormal chest CT in all age groups

Pediatric:

Overall Effect size of Imaging manifestations was 0.45 (ES; 95 CI (0.29, 0.61)) (I^2 = 0%; P =0.99) (Figure4).

Subgroup meta-analysis

Ground Glass Opacity and Consolidation: Effect size was 0.47 (ES; 95 CI (-0.42, 1.36)) (I^2 = 0%; P =0.61) (Figure4).

Ground-glass opacity: Effect size was 48 (ES; 95 CI (0.30, 0.66)) (I^2 = 0%; P =0.84) (Figure4).

Halo signs: Effect size was 0.39 (ES; 95 CI (-0.17, 0.95)) (I^2 = 0%; P =0.92) (Figure4).

Increased lung markings: Effect size was 0.22 (ES; 95 CI (-0.33, 0.77)) (I^2 = 0%; P =0.67) (Figure4).

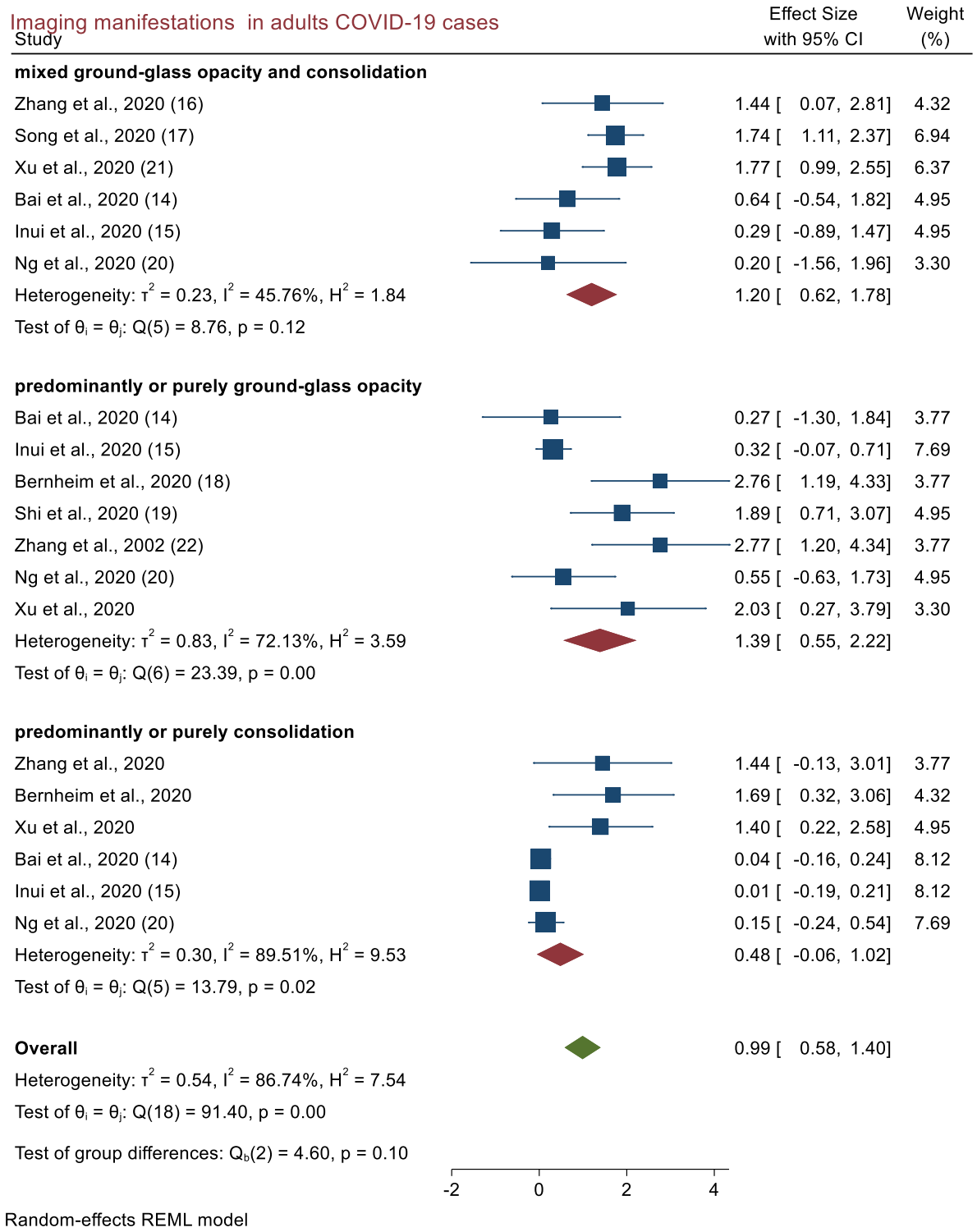

Figure 3. Forest plot showed Imaging manifestations of adult COVID-19 patients

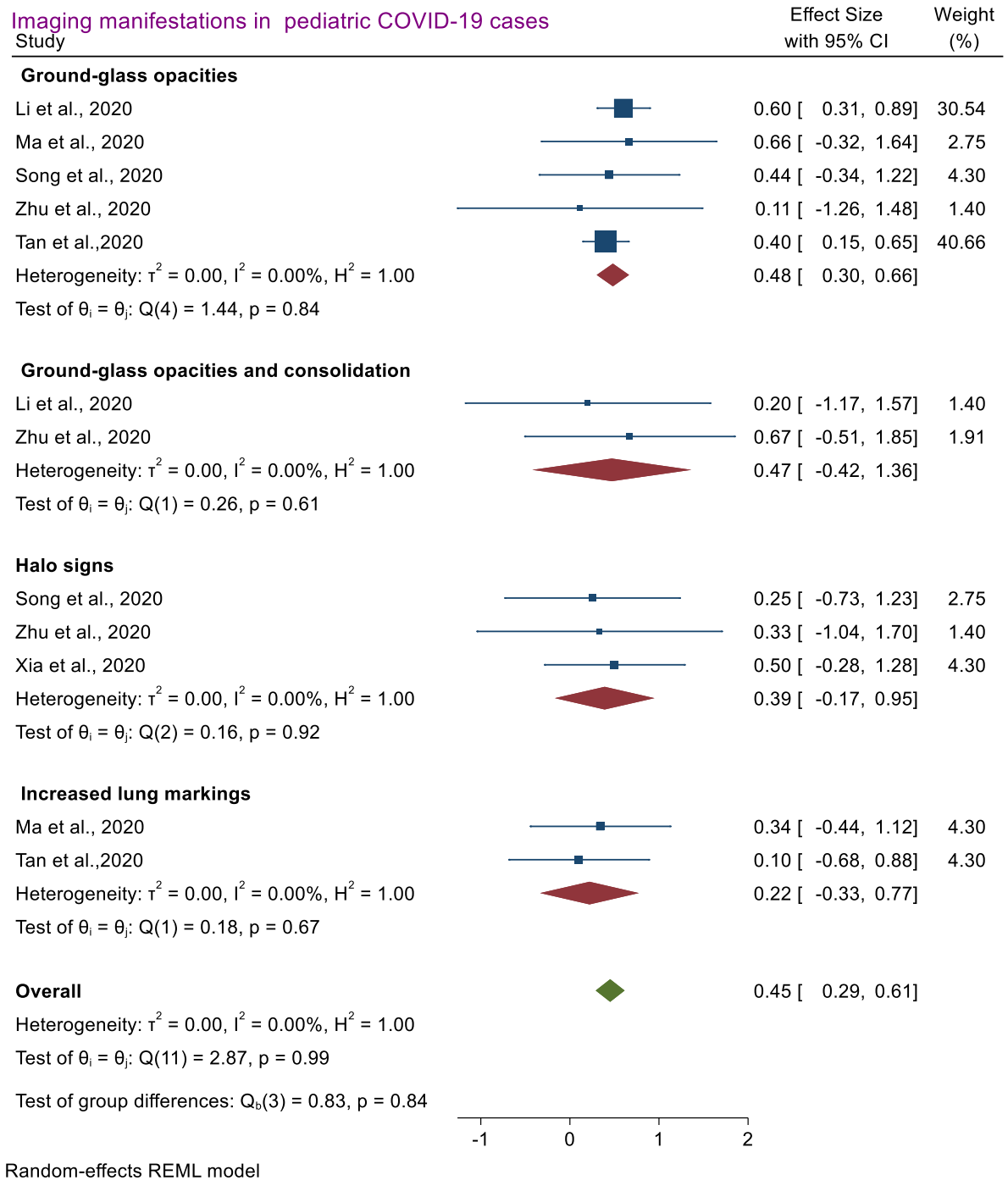

Figure 4. Forest plot showed Imaging manifestations of pediatric COVID-19 patients

Discussion

On December 31, 2019, China Health reported to WHO that several cases of unknown pneumonia had been reported in Wuhan, China, Hubei Province(33). The disease has spread rapidly in China and around the world, with the latest WHO figures showing that the number of people with Covid-19 infection has risen 452,201,564 and 6,029,852 deaths were reported (12 March 2022) (34). In assessing the extent of lung tissue involvement and in the case of individuals in different groups in this category, data on the destruction of lung tissue by the

corona virus can be examined and Several common imaging features such as Ground Glass Opacity with Mixed Consolidation, Ground-glass opacity and consolidation, and two-way distribution can be a good guide to identify patients suspected of having Covid-19(35). According to meta-analysis Abnormal chest CT findings are more evident in adults than pediatric COVID-19 patients. According to studies, the most age group involved in Covid-19 is the population over 30 years old, which has a higher mortality rate in the elderly over 60 years(36); Especially in people who have underlying diseases, mortality is higher(37). Hence, one of the reasons for these findings is that children are less likely to have underlying diseases. According to recorded reports, the mortality rate of children is lower than that of adults (38, 39). According to the present meta-analysis, Ground Glass Opacity is an imaging manifestation in adults and children and should be carefully evaluated; On the other hand, Ground Glass Opacity with Mixed Consolidation, Consolidation, Halo signs and increased lung markings were also imaging manifestations that should be examined. However, Halo signs are rare in adults and the incidence was 39% in children with Covid-19. Pericardial effusions are also rare in children and are more commonly examined for adult CT images. Based on the present meta-analysis, Covid-19 can affect any lobe of the lung; Studies show that the virus often infects the lungs bilaterally in children and unilaterally in adults. Therefore, the study of imaging manifestations in children is very important and can lead to treatment measures and early diagnosis of the disease(40). Another interesting point that was found in the reports is that, in patients with CCOVID-19, left upper lobe involvement, Reverse Halo and lymphadenopathy were found(41, 42). Frequency of Ground-glass opacity in patients with abnormal CT scan finding in the study of Ai et al., 2020 (43) was 46%. Yuan et al., 2020 reported Incidence rate 67% of Ground-glass opacity(44). Based on the available evidence, Computed tomography imaging features in children are similar to those in adults with Covid-19; however, their intensity is less. Also, more than half of the population of children with Covid-19 CT scans do not show abnormal CT imaging. Nino et al., 2021 reported that Chest CT manifestations in pediatric COVID-19 patients could potentially be used for early identification and prompt intervention in the pediatric population(45). Also Zang et al., 2021 Reported that Abnormal Computed tomography imaging is much lower in children than in adults. The incidences of bilateral lesions, unilateral lesions, and peripheral lesions were 35%, 22%, and 26%, respectively(45). The present study had some limitations. In the adult population, there is a high heterogeneity between the findings of the study. These findings should be examined more carefully and future studies should be done in the same way. However, the heterogeneity in the child population was very low. Similar studies were consistent; also, the sample size is very small, which requires more sample size to provide stronger evidence. Most of the studies were done in China, and it is suggested that studies on Lung imaging features in COVID-19 cases be performed in other countries as well, in order to provide a better and more comprehensive comparison.

Conclusion

Based on the findings of the present meta-analysis, Abnormal CT imaging was lower in the pediatric population than in adults with Covid-19. Ground Glass Opacity was more pronounced in both age groups. Further studies are needed to provide stronger evidence, especially in other

parts of the world. It is hoped that the findings of the present study can be helpful in timely identification and early intervention. However, research with higher and deeper sample sizes is needed because high heterogeneity was observed in the results of adult population studies. Also, given that vaccination has been performed worldwide, it is suggested that future studies on the mechanisms of the immune response and vaccine development and CT imaging findings in people who have received the vaccine.

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