INTRODUCTION

COVID-19, also called Coronavirus Disease 2019, is an infectious disease caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2).\(^1\) It originated in Wuhan, China, in late December 2019 and has since evolved into a global pandemic.\(^2\) As of July 2022, the worldwide incidence of COVID-19 cases has exceeded 560 million, resulting in 6.37 million deaths, according to the World Health Organization.\(^3\) In Indonesia, the cumulative number of COVID-19 cases has reached 6.12 million, with 157,000 deaths, as the Ministry of Health reported.\(^4\) In South Sulawesi, the cumulative number of COVID-19 cases has reached 112,000 with 2,248 deaths, according to the Indonesian Ministry of Health.\(^5\)

The initial report from Wuhan revealed that a small number of children have been affected by COVID-19.\(^6\) Common symptoms among children include fever, cough, difficulty breathing, and sometimes gastrointestinal issues. Despite typically experiencing mild symptoms, children can still serve as potential virus carriers. Computed Tomography (CT) of the chest has emerged as a crucial procedure for screening, diagnosing, and monitoring COVID-19 patients while also providing prognostic information.\(^5,6\) CT has demonstrated a high sensitivity rate, surpassing polymerase chain reaction tests, with a negative predictive value of nearly 99%. However, its specificity and positive predictive value are relatively low.\(^7\) Comparatively, thorax radiography (CXR) has received less attention, although similar findings to CT have been reported with lower sensitivity. This highlights the need for research to assess CXR findings in children with COVID-19.\(^6,7\) Given children’s heightened radiation sensitivity, routine CT scans are not recommended. CXR, on the other hand, is believed to be valuable for clinical decision-making and management of suspected COVID-19 cases in children.

Based on those mentioned above, this study aims to evaluate the descriptive findings of chest radiography in pediatric patients with COVID-19 treated at the Wahidin Sudirohusodo General Hospital in Makassar, South Sulawesi, Indonesia.
METHODS
This study was conducted at the Radiology Department of Dr. Wahidin Sudirohusodo General Hospital from January 1st 2020, to December 31st 2021. The population included all pediatric patients with positive SARS-CoV-2 RT-PCR results hospitalized at Dr. Wahidin Sudirohusodo General Hospital in Makassar. The inclusion criteria for this study were patients with confirmed COVID-19 based on RT-PCR testing, patients under the age of 17, and the availability of thorax radiography data obtained from the Radiology Department of Dr. Wahidin Sudirohusodo General Hospital. The exclusion criteria of this study were pediatric patients confirmed with COVID-19 by positive RT-PCR SARS-CoV-2 results who had a history of congenital heart disease and pulmonary congenital abnormalities.

This observational study utilized consecutively collected secondary data from medical records during the research period. It aimed to assess chest radiography findings in pediatric patients with COVID-19 infection. Data from patients who met the inclusion criteria and were free from exclusion criteria during the study period were described in a table showing the percentage and distribution of pathological lesions and their locations in the lungs and their distribution in each age group of children who underwent chest radiography examination.

Radiography thorax examination on confirmed COVID-19 patients at Dr. Wahidin Sudirohusodo General Hospital was conducted using computed radiography according to the applicable examination protocol. The radiology residents analyzed the results of the radiography thorax examination to identify any radiological abnormalities, which were confirmed by one radiology specialist as scheduled in the Radiology Department of Dr. Wahidin Sudirohusodo General Hospital. The radiography thorax findings observed in this study were ground-glass opacity (GGO), consolidation, infiltrate spot, bronchial wall thickening, and pleural effusion. Data were analyzed using SPSS version 20.0 for Windows.

RESULTS
From the collected data, a total of 3,911 patients with a diagnosis of COVID-19 were admitted to Dr. Wahidin Sudirohusodo Hospital Makassar. Among these patients, 597 were children (<17 years old). Out of the children diagnosed with COVID-19, 288 patients met the inclusion criteria for this study. The distribution of respondents based on age and gender is presented in Table 1. In this descriptive study, the most common age group was 0-<1 month, with 83 samples (28.82%). It was followed by the age group of 10-<17 years, with 80 samples (27.77%). The age group of 5-<6 years had the least findings, with 10 samples (3.47%). Based on the obtained data, there were 166 male samples (57.64%), which exceeded the number of female samples, which was 122 (42.36%) (Table 1).

Table 2 illustrates the distribution of pathological lesions detected in each age group. For example, among the subjects in the 0-<1 month age group, 46 specimens (55.43%) exhibited anomalies in their chest radiography. The most frequently encountered finding in this age group was consolidation, which was evident in 30 samples (20.41%). On the other hand, in the 1-<5 years age group, infiltrate spots were observed more commonly than consolidation, at a ratio of 12.24% to 8.16%.

In this study, most samples exhibited a diffuse distribution of Ground Glass Opacity (GGO) (80%), while 20% showed peripheral distribution. For instance, Figure 1 displays a case of ground glass opacity (GGO) with diffuse distribution found in both lung fields of a 2-month-old male pediatric patient with COVID-19 infection.

In this study, diffuse consolidation was observed in 56.25% of the samples, while a parahilar distribution was seen in only 21.25% of the cases. Figure 2A illustrates a radiograph of a 15-year-old female patient, displaying radiological evidence of consolidation in the right paracardial region of the lung.

From a pathophysiological perspective, the term “infiltrate” refers to the accumulation of an abnormal substance within the cells or tissues of the body or the presence of any substance or cell type

Table 1. Distribution of Respondent Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Category</th>
<th>Sample (N=288)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0 - &lt;1 month</td>
<td>83</td>
<td>28.82</td>
</tr>
<tr>
<td></td>
<td>1 month - &lt;1 year</td>
<td>31</td>
<td>10.76</td>
</tr>
<tr>
<td></td>
<td>1 - &lt;5 year</td>
<td>55</td>
<td>19.09</td>
</tr>
<tr>
<td></td>
<td>5 - &lt;6 year</td>
<td>10</td>
<td>3.47</td>
</tr>
<tr>
<td></td>
<td>6 - &lt;10 year</td>
<td>29</td>
<td>10.09</td>
</tr>
<tr>
<td></td>
<td>10 - &lt;17 year</td>
<td>80</td>
<td>27.77</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>166</td>
<td>57.64</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>122</td>
<td>42.36</td>
</tr>
</tbody>
</table>

Table 2. Findings of Lesions on Thorax Radiography Based on Age Group

<table>
<thead>
<tr>
<th>Age</th>
<th>Consolidation N (%)</th>
<th>Infiltrate N (%)</th>
<th>GGO N (%)</th>
<th>Pleural Effusion N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-&lt;1 Month</td>
<td>30 (20.41)</td>
<td>20 (13.61)</td>
<td>0 (0.00)</td>
<td>3 (2.04)</td>
</tr>
<tr>
<td>1 month-&lt;1 year</td>
<td>9 (6.12)</td>
<td>11 (7.48)</td>
<td>0 (0.00)</td>
<td>2 (1.36)</td>
</tr>
<tr>
<td>1-&lt;5 year</td>
<td>12 (8.16)</td>
<td>18 (12.24)</td>
<td>1 (0.68)</td>
<td>3 (2.04)</td>
</tr>
<tr>
<td>5-&lt;6 year</td>
<td>3 (2.04)</td>
<td>3 (2.04)</td>
<td>1 (0.68)</td>
<td>1 (0.68)</td>
</tr>
<tr>
<td>6-&lt;10 year</td>
<td>7 (4.76)</td>
<td>7 (4.76)</td>
<td>2 (1.36)</td>
<td>2 (1.36)</td>
</tr>
<tr>
<td>10-&lt;18 year</td>
<td>19 (12.93)</td>
<td>10 (6.80)</td>
<td>1 (0.68)</td>
<td>11 (7.48)</td>
</tr>
</tbody>
</table>
that spreads through the interstices of the lung and is foreign to the lung or present in greater than normal amounts. When combined with more specific anatomical references such as alveolar, airspace, interstitial, or nodular, the term “infiltrate” can provide insights into the underlying pathological basis of radiographic findings. In the thoracic radiography images (Figure 3A and 3B), diffuse infiltrate patches were observed in both lung fields of a 1-year-old and a 1-month-old female child. The study findings revealed diffuse distribution was the most common finding, with 39 samples (56.52%), while parahilar distribution was the least common, observed in only 13 samples (18.84%).

Bronchial wall thickening, or peribronchial cuffing, is a radiological term used to describe the increased opacity or density around the walls of large bronchi or bronchioles visible in an end-on view (Figure 4). This feature can be observed on both thoracic radiography and CT scans. However, it is important to note that not all thoracic radiography samples assessed in this investigation exhibited this imaging feature.

Pleural effusion is characterized by an abnormal accumulation of fluid in the pleural cavity, the space between the lungs and the chest wall. The lack of specificity in this term is primarily due to the limitations of available imaging modalities, particularly chest radiography. In the context of this study, 22 specimens exhibited pleural effusion, indicating the presence of fluid accumulation in the pleural cavity. Figure 5 provides a visual representation of one case, demonstrating the radiographic appearance of pleural effusion.

**DISCUSSION**

Thoracic radiography plays a crucial role in diagnosing COVID-19 patients and monitoring the progression and recovery of the disease. While no significant variations were found among different age groups, certain age cohorts, including children aged 0-<1 year and 10-<17 years, showed a higher incidence. The optimal age range for COVID-19 infection in pediatric patients remains a topic of debate, with some authors suggesting that children between 1.5 months and 7 years old are the most commonly affected. According to extensive epidemiological investigations primarily involving adults, the majority (87%) of cases fell between the ages of 30 and 79. In adults, chest radiography exhibits sensitivity rates ranging from 25% to 69%, while CT scans demonstrate higher sensitivity. Notably, a previous study reported a CT scan sensitivity rate of 86% in detecting COVID-19 infection. Among pediatric patients, radiological presentations appear to be less pronounced, and most literature on children relies on CT scans, with a significant portion indicating normal initial imaging findings.

In this investigation, 51.05% of initial thoracic radiographs displayed abnormalities. The most prevalent anomalies were consolidation (27.77%) and infiltrate patches (23.95%). A previous study also noted consolidation as a major observation (47%) in thoracic radiographs. Furthermore, lung consolidation has been identified as a critical finding in pediatric cases. This investigation observed an initial radiographic presentation of consolidation in 27.77% of thoracic radiographs, with a bilateral and diffuse distribution seen in 15.62% of cases. A previous study also reported that approximately 50% of pediatric cases exhibited consolidation accompanied by a surrounding halo sign, emphasizing the significance of this pattern as a characteristic feature in children. However, the inverted halo sign was not observed in all thoracic radiographs analyzed in this investigation.

Opacification findings near the visceral pleural surface and displaying a multifocal pattern suggest COVID-19. Pediatric thoracic CT scans have demonstrated
Figure 3. (A) The chest radiograph of a 1-year-old female patient revealed diffuse infiltrates with bilateral distribution (green circle). (B) The chest radiograph of a 1-month-old female patient showed diffuse infiltrates with bilateral distribution (yellow circle). Both patients were confirmed to have COVID-19 infection.

Figure 4. (A) The thorax radiography of a 3-year-old boy with a positive confirmation of COVID-19 revealed inhomogeneous consolidation in the right parahilar region (red circle) accompanied by diffusely scattered infiltrates in both lung fields (blue circle). (B) The thorax radiography of a child with COVID-19 infection showed peribronchial thickening (white arrow).

Figure 5. Parenchymal consolidation in the upper and middle fields of the left lung (blue circle), accompanied by a picture of left pleural effusion (red circle), was observed in a 7-year-old male pediatric patient with COVID-19 infection.

typical imaging characteristics, such as unilateral or bilateral subpleural opacities appearing as ground-glass density. These features may be less conspicuous and frequently overlooked in thoracic radiography than in CT examinations. Nevertheless, opacities are still present in conventional radiographs (33%-56%). In this study, opacities were identified in only 1.73% of chest radiographs (CXR) and were predominantly diffuse. The opacities were typically small, round, and irregular in shape. Although a preference for the lower lobes has been reported, this finding is not consistently observed, and the peripheral distribution of opacities may not be as frequent in children compared to adults.

Peribronchial cuffing refers to increased density around the walls of the pulmonary bronchi, which is a non-specific response and can be seen in early infectious and non-infectious diseases. It is also a common finding in other viral pneumonia, such as H1N1 influenza, rhinovirus, respiratory syncytial virus, adenovirus, and other coronaviruses. However, this study did not detect peribronchial cuffing in thorax radiography. Given its low specificity, peripheral pulmonary involvement should not be considered a definitive sign of COVID-19. Nonetheless, this radiological feature is commonly associated with COVID-19 and previously emerging coronaviruses, such as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS).

In this study, pleural effusion was observed in 7.63% of thorax radiographs, consistent with a meta-analysis that reported a prevalence of approximately 4% in children with COVID-19 infection. However, due to its low frequency in various studies, pleural effusion cannot be regarded as a definitive indicator of COVID-19 infection in children.

The current study observed normal findings in 141 patients (48.95%) on thorax radiography. This aligns with previous studies, such as the one conducted by an earlier study, which reported that 48.4% of children with COVID-19 infection exhibited normal findings on thoracic radiography. The limited sensitivity of radiography as a diagnostic tool for
COVID-19 screening may explain this observation. 16-18

In this study, there are still limitations, namely the absence of thoracic radiography data collection in COVID-19 symptomatic patients who tested negative in the PCR examination. As a result, statistical analysis could not be conducted on this modality. It is hoped that future researchers can include such data to assess sensitivity, specificity, and positive and negative predictive values.

CONCLUSION

The present study demonstrates that thoracic radiography reveals abnormal findings in most pediatric patients presenting with clinical symptoms of COVID-19. These findings are non-specific, indicating that thorax radiography cannot be recommended for screening purposes or as a primary diagnostic tool. Nevertheless, it can be considered an adjunct to these patients’ overall management. CT scanning may be reserved for cases with prolonged clinical course or complications but is not routinely employed.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

ETHICS CONSIDERATION

This study does not require ethical approval as it does not alter the clinical pathway, and the data collected are secondary data from the radiology system of Dr. Wahidin Sudirohusodo General Hospital.

FUNDING

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AUTHOR CONTRIBUTION

All authors contribute equally to this study from the conceptual framework, data acquisition, and data analysis until the study results are interpreted through publication.

REFERENCES