Received: 28 November 2020 | Revised: 20 August 2021 | Accepted: 25 August 2021

DOI: 10.1002/ppul.25654

ORIGINAL ARTICLE: COVID 19

WILEY

Clinical and laboratory characteristics of children with SARS-CoV-2 infection

Emel Berksoy MD[1] | Ali Kanik MD[2] | Alper Çiçek MD[1] | Şefika Bardak MD[1] | Pelin Elibol MD[1] | Gülşah Demir MD[1] | Nisel Yilmaz MD[3] | Tuğçe Nalbant MD[1] | Gamze Gökalp MD[1] | Dilek Yilmaz Çiftdoğan MD[4]

[1]Pediatric Emergency Department, İzmir Tepecik Education and Research Hospital, İzmir, Turkey

[2]Department of Pediatrics, Faculty of Medicine, İzmir Katip Çelebi Üniversity, İzmir, Turkey

[3]Department of Microbiology, İzmir Tepecik Education and Research Hospital, İzmir, Turkey

[4]Pediatric Infection Department, Faculty of Medicine, İzmir Katip Çelebi Üniversity, İzmir, Turkey

Correspondence
Emel Berksoy, MD, Pediatric Emergency Department, İzmir Tepecik Education and Research Hospital, Yalı Mah. 6523.sk. 3/12, Karşıyaka, İzmir 35550, Turkey.
Email: emelberksoy@hotmail.com

Abstract

We describe the demographic, clinical, radiological, and laboratory findings of 422 children (0–18 year-of-age) suspected of having severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection admitted to a pediatric emergency department between March 23, and July 23, 2020. We compared the characteristics of SARS-CoV-2-positive patients to SARS-CoV-2-negative patients. SARS-CoV-2 infection was confirmed in 78 (18.4%). Fever (51.2%) and cough (43.5%) were the most commonly reported signs in the SARS-CoV-2-positive patients. Isolated rhinorrhea (7.2%) was reported only in the SARS-CoV-2-negative group ($p = .0014$). Patients with SARS-CoV-2 infection were classified according to severity, with the percentages of asymptomatic, mild, moderate, severe, and critical cases determined to be 29.5%, 56.4%, 12.9%, 1.2%, and 0%, respectively. Of the 422 children, 128 (30.3%) underwent nasopharyngeal polymerase chain reaction testing for other respiratory viral pathogens; 21 (16.4%) were infected with viral pathogens other than SARS-CoV-2. Only one patient (4.7%) with confirmed coronavirus disease 2019 (COVID-19) disease was coinfected with respiratory syncytial virus and rhinovirus. The results indicate lower median white blood cell, neutrophil, and lymphocyte counts, lower lactate dehydrogenase, D-dimer, and procalcitonin levels in the SARS-CoV-2-positive group ($p \leq .001$). Our findings confirm that COVID-19 in children has a mild presentation. In our cohort, no patient with SARS-CoV-2 infection had isolated rhinorrhea.

KEYWORDS
children, clinical features, COVID-19, SARS-CoV-2

1 | INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), affected more than 28 million people worldwide by September 9, 2020.[1]

Although it is constitutively defined in adults, a systematic review conducted by Ludvigsson et al.[2] showed that children have accounted for 1%–5% of confirmed SARS-CoV-2 cases. A multicenter observational cohort study including 69,516 patients of all ages reported that patients aged below 19 years with confirmed SARS-CoV-2 constituted 0.9% of the total cohort.[3] A report on a Chinese cohort

revealed that the majority of children and adolescents infected with SARS-CoV-2 had a milder disease course and a very low fatality rate compared with infected adults. Accordingly, 5% of pediatric cases were severe, and 0.6% of them had critical COVID-19.[4] Since the first pediatric COVID-19 case was identified on January 20, 2020, several studies have described the epidemiological and clinical features of COVID-19 in pediatric patients.[3,5] Differential diagnosis of COVID-19 can be challenging because its signs and symptoms (e.g., fever, cough, and rhinitis) are similar to those caused by other respiratory pathogens (RPs), which represent a common reason of admission to emergency rooms.[5–9] Moreover, as the pandemic continues, the number of children infected by SARS-CoV-2 is increasing gradually.

In this study, we aimed to determine the demographic, clinical, and laboratory characteristics of children suspected of having SARS-CoV-2 infection admitted to the pediatric emergency room during the first 4 months of the pandemic in İzmir, the third-largest city in Western Turkey. We also aimed to evaluate coinfections with other community-acquired respiratory tract pathogens.

2 | MATERIALS AND METHODS

2.1 | Study population and case definitions

From March 23, to July 23, 2020, we conducted a cross-sectional study of the epidemiological, clinical, and laboratory characteristics of 422 children (aged 0–18 years) with suspected SARS-CoV-2 infection admitted to the Pediatric Emergency Department of Tepecik Teaching Hospital, University of Health Sciences, İzmir, Turkey.

We followed the periodic updates of case definitions in the national guidelines of the Ministry of Health, Turkey. In accordance with the guidelines, we assessed suspected cases based on epidemiological characteristics (household exposure or a history of contact with an individual who tested positive for SARS-CoV-2 infection) or respiratory system findings such as tachypnea, acute cough, or oxygen saturation measured by pulse oximetry less than 92% in room air or history of fever (body temperature ≥ 38°C). A quantitative real-time reverse transcriptase-polymerase chain reaction (qRT-PCR) test was requested in asymptomatic patients when at least two members of the same household were diagnosed with COVID-19, and in infants less than 9 months of age with a mother diagnosed with COVID-19, in accordance with the national guidelines. However, national guidelines for the evaluation of contact risk were not available at the time of the study, so we performed the nasopharyngeal PCR test for SARS-CoV-2 in asymptomatic patients with a contact history over the previous 14 days, regardless of the day of contact.

The clinical status of patients with SARS-CoV-2 infection, was classified based on the clinical characteristics, and radiologic imaging results, defined by Dong et al.[4] as follows: (a) asymptomatic infection (absence of clinical and radiologic signs and symptoms), (b) mild disease (upper respiratory tract infection: runny nose, fever, malaise, sneezing, cough, nausea, vomiting, and diarrhea but without clinical or radiological pneumonia), (c) moderate disease (clinical pneumonia without obvious hypoxemia or the presence of lung lesions on chest imaging without signs or symptoms of respiratory tract infection), (d) severe disease (progressive respiratory disease, dyspnea, and central cyanosis), and (e) critical disease (respiratory failure requiring mechanical ventilation, acute respiratory distress syndrome [ARDS], dyspnea with an oxygen saturation less than 92%, septic shock, or multiple organ failure).

The study population was divided into SARS-CoV-2-positive and SARS-CoV-2-negative groups based on the result of the PCR test.

2.2 | Procedures and data sources

The diagnosis of COVID-19 was routinely based on the identification of SARS-CoV-2 RNA in respiratory secretions (such as on nasal and pharyngeal swabs) by qRT-PCR assay (Bio-Speedy; Bioeksen). Patients were also tested for other RPs to detect concomitant infections. Influenza virus types A and B, respiratory syncytial virus type A/B, parainfluenza virus types 1–4, coronaviruses (229E, NL63, and OC43), metapneumovirus, rhinovirus, enterovirus, adenovirus, parechovirus, and bocavirus were detected by multiplex PCR tests (Respiratory Pathogens Panel Kit v. 4; Anatolia GeneWorks) of nasopharyngeal swab samples from children. During the study period, PCR tests to search for RPs were temporarily suspended to alleviate the laboratory workload. For this reason, we preserved the swab samples at −80°C for 2 months for future analysis.

A complete blood count (CBC) and C-reactive protein (CRP) levels were obtained for all symptomatic patients in accordance with the national guidelines. Additional laboratory tests such as serum electrolytes, procalcitonin, alanine aminotranferase, aspartate aminotranferase, creatine phosphokinase (CPK), creatinine, and coagulation parameters (including D-dimer and fibrinogen) were performed in patients who required hospitalization.[10]

As the first-line screening modality, due to the long qRT-PCR turnaround time, chest X-ray (CXR) was performed for each symptomatic patient suspected of having COVID-19 disease. In accordance with the national guidelines, chest computed tomography (CT) was performed when CXR did not explain respiratory findings, and in cases showing clinical deterioration or the presence of infiltration on CXR. Chest CT without contrast agent was performed using a Siemens Go Up with a 1-mm slice thickness and 1-mm increments. If the CXR was normal, chest CT was performed with a 2-mm slice thickness to reduce the examination time and thus the irradiation dose.

Demographic, clinical, laboratory, radiologic features, the SARS-CoV-2 PCR test results, the presence of other RPs detected with the nasopharyngeal swab, pre-existing comorbidities, and disposition were recorded using a standardized case report form.

2.3 | Statistical analysis

Means, standard deviations, medians, interquartile ranges (IQRs), and percentiles were calculated for discrete and continuous

TABLE 1 Demographic and clinical characteristics of children with SARS-CoV-2-negative and SARS-CoV-2-positive cohorts

Characteristics	SARS-CoV-2 (−) *n* = 344	SARS-CoV-2 (+) *n* = 78	All cases *n* = 422	*p* Value
Age (mo), median (IQR)	51.9 (117.3)	132.6 (136.1)	61.8 (133.0)	**<.001**
Age groups (years), *n* (%)				
<1	77 (22.4)	9 (11.5)	86 (20.4)	**<.001**
1–6	124 (36.0)	18 (23.1)	142 (33.6)	
6–12	66 (19.2)	16 (20.5)	82 (19.5)	
>12	77 (22.4)	35 (44.9)	112 (26.5)	
Gender, *n* (%)				
Girl	146 (42.4)	33 (42.3)	179 (42.4)	.543
Boy	198 (57.6)	45 (57.7)	243 (57.6)	
COVID-19 contact history *n* (%)				
Positive	88 (25.5)	61 (78.2)	149 (35.3)	**<.001**
Negative	256 (74.5)	17 (21.8)	273 (64.7)	
Presence of comorbidity (+/−), *n*	57/287	3/75	60/362	.004
Symptoms (+/−), *n*				
Fever	218/126	40/38	258/164	**.048**
Cough	235/109	34/44	269/153	**<.001**
Sore throat	36/308	7/71	43/379	.694
Rhinorrhea	25/319	0/78	25/397	**.014**
Diarrhea	27/316	5/73	32/389	.810
Nausea-vomiting	29/315	5/73	34/388	.554
Others (headache, myalgia, weakness, etc.)	59/285	17/61	76/346	.335
Tachypnea	151/189	16/62	167/251	**<.001**
Signs at admission, mean (SD)				
Fever (°C)[a]	37.28 (1.02)	36.87 (0.63)	37.20 (0.97)	**<.001**
Pulse (per minute)	129.32 (26.71)	113.97 (22.70)	127.52 (26.70)	**.001**
Tachypnea[b]	151/189	16/62	167/251	**<.001**
Respiratory support, *n* (%)				
None	284 (82.6)	71 (91.0)	355	.251
Oxygen mask	40 (11.6)	6 (7.7)	46	
CPAP	18 (5.2)	1 (1.3)	19	
Entubation	2 (0.6)	0 (0.0)	2	
Chest X-ray				
Normal/abnormal	213/94	65/8	278/102	**.001**
CT findings, *n*				
Normal/abnormal	60/61	21/9	81/70	.077
Compatible with COVID	3	2	5	
Disposition, *n* (%)				
Follow-up at home	242 (70.3)	55 (70.5)	297 (70.4)	.440

TABLE 1 (Continued)

Characteristics	SARS-CoV-2 (−) *n* = 344	SARS-CoV-2 (+) *n* = 78	All cases *n* = 422	*p* Value
Admission to inpatient ward	91 (26.4)	23 (29.5)	114 (27.0)	
Admission to PICU	10 (2.9)	0 (0.0)	10 (2.4)	
Exitus	1 (0.3)	0 (0.0)	1 (0.2)	

Note: Bold values are statistically significant.

Abbreviations: ARDS, acute respiratory distress syndrome; COVID-19, coronavirus disease 2019; CPAP, continuous positive airway pressure; CT, computed tomography; IQR, interquartile range; PICU, pediatric intensive care unit; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

[a]Fever was defined as a body temperature above 38°C (axilla).

[b]Tachypnea was defined as a respiration rate/minute greater than normal for age.

variables. The homogeneity of the variances, a prerequisite of parametric tests, was checked by the Levene test. The assumption of normality was tested by the Shapiro–Wilk test. The Student's *t* test was used to compare two groups when the parametric test prerequisites were fulfilled; the Mann–Whitney *U* test was used otherwise. A χ^2 test was used to determine the relationships between two discrete variables. The data were analyzed using SPPS software (v. 25.0; IBM Corp). A *p* value of less than .05 was considered indicative of statistical significance.

2.4 | Ethics

This study was approved by the Ministry of Health, Turkey, and the Ethics Committee of the Tepecik Education and Training Hospital (2020/7-10). Written informed parental/patient consent was obtained from each patient before enrollment in the study.

3 | RESULTS

3.1 | Demographic and epidemiological characteristics

In total, 422 children (243 boys [57.6%] and 179 girls [42.4%]; $p = .543$) were recruited and 78 (18.4%) were identified as SARS-CoV-2-positive patients. The median age of the SARS-CoV-2-positive group was 132.6 months (IQR: 136.1), and the median age of the SARS-CoV-2-negative group was 51.9 months (IQR: 117.3; $p < .001$). The percentages of SARS-CoV-2-positive and -negative patients according to age distribution are presented in Table 1. Regarding exposure history, 61 (78.2%) patients with SARS-CoV-2 infection were household contacts of adults; 23 (29.5%) of these were asymptomatic based on a screening test for household contacts. Eighty-eight (25.5%) SARS-CoV-2-negative cases had a history of contact with a SARS-CoV-2-positive adult at home. Among the SARS-CoV-2-positive patients, 17 (21.8%) had been exposed to SARS-CoV-2 via an unknown source (Table 1).

3.2 | Clinical characteristics and outcome

Fever (40/78, 51.2%) and cough (34/78, 43.5%) were the most common signs in SARS-CoV-2-positive patients. Less common signs and symptoms included myalgia/weakness (17/78, 21.7%), headache (17/78, 21.7%), sore throat (7/78, 8.9%), nausea/vomiting (5/78, 6.4%), and diarrhea (5/78, 6.4%). Rhinorrhea (25/344, 7.2%) was seen only in the SARS-CoV-2-negative group ($p = .0014$; Table 1). The physical signs, supporting management, and disposition data of all patients are shown in Table 1. Asymptomatic and mild cases accounted for 23 (29.5%) and 44 (56.4%) patients, respectively, representing 85.9% of all SARS-CoV-2-positive cases. The proportions of moderate and severe cases were 12.9% and 1.2% for the SARS-CoV-2-positive group. In the SARS-CoV-2-negative cohort, 101 patients (29.3%) were admitted to hospital wards, with nearly one-tenth ($n = 10$, 2.9%) requiring a pediatric intensive care unit and two requiring invasive mechanical ventilation due to ARDS. No critical cases were reported in SARS-CoV-2-positive group. The frequencies of pneumonia in the SARS-CoV-2-positive patients were 44.4%, 5.5%, 18.7%, and 8.5% in the ≤1, 2–6, 7–12, and ≥12 years age groups, respectively. All patients with pneumonia in the SARS-CoV-2-positive cohort had both clinically and radiologically identified pneumonia.

Only three patients with confirmed COVID-19 had a pre-existing comorbidity. One of these patients had been followed up by the pediatric neurology clinic due to developmental delay and epilepsy. This patient had mild COVID-19, and his household contact history was positive. The second patient, who had asthma, also had mild COVID-19 and a positive contact in the family. These two patients were discharged from the emergency room and followed up at home. The third patient, who had been investigated and followed up due to neurometabolic disease and a possible genetic disorder, was the patient exposed to SARS-CoV-2 via an unknown source. The latter was admitted to the inpatient ward for moderate COVID-19. All three patients recovered.

3.3 | Radiological findings

Of the SARS-CoV-2-positive cases, 65 (89%) had normal CXR findings on admission. Chest CT was performed in 26 (40%) of those

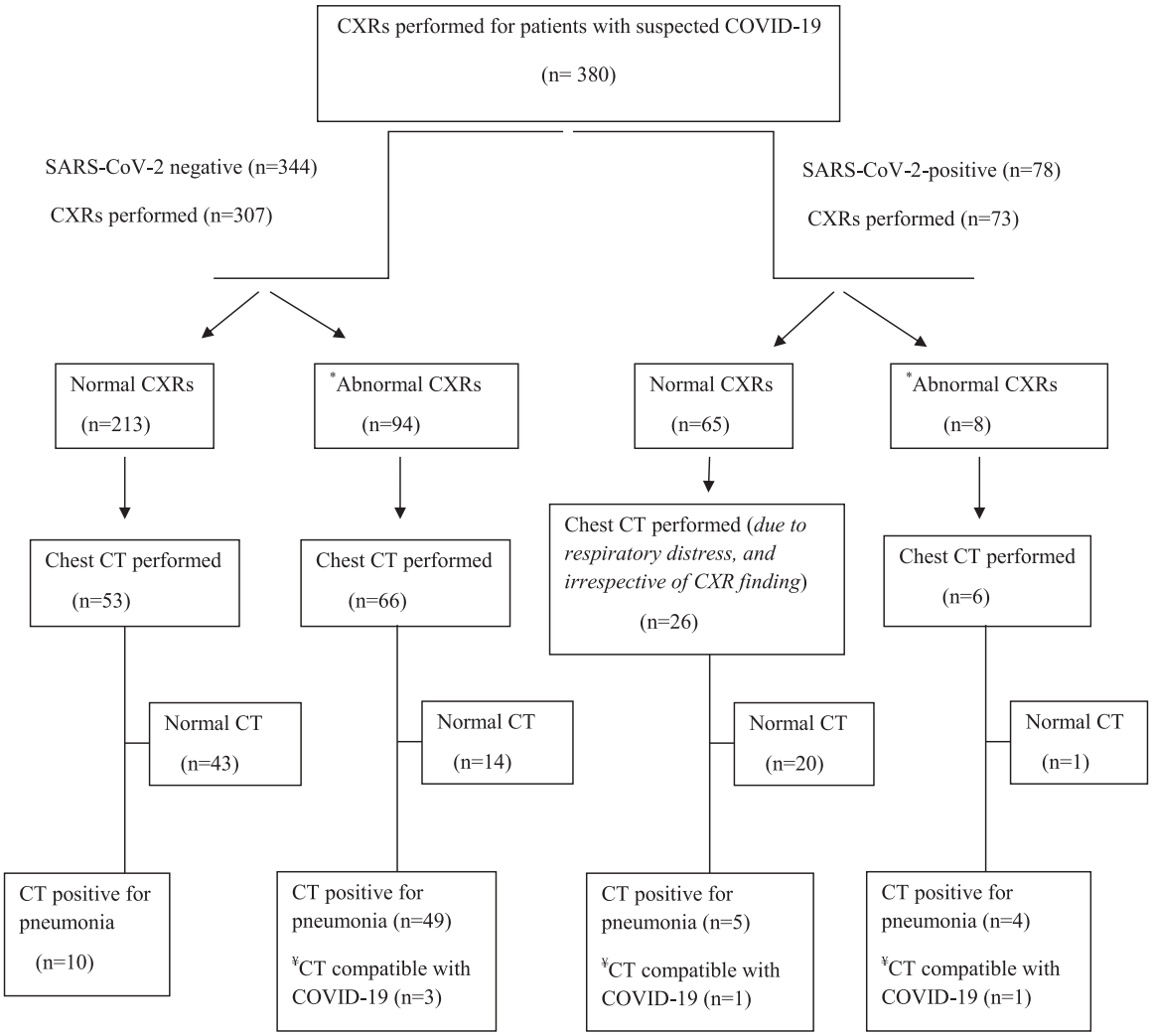

FIGURE 1 Flow chart showing imaging findings. *Abnormal CXRs was defined as any patchy consolidation, presence of air-bronchogram, atelectasis, pleural fluid, flatting of ribs, and any presentation on CXR except normal finding. ¥Chest CT compatible with COVID-19 was defined by the pediatric radiologist as CT features of subpleural lesions with localized infiltration, consolidation with surrounding halo sign, ground-glass opacity, unilateral or bilateral peripheric pulmonary lesions, and air-bronchogram sign. Chest CT, computed tomography of the chest; COVID-19, coronavirus disease 2019; CXR, chest X-ray; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2

patients, who had respiratory distress; in turn, 20 (76.9%) of those patients had normal findings, 6 (23.1%) with abnormal findings and one of these had radiological findings reported as compatible with COVID-19. In total, 8 (10.9%) of the 73 SARS-CoV-2-positive patients who underwent CXR had bilateral patchy infiltration. Chest CT was performed in six of these patients due to clinical deterioration and the necessity for isolation and hospitalization while awaiting the PCR results. Five of these scans were abnormal, with one being reported to be compatible with COVID-19 (Figure 1).

3.4 | Laboratory findings

Of the 422 children, 128 (30.3%) underwent nasopharyngeal PCR testing for RPs, 22 (17.1%) of whom were patients with SARS-CoV-2 infection. In total, 21 (16.4%) of 128 patients were infected with other RPs: seven with rhinovirus, five with metapneumovirus, three with adenovirus, two with bocavirus, two with RSV, and two with both RSV and rhinovirus. In comparison, 1 patient (4.7%) among the 22 with confirmed COVID-19 had coinfection with RSV and rhinovirus; this patient was 5 months of age and had a mild disease course without pneumonia. The median values of the laboratory parameters are shown in Table 2.

4 | DISCUSSION

Studies of pediatric patients with COVID-19 have increased during the pandemic.[5,9,11] Clarifying the clinical, laboratory, and radiographic characteristics of pediatric patients is important for differential diagnosis of SARS-CoV-2 infection from other viral respiratory infections, particularly in busy emergency departments. We report that some clinical and laboratory characteristics differed between SARS-

TABLE 2 Laboratory findings of children with SARS-CoV-2-negative and SARS-CoV-2-positive cohorts

Variable	SARS-CoV-2 negative	SARS-CoV-2 positive	*p* Value*
CBC parameters, median (IQR)			
WBC (×10^3/mm)	10.62 (6.65)	5.70 (2.60)	**<.001**
Neutrophil count (×10^3/ul)	5.40 (4.95)	3.00 (2.30)	**<.001**
Lymphocyte count (×10^3/ul)	3.10 (2.75)	2.10 (1.50)	**<.001**
NLR	1.78 (2.38)	1.42 (1.46)	.460
Platelet count (×10^3/μl)	315 (130)	244 (86)	**<.001**
PLR	98.07 (62.88)	114.09 (103.38)	**<.001**
Other parameters, median (IQR)			
CRP (mg/L)	6.80 (23.6)	2.20 (5.7)	**.001**
PCT (μg/L)	0.07 (0.15)	0.03 (0.06)	**<.001**
CPK (U/L)	118 (82)	82 (45)	**<.001**
LDH (U/L)	326 (154)	222 (135)	**<.001**
Troponin (ng/L)	2.50 (0.86)	2.55 (0.00)	.082
D-dimer (μg/L)	490 (575)	340 (310)	**<.001**
Fibrinogen (mg/dl)	280 (122)	245 (41)	**.014**

Note: Bold values are statistically significant.

Abbreviations: CBC, complete blood count; CPK, creatine (phospho) kinase; CRP, C-reactive protein; IQR, interquartile range; LDH, lactate dehydrogenase; NLR, neutrophil-to-lymphocyte ratio; PCT, procalcitonin; PLR, platelet-to-lymphocyte ratio; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; WBC, white blood cell.

*Mann–Whitney *U* test.

CoV-2-negative and SARS-CoV-2-positive pediatric patients. The first COVID-19 case reported in Turkey was on March 13, 2020. During the early months of the pandemic, we evaluated pediatric patients with suspected SARS-CoV-2 infection in the pediatric emergency room.

Among children with suspected SARS-CoV-2 infection, 18.4% were confirmed to have SARS-CoV-2 by a PCR test. This high rate was due to children with a history of contact with SARS-CoV-2 carriers being evaluated to confirm the diagnosis. Although the definition of suspected SARS-CoV-2 infection has changed during the outbreak, children are typically infected by a parent or adult family member who is either sick or an asymptomatic carrier. Of the 78 SARS-CoV-2-positive patients in this study, 78.2% had an adult household contact, similar to prior reports.[12–14] However, the route of transmission was not identified for 21.8% of the cases. We could not evaluate other transmission routes because schools were closed during the study period, and none of the children had a history of hospitalization or foreign travel. Lu et al.[14] reported that the median age of 171 pediatric patients was 6.7 years (1 day–15 years). Wu et al.[15] reported that the median age of infected children was 6 years, and almost half were aged 3–10 years. Dong et al.[4] reported that the median age of SARS-CoV-2-negative and -positive patients was 7 years. In this study, the median age of infected children was 11 years (1 day–18 years), comparable to that of the 2572 pediatric confirmed cases in the United States. Nearly half of the confirmed cases were aged above 12 years, possibly because adolescents are more active and spend more time outside the home. The proportion of boys was slightly higher than that of girls, in agreement with previous epidemiological studies.[4,14,15]

In children, COVID-19 has a favorable clinical course and is typically mild. In this study, more than half of the confirmed cases were mild, and one-third were asymptomatic and admitted to the emergency room after a family member had been diagnosed with COVID-19. More than half of the patients with a history of contact were SARS-CoV-2-negative by PCR. We did not test those who tested negative at first screening multiple times, even if they were admitted. Therefore, this may be an underestimation, as swab sampling was performed soon after exposure and may have missed some patients who subsequently became SARS-CoV-2-positive. Almost half of the clinical COVID-19 pneumonia cases were infants. Another issue to consider is coinfection with RPs; the coinfection rates in this study were lower than in previous reports.[15–17] This may have been because the samples were stored at −80°C and examined later, or because the incidence of other viral agents was low during the study period.

Although the percentages of fever and cough were higher in all of the groups, more patients in the SARS-CoV-2-negative group had fever and cough compared to the confirmed cases. Moreover, pneumonia and severe illness were more frequent among the PCR-negative patients. This hampers the differential diagnosis of COVID-19 in practice. The most important finding in terms of symptomatology was the absence of rhinorrhea in the SARS-CoV-2-positive group. This is not in agreement with the results of Lu et al.,[14] who reported nasal signs including rhinorrhea in 171 children with COVID-19. Larger studies are needed to clarify this important issue.

Wu et al.[15] reported that 12.6% of 37 cases showed ground-glass opacity on chest CT, whereas in our study 28 cases showed nonspecific changes suggestive of pneumonia. The low rate of ground-glass opacity on CT may have been because only 11 of the 78 infected patients had pneumonia. We performed radiographic examinations at admission to the emergency room. During the early stages of the disease, CXR findings may be normal.[18] Although remarkable radiologic features of infected children have been reported previously, the role of chest CT in the diagnosis and management of children with COVID-19 needs to be reconsidered because the risk associated with radiation exposure is of great concern. Based on our results, CXR and chest CT are not recommended as screening tools for diagnosing COVID-19 in children, as the majority of pediatric patients have mild disease.

The laboratory findings of the SARS-CoV-2-positive cases differed from those of the SARS-CoV-2-negative cases. The white blood cell (WBC), neutrophil, lymphocyte, and platelet counts were significantly lower in the positive cases than in the negative cases. Some viral respiratory infections can cause leucopenia, lymphopenia, and thrombocytopenia.[19] Lymphocyte counts have been used to distinguish between patients with

COVID-19 and other respiratory diseases and to evaluate clinical severity in adult patients.[20,21] Leukopenia and an increased serum CRP level have been reported in adult patients with COVID-19.[22–24] Previous reports have indicated considerable variance in WBC counts in children.[11,25–29] Similarly conflicting results are extant for lymphocyte and platelet counts.[29,30] Lactate dehydrogenase (LDH) and CRP levels are high and positively correlated with COVID-19 severity in adult patients.[31,32] Similarly, elevations of CPK and D-dimer levels have been reported in severe pediatric cases.[33] We found significant differences in all CBC parameters (WBC, neutrophil, lymphocyte, and platelet counts), acute-phase reactants, LDH, and CPK. Nevertheless, the median laboratory values of the SARS-CoV-2-positive patients were in the normal ranges.

5 | LIMITATIONS

There were several limitations to this study. First, the clinical and laboratory findings could not be compared between pneumonia cases in the SARS-CoV-2-negative and -positive cohorts because of the low rate of pneumonia in the SARS-CoV-2-positive cohort. Second, we could not perform PCR for other RPs in all patients and this may have underestimated the number of RPs infection in our population. Third, we obtained samples from asymptomatic patients at the time of admission regardless of the contact date. However, our findings are based on a reliable PCR test of SARS-CoV-2 and other RPs, and this is one of the few studies to report concomitant infections in these cases during the COVID-19 pandemic.

6 | CONCLUSION

Briefly, our findings confirm that COVID-19 in children has a mild presentation. The absence of isolated rhinorrhea in children with SARS-CoV-2 infection was the most important finding of this study. Further epidemiological studies with higher numbers of patients are needed to verify these data in the future.

ACKNOWLEDGMENT

The authors thank all healthcare professionals for their efforts in the diagnosis and treatment of patients.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

Emel Berksoy, Şefika Bardak, Alper Çiçek: conceptualization (lead); data curation (lead); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (lead); project administration (lead); resources (equal); supervision (lead); validation (equal); visualization (equal); writing original draft (lead); writing review & editing (lead). **Alper Çiçek, Ali Kanik**: conceptualization (equal); data curation (lead); formal analysis (equal); funding acquisition (equal); investigation (supporting); methodology (equal); project administration (equal); supervision (supporting); validation (supporting); visualization (equal); writing original draft (supporting); writing review & editing (equal).

ORCID

Emel Berksoy https://orcid.org/0000-0002-6831-1353
Ali Kanik https://orcid.org/0000-0003-3304-0992
Alper Çiçek https://orcid.org/0000-0001-5017-4525
Şefika Bardak https://orcid.org/0000-0003-1211-6943
Pelin Elibol https://orcid.org/0000-0002-2195-7421
Gülşah Demir https://orcid.org/0000-0001-7841-4682
Nisel Yilmaz https://orcid.org/0000-0001-7435-2461
Tuğçe Nalbant https://orcid.org/0000-0002-7408-2382
Gamze Gökalp https://orcid.org/0000-0001-9467-3617
Dilek Yilmaz Çiftdoğan https://orcid.org/0000-0002-1065-9066

REFERENCES

1. World Health Organization. Weekly Operational Update on COVID-19 September 27. World Health Organization (WHO). 2020. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports- September-2021
2. Ludvigsson JF. Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. *Acta Paediatr*. 2020;109(6):1088-1095.
3. Swann OV, Holden KA, Turtle L, et al. Clinical characteristics of children and young people admitted to hospital with COVID-19 in the United Kingdom: prospective multicentre observational cohort study. *BMJ*. 2020;370:m3249.
4. Dong Y, Mo X, Hu Y, et al. Epidemiology of COVID-19 among children in China. *Pediatrics*. 2020;145(6):e20200702.
5. Parri N, Lenge M, Cantoni B, et al. COVID-19 in 17 Italian pediatric emergency departments. *Pediatrics*. 2020;146(6):e20201235.
6. Wee LE, Ko KKK, Ho WQ, Kwek GTC, Tan TT, Wijaya L. Community-acquired viral respiratory infections amongst hospitalized inpatients during a COVID-19 outbreak in Singapore: co-infection and clinical outcomes. *J Clin Virol*. 2020;128:104436.
7. Kim D, Quinn J, Pinsky B, Shah NH, Brown I. Rates of co-infection between SARS-CoV-2 and other respiratory pathogens. *JAMA*. 2020;323(20):2085-2086.
8. Alpern ER, Stanley RM, Gorelick MH, et al. Epidemiology of a pediatric emergency medicine research network: the PECARN core data project. *Pediatr Emerg Care*. 2006;22(10):689-699.
9. Parri N, Magistà AM, Marchetti F, et al. Characteristic of COVID-19 infection in pediatric patients: early findings from two Italian pediatric research networks. *Eur J Pediatr*. 2020;179(8):1315-1323.
10. Chavez S, Long B, Koyfman A, Liang SY. Coronavirus disease (COVID-19): a primer for emergency physicians. *Am J Emerg Med*. 2020;S0735–6757(20):30178-30179.
11. Xia W, Shao J, Guo Y, Peng X, Li Z, Hu D. Clinical and CT features in pediatric patients with COVID-19 infection: different points from adults. *Pediatr Pulmonol*. 2020;55(5):1169-1174.
12. Cura Yayla BC, Ozsurekci Y, Aykac K, et al. Characteristics and management of children with COVID-19 in Turkey. *Balkan Med J*. 2020;37(6):341-347.
13. Choi SH, Kim HW, Kang JM, Kim DH, Cho EY. Epidemiology and clinical features of coronavirus disease 2019 in children. *Clin Exp Pediatr*. 2020;63(4):125-132.

14. Lu X, Zhang L, Du H, et al. SARS-CoV-2 infection in children. *N Engl J Med*. 2020;382(17):1663-1665.
15. Wu Q, Xing Y, Shi L, et al. Coinfection and other clinical characteristics of COVID-19 in children. *Pediatrics*. 2020;146(1): e20200961.
16. Xing Q, Li G, Xing Y, et al. Precautions are needed for COVID-19 patients with coinfection of common respiratory pathogens. *MedRxiv*. 2020. https://doi.org/10.1101/2020.02.29.20027698
17. Ai J-W, Zhang H-C, Xu T, et al. Optimizing diagnostic strategy for novel coronavirus pneumonia, a multi-center study in Eastern China. *MedRxiv*. 2020. https://doi.org/10.1101/2020.02.13.20022673
18. Shen KL, Yang YH, Jiang RM, et al. Updated diagnosis, treatment and prevention of COVID-19 in children: experts' consensus statement (condensed version of the second edition). *World J Pediatr*. 2020;16(3): 232-239.
19. Pascutti MF, Erkelens MN, Nolte MA. Impact of viral infections on hematopoiesis: from beneficial to detrimental effects on bone marrow output. *Front Immunol*. 2016;7:364.
20. Wang T, Du Z, Zhu F, et al. Comorbidities and multi-organ injuries in the treatment of COVID-19. *Lancet*. 2020;395(10228):e52.
21. Ruan Q, Yang K, Wang W, Jiang L, Song J. Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. *Intensive Care Med*. 2020;46(5):846-848.
22. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020; 395(10223):497-506.
23. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet*. 2020;395(10223):507-513.
24. Guan WJ, Ni ZY, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med*. 2020;382(18):1708-1720.
25. Wang D, Ju XL, Xie F, et al. Clinical analysis of 31 cases of 2019 novel coronavirus infection in children from six provinces (autonomous region) of northern China. Zhonghua er ke za zhi = Chinese. *J Pediatr*. 2020;58(4):269-274.
26. Feng K, Yun YX, Wang XF, et al. Analysis of CT features of 15 children with 2019 novel coronavirus infection. Zhonghua er ke za zhi = Chinese. *J Pediatr*. 2020;58(0):E007.
27. Li Y, Guo FF, Cao Y, Li LF, Guo YJ. Insight into COVID-2019 for pediatricians. *Pediatr Pulmonol*. 2020;55(5):E1-E4.
28. Park JY, Han MS, Park KU, Kim JY, Choi EH. First pediatric case of coronavirus disease 2019 in Korea. *J Korean Med Sci*. 2020; 35(11):e124.
29. Zheng F, Liao C, Fan QH, et al. Clinical characteristics of children with coronavirus disease 2019 in Hubei, China. *Curr Med Sci*. 2020; 40(2):275-280.
30. Zhang T, Cui X, Zhao X, et al. Detectable SARS-CoV-2 viral RNA in feces of three children during recovery period of COVID-19 pneumonia. *J Med Virol*. 2020;92(7):909-914.
31. Zhang JJY, Lee KS, Ang LW, Leo YS, Young BE. Risk factors for severe disease and efficacy of treatment in patients infected with covid-19: a systematic review, meta-analysis, and meta-regression analysis. *Clin Infect Dis*. 2020;71(16): 2199-2206.
32. Chen W, Zheng KI, Liu S, et al.Plasma CRP level is positively associated with the severity of COVID-19. *Ann Clin Microbiol Antimicrob*. 2020; 19(1):18.
33. Chen ZM, Fu JF, Shu Q, et al. Diagnosis and treatment recommendations for pediatric respiratory infection caused by the 2019 novel coronavirus. *World J Pediatr*. 2020;16(3): 240-246.

How to cite this article: Berksoy E, Kanik A, Çiçek A, et al. Clinical and laboratory characteristics of children with SARS-CoV-2 infection. *Pediatric Pulmonology*. 2021;56: 3674-3681. https://doi.org/10.1002/ppul.25654