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Sourabh Verma, MD, Rishi Lumba, MD, Heda M. Dapul, MD, Gabrielle Gold-von Simson, MD, MS, Colin K. Phoon, MD, M. Phil, Jennifer L. Lighter, MD, Jonathan S. Farkas, MD, Alexandra Vinci, MD, Asif Noor, MD, Vanessa N. Raabe, MD, David Rhee, MD, MS, Mona Rigaud, MD, Pradeep V. Mally, MD, Tara M. Randis, MD, MS, Benard Dreyer, MD, Adam J. Ratner, MD, MPH, Catherine S. Manno, MD, Arun Chopra, MD

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Characteristics of Hospitalized Children With SARS-CoV-2 in the New York City Metropolitan Area

Sourabh Verma, MD[1,5], Rishi Lumba, MD[1], Heda M. Dapul, MD[1,5], Gabrielle Gold-von Simson, MD, MS[1], Colin K. Phoon, MD, M. Phil[1,5], Jennifer L. Lighter, MD[1,5], Jonathan S. Farkas, MD[1,5], Alexandra Vinci, MD[2], Asif Noor, MD[2], Vanessa N. Raabe, MD[1,5,6], David Rhee, MD, MS[1], Mona Rigaud, MD[1], Pradeep V. Mally, MD[1,5], Tara M. Randis, MD, MS[4], Benard Dreyer, MD[1,5], Adam J. Ratner, MD, MPH[1,3,5], Catherine S. Manno, MD[1], Arun Chopra, MD[1,5]

[1] Department of Pediatrics, New York University Grossman School of Medicine, New York, NY, USA
[2] Department of Pediatrics, New York University Long Island School of Medicine, New York, NY, USA
[3] Department of Microbiology, New York University Grossman School of Medicine, New York, NY, USA
[4] Departments of Pediatrics and Molecular Medicine, University of South Florida, Tampa, FL, USA
[5] Department of Pediatrics, Bellevue Hospital Center, New York, NY, USA
[6] Department of Medicine, NYU Langone Vaccine Center, New York, NY, USA

Corresponding author:
Sourabh Verma, MD, FAAP
Assistant Professor of Pediatrics, Department of Pediatrics
New York University Grossman School of Medicine
317, East 34th Street, Suite 902, New York, NY 10016 (USA)
Tel.: 212-263-7286; Fax: 212-263-7950; E-mail: sourabh.verma@nyulangone.org

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Dr. Verma, Dr. Lumba, Dr. Dapul, Dr. Vinci and Dr. Noor conceptualized and designed the study; did acquisition of data, helped in analysis and interpretation of data; drafted the initial manuscript; critically reviewed and revised the manuscript.

Dr. Chopra, Dr. Ratner, Dr. Gold-von Simson, Dr. Phoon, Dr. Lighter, Dr. Raabe and Dr. Mally conceptualized and designed the study; helped in analysis and interpretation of data; critically reviewed and revised the manuscript.

Dr. Farkas and Dr. Rhee provided substantial contribution to acquisition of data, critically reviewed and revised the manuscript.

Dr. Dreyer, Dr. Manno, Dr. Rigaud and Dr. Randis provided substantial contribution to analysis and interpretation of data, critically reviewed and revised the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Abstract

Objective: To describe the characteristics of hospitalized children with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in New York City metropolitan area.

Patients and Methods: This was a multicenter, retrospective cohort study at four hospitals comprising 82 hospitalized children (0-21 years) who tested positive for SARS-CoV-2 after symptoms and risk screening between March 1 and May 10, 2020. We subdivided patients based on their admission to acute or critical care units and by age groups. Further sub-analyses were performed between patients requiring respiratory support or no respiratory support.

Results: Twenty-three (28%) patients required critical care. Twenty-nine (35%) patients requiring respiratory support with 9% needing mechanical ventilation and one required extracorporeal support. All patients survived to discharge. Children with any comorbidity were more likely to require critical care (70% vs. 37%, P=0.008), with obesity as the most common risk factor for critical care (63% vs. 28%, P=0.02). Children with asthma were more likely to receive respiratory support (28% vs. 8%, P=0.02), with no difference in need for critical care (P=0.26). Children admitted to critical care had higher rates of renal dysfunction at presentation (43% vs. 10%, P=0.002).

Conclusion: Children with comorbidities (obesity and asthma in particular) were at increased risk for critical care admission and/or need for respiratory support. Children with renal dysfunction at presentation were more likely to require critical care.

Background

The Coronavirus Disease 2019 (COVID-19) pandemic has spread to more than 210 countries, with the highest number of infections and deaths reported in the United States (US). Although the number of new infections and deaths are declining in prior US hotspots, many other states are now reporting a concerning upsurge in the number of new infections[1,2]. Children have had a relatively low rate of symptomatic infections and a less serious course of infection, as reported to date[3,4]. There is a recently described entity called Multisystem Inflammatory Syndrome in Children (MIS-C)[5-9], which is associated with recent infection or exposure to SARS-CoV-2, suggesting that children may also suffer from distinctive consequences of this infection.

There is still a paucity of published data among hospitalized children with SARS-CoV-2. The early-published reports originating from China[3] describing the clinical spectrum of this infection in children have different results and risk factors from recent small case series from the US[10-15]. In addition, the final clinical outcome for many patients (up to one-third) had not yet been determined at the time of publication from majority of smaller case series from the US. To this end, we studied the clinical characteristics, laboratory findings, and short-term outcomes among pediatric and adolescent inpatients testing positive for SARS-CoV-2 through hospital discharge.

Methods

This was a multicenter, retrospective cohort study including patients aged 0-21 years who were admitted to any of the pediatric acute or critical care units during hospitalization at a large healthcare system and its academic affiliate, between March 1 and May 10, 2020. All patients were followed until discharge or end of the study period (June 10, 2020). The patients were admitted to acute or critical care units based on individual unit admission guidelines at clinical teams' discretion. The diagnosis of SARS-CoV-2 was made by real-time reverse transcriptase polymerase chain reaction (RT-PCR) of nasopharyngeal swabs of patients with any evolving symptoms of COVID-19 as described by the Centers for Disease Control and Prevention (CDC)[16] such as fever, respiratory symptoms, fatigue, headache, gastrointestinal symptoms and new loss of taste or smell and upon risk assessment based on history. The testing was mostly uniform across all institutions due to being a part of the same healthcare system or university affiliation. Initially testing samples were sent to New York City Department of Health and Mental Hygiene for processing. By April 1, all participating hospitals were performing 'in-house' testing after Food and Drug Administration granted Emergency Use Authorization of RT-PCR test for SARS-CoV-2 (Roche

Cobas® SARS-CoV-2 Test and Cepheid Xpert® Xpress SARS-CoV-2 Test). The local institutional review boards approved the study with a waiver of consent and relevant data user agreements. Seven of these patients were included in other case series publications[7,8,17,18].

Information collected included demographics, presenting symptoms, laboratory and imaging results, treatments, and clinical outcomes. Patients were subdivided and compared by highest level of care during admission (acute care vs. critical care unit) and by age groups (<1 year, 1-5 years, 6-14 years, and 15-21 years). Further sub-analyses of the data were performed comparing patients who received any respiratory support to those who required no respiratory support during hospitalization. Body mass index (BMI) was calculated using a BMI calculator from CDC for age/sex, and subjects were categorized as obese if they were at or above 95th percentile or BMI≥30, and as overweight if they were 85th-95th percentile or BMI 25 to <30 for age ≥2 years[19]. Due to nature of the study, data collection for obtaining history was not standardized within the cohort, as well as all testing and management plans were undertaken at the clinical team's discretion. Categorical variables were compared using Pearson's chi-squared test or Fisher's exact test. Medians of continuous variables were compared using the Mann-Whitney test and means were compared using Student's *t* test. GraphPad Prism8 software was used for statistical analysis. A P value of <0.05 was considered significant.

Results

We identified 82 hospitalized children who tested positive for SARS-CoV-2. The majority were male (63%), and the median age was 5 years (interquartile range [IQR]: 2.5 months-15.2 years)

(Table 1). Among all patients, twenty-three (28%) were admitted to critical care units during hospitalization. One patient required veno-venous extracorporeal membrane oxygenation (ECMO). At the end of the study period, all patients remained alive and were discharged from the hospital. The median duration from symptom onset to hospital admission was one day (IQR: 1-4 days) and length of stay was three days (IQR: 2-5 days). Majority of the patients were admitted due to respiratory distress, sepsis evaluation or severity of gastrointestinal symptoms.

Demographics

About half of all patients (49%) were Hispanic/ Latino, 22% non-Hispanic White, 9% non-Hispanic African-American, 5% non-Hispanic Asian, and 15% multiple/other/unknown race. This was consistent with overall patient population at these four institutions. African-American, Hispanic, and Asian patients together were represented more frequently among those requiring critical care vs. acute care but this difference was not statistically significant (74% vs. 59%, P=0.22). Thirty-three patients (40%) were aged <1 year, nine (11%) were aged 1-5 years, nineteen (23%) were aged 6-14 years, and twenty-one (26%) were aged 15-21 years. Distribution of presenting symptoms and need for admission to critical care or acute care units among patients of all age groups is shown in Figure 1 and 2. Fourteen patients (67%) in the 15-21 year age group and nine patients (47%) in the 6-14 years age group had a BMI in the overweight or obese range.

Clinical presentation

Fifty percent of the patients had a known sick contact with confirmed or suspected COVID-19. Forty-five percent of all patients had at least one comorbidity at initial presentation, with obesity,

asthma, and malignancy as the most common pre-existing conditions (Table 1). Fever (80%) was the most common presenting symptom, followed by cough (39%) and shortness of breath/ dyspnea (29%) (Figure 1). Overall, older children had similar symptomatology to those described in adult patients with COVID-19[20]. There were nine patients (11%) with acute appendicitis (7 were aged 6-14 years and 2 were aged 15-21 years; three patients had perforated appendix), and two children (2%) with intussusception.

Laboratory characteristics at initial presentation

Leukopenia and lymphopenia were observed in 22% and 36% of the patients respectively. C-reactive protein (CRP) was elevated in 67% (n=54) of patients and procalcitonin was elevated in 34% (n=35) of patients. Other inflammatory markers, such as interleukin-6 (IL-6), D-dimer and lactate dehydrogenase (LDH) were elevated in two-thirds and ferritin was increased in one-third of the patients (Table 2).

Chest radiographic imaging

Forty-eight (59%) patients had chest radiographs performed, of which forty-two (88%) were abnormal. Chest radiographic findings included bilateral ground glass or hazy opacities in twenty (42%) patients, focal consolidation in six (13%), small airway inflammation in fifteen (31%), pleural effusion in three (6%), and pneumothorax in one (1%) patient. Five children (6%) had computerized tomography of the chest and four of them had bilateral ground glass or patchy airway opacities in the lungs.

Co-infections

Twelve patients (15%) in this cohort had co-infections. Sterile site cultures were negative with the exception of two positive blood cultures (*Klebsiella pneumoniae* in a patient requiring mechanical ventilation and ECMO support; *Klebsiella oxytoca* and *Streptococcus constellatus* in a patient with a perforated appendix) and two positive urine culture (*Pseudomonas aeruginosa* in patient with history of posterior urethral valve and Hutch diverticulum; and *Candida dubliniensis* in a patient with diabetic ketoacidosis). Three patients had viral co-infections (rhino/enterovirus, respiratory syncytial virus, and influenza B).

Therapies used for COVID-19

Hydroxychloroquine (alone or in combination with other therapies) was administered to 26% of patients, predominately early in the reporting period. Other therapies included tocilizumab (10%), remdesivir (6%), lopinavir/ritonavir (2%), and convalescent plasma (1%). Patients with respiratory symptoms or with comorbidities were more likely to receive medications for the treatment of COVID-19. 76% patients requiring respiratory support received therapies for COVID-19 compared to 6% of those who did not require any respiratory support ($P<0.001$). Similarly, higher proportions of patients with any comorbidity received medications for COVID-19 than those who had no comorbidities (53% vs. 11%, $P<0.001$).

Respiratory support

Twenty-nine patients (35%) required some form of respiratory support, of which seven patients (9%) needed mechanical ventilation. The non-invasive ventilation modalities (maximum respiratory support required) included twelve patients (15%) on nasal cannula, nine (11%) on high-flow nasal cannula, and one (1%) on bi-level positive airway pressure support. We performed a sub-analysis and comparison between children who required any form of respiratory support and those who required no respiratory support during hospitalization. Patients who required respiratory support were older (median age: 17.1 years [IQR 8.1 year-18.8 years] vs. 9 months [IQR: 5 months- 10.2 years], P<0.001) and more frequently had pre-existing comorbidities (69% vs. 32%, P=0.001). Children with obesity had increased need for respiratory support, but this was not statistically significant (41% vs. 30%, P=0.21]. Children with a history of asthma were more likely to require respiratory support during hospitalization (28% vs. 8%, P=0.02).

Critical care vs. acute care admission

Children with any pre-existing comorbidity were more likely to require critical care than acute care during hospitalization (70% vs. 37%, P=0.008). Obesity is the most common risk factor associated with the need for critical care (63% vs. 28%, P=0.02). There was no difference in the proportions of overweight children (≥ 2 years) admitted to acute or critical care (25% vs. 13%, P=0.41). Children admitted to critical care were more likely to have sick contacts than those admitted to acute care units (78% vs. 45%, P=0.008). In addition, they were more likely to have elevated CRP, IL-6, and alanine aminotransferase (Table 2). Children admitted to critical care had higher rates of renal dysfunction at presentation than those admitted to acute care with elevated

creatinine levels for age[21] (43% vs. 10%, P=0.002) and low estimated glomerular filtration rate[22,23] (56% vs. 19%, P=0.01). Initial vital signs were not significantly different between two groups. The median length of stay was higher among patients needing critical care (8 days [IQR: 4-24] vs. 2 days [IQR: 2-4], P<0.001).

Discussion

In this study, we describe the largest pediatric case series to date in the US of hospitalized children with SARS-CoV-2. In contrast to previously published pediatric SARS-CoV-2 inpatient cohorts, in which the final clinical outcome of many patients (up to one-third) had not yet been determined at the time of publication, our study captures clinical outcomes through hospital discharge for all patients[12-14]. We compared these patients based upon their level of care and age groups. Additionally, we described a more granular comparison between children who required respiratory support to those with no respiratory support than previously described in the literature.

Categorization of the disease severity among children with SARS-CoV-2 has been variable among limited published data[3,11-15], with the main focus being patients requiring mechanical ventilation. Non-invasive respiratory support poses a significant morbidity burden for both patients and healthcare systems. The guidance regarding performing early intubation or trying non-invasive ventilation modalities has rapidly evolved for patients with COVID-19 and worsening respiratory status. Therefore, our study has looked at the data in a more comprehensive manner, and compared children based on their level of care to understand the burden of acute and critical care admissions in pediatric patients as well as elucidated the features of those children who required respiratory

support (invasive or non-invasive). We recognize the need for standardizing descriptions of disease acuity and clinical course in the pediatric literature, so we can arrive at a more meaningful understanding of the impact of SARS-CoV-2 infection in children.

Children with comorbidities were noted to be at increased risk for critical care admission and need for respiratory support in this study. Obesity is an important risk factor for SARS-CoV-2 admission in patients <60 years of age[24] and is associated with an increased need for mechanical ventilation in at least one pediatric study[14]. We speculate that children with obesity may be at increased risk for more severe illness due to SARS-CoV-2, as demonstrated for other viral infections such as influenza A[25] and among children requiring critical care during hospitalization[26-28]. This may be related to an altered immune response[25], reduced baseline pulmonary function, and association of progression to an inflammatory syndrome as described with other co-morbid conditions in patients with obesity[29,30]. In previously published case series from the US[11,12], children with asthma were not at increased risk for critical care admission, but morbidities such as need for respiratory support were not described among them. In our larger cohort, asthma as a comorbidity was significantly higher among children who required some form of respiratory support when compared to those who required no respiratory support, although there was no statistically significant increase in the need for critical care admission. We suggest that pediatricians and other care providers consider all comorbidities, particularly obesity and asthma, as potential risk factors for severe illness while caring for children during this pandemic.

In the described cohort, patients aged 15-21 years were the most severely affected, three-quarters of whom required some form of respiratory support. Patients aged <1 year and 1-5 years had relatively milder symptoms and few of them required respiratory support. These findings are in contrast to a large retrospective pediatric study from China, where the largest proportion of severe and critical cases were in children aged <1 year and 1-5 years[3]. One-third of those cases were not laboratory confirmed for SARS-CoV-2 and there was no standardized testing for other viral illnesses in the Chinese study. The reasons for differences observed in disease severity among various age groups, despite higher nasopharyngeal viral load observed among infants compared to older children[31], is yet to be determined. Some possible explanations could be due to evolving immunological response to the viral infections in early life and age-dependent differential expression of cell surface angiotensin-converting enzyme 2 receptors[32-34].

Children less than one year of age were the most represented age group in this study, which is similar to or slightly higher than other smaller studies from NYC[15,31]. In the beginning of pandemic spread in the US, when data on children with COVID-19 from China suggested higher severity of infection among infants and younger children, it's possible that more infants with confirmed infection were admitted to ensure safety of these children. We did observe a decreasing trend of admitting infants from the emergency room over time during course of pandemic as our understanding of this infection in children increased.

The most common presenting symptoms in this study were fever and/or dry cough. Several children had atypical non-respiratory presenting symptoms, such as acute abdominal pain, new-

onset seizure and new-onset diabetes. While some of these associations have been described in adult and pediatric literature[14,35,36], it is unclear whether SARS-CoV-2 was the causative agent or if it was co-incidentally diagnosed. Children admitted to critical care were more likely to have sick contacts than those admitted to acute care units. It is possible that families of patients admitted to critical care units may have reflected more on sick contacts or other aspects related to history (recall bias) or the clinical teams obtaining detailed history. Inflammatory markers were elevated in many of our patients, but only a few were associated with the need for critical care (CRP and IL-6). These findings suggest a similar, but likely less severe inflammatory process, to that described in adult studies[37,38]. Renal dysfunction was observed more in patients requiring critical care, which has been previously described in pediatric patients with greater illness severity[39]. None of the patients required renal replacement therapy. The reasons for higher rate of renal dysfunction could be multifactorial, including hyperinflammation, cytokine storm and complement dysregulation associated with COVID-19[40,41]. In addition, kidneys have increased expression of angiotensin converting enzyme 2 receptor, potentially leading to viral entry and injury to the cells[42]. Among radiographic findings, majority of the patients requiring respiratory support had bilateral ground glass or patchy opacities in lungs, while in a few cases these findings did not correlate with the level of clinical support required. Potential targeted therapies for COVID-19 have limited efficacy data among children. However, these treatments were given based upon individual patient clinical characteristics and in an effort to treat the most severely affected children.

Thirteen percent patients in our described cohort were diagnosed with acute appendicitis or intussusception on presentation. This is higher rate than previously published case series from

NYC area[14]. All of these patients had gastrointestinal symptoms (abdominal pain, vomiting or diarrhea), three-quarter of them had fever, and one-quarter had respiratory symptoms. It's possible that children taken to operating theatre were more likely to get tested as per local infection prevention measures and were coincidentally found positive for SARS-CoV-2 during high prevalence of infection in the region. Viral infections are known to cause lymphadenopathy and hyperplasia of other lymphatic tissues such as Peyer's patches in the intestines[43-45], which may serve as a lead point resulting in intussusception[46,47] and inflammation of lymphoid tissue around appendix resulting in acute appendicitis. This association of acute appendicitis and intussusception with SARS-CoV-2 infection needs further exploration, including analysis of pathological changes in the surgically removed appendix.

Our study has several important limitations, including a small sample size, limited geographical range, and its observational nature. Due to rapidly evolving testing and management guidelines for suspected cases with SARS-CoV-2 at all study locations; there may have been some initial inconsistency in diagnosis and management over this study period. Also, some of the associations and risk factors observed in our relatively small study cohort, needs to be explored in detail on a larger dataset. Nonetheless, our focus on hospitalized pediatric patients with SARS-CoV-2 in four NYC Metropolitan area hospitals with widespread community transmission provides important data for pediatric clinicians.

Conclusion

This described cohort is the largest case series to date of hospitalized children with confirmed SARS-CoV-2 followed from admission to discharge. We observed that children with comorbidities, particularly obesity and asthma, are at increased risk for critical care admission and/or the need for respiratory support. Children with renal dysfunction at presentation may be at greater risk for the need for critical care. Understanding risk factors associated with severity of illness among children requires further investigation on a larger dataset.

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Table 1. Baseline characteristics of all hospitalized pediatric and adolescent patients with SARS-CoV-2 and comparison between those admitted to acute or critical care units.

	All patients (n=82)	**Acute care admission (n=59)**	**Critical Care admission (n=23)**	**P-value**
Age, median [IQR]	5 years [2.5 months-15.2 years]	6.7 months [1 month-11.5 years]	10 years [2.7 months-18 years]	0.16
Sick contacts, n (%)	45 (55)	27 (45)	18 (78)	**0.008**
Comorbidities, n (%)				
-Any comorbidity	38 (46)	22 (37)	16 (70)	**0.008**
-Asthma	12 (15)	7 (12)	5 (22)	0.26
-Obesity*	19 (40)	9 (28)	10 (63)	**0.02**
-Chronic lung disease	4 (5)	1 (2)	3 (13)	0.06
-Congenital heart disease	1 (1)	0	1 (4)	0.28
-Diabetes mellitus (type 1 or 2)	1 (1)	0	1 (4)	0.28
-Malignancy/ Immunosuppression	9 (11)	4 (7)	5 (22)	0.10
-Other	13 (16)	7 (12)	6 (26)	0.11

Abbreviations- IQR: [Interquartile range]

*Denominator for obesity includes patients ≥2 years age, 32 in acute care vs. 16 in critical care.

Table 2: Laboratory and microbiological indices among pediatric and adolescent patients with SARS-CoV-2 and comparison between those admitted to acute or critical care units.

Laboratory indices[#]	Available data, N	All (n=82)	Acute Care (n=59)	Critical care (n=23)	P-value
Hemoglobin, <10 mg/dL	78	11/78 (14)	7/56 (13)	4/22 (18)	0.49
Platelets, <150×10^3/μL	76	11/76 (15)	6/54 (11)	5/22 (23)	0.19
White blood cells count					
<5×10^3/μL	78	17/78 (22)	14/56 (25)	3/22 (14)	0.37
>11×10^3/μL [$]	65[$]	21/65 (32)	12/45 (27)	9/20 (45)	0.15
>30×10^3/μL for newborns <28 days of life	13	0/13	0/11	0/2	-
Absolute lymphocyte count, <1500 cells/μL	77	28/77 (36)	18/56 (32)	10/21 (48)	0.21
Absolute neutrophils count, <1500 cells/μL	78	10/78 (13)	9/56 (16)	1/22 (5)	0.27
C-Reactive protein, >10 mg/dL	54	36/54 (67)	18/34 (53)	18/20 (90)	**0.005**
Procalcitonin, ≥0.5 ng/mL	35	12/35 (34)	5/19 (26)	7/16 (44)	0.41
Interleukin-6, ≥5 pg/mL	29	20/29 (69)	10/18 (56)	10/11 (91)	**0.04**
D-dimer, ≥250 ng/mL	23	15/23 (65)	9/14 (64)	6/9 (67)	0.91
Ferritin, ≥250 ng/mL	21	8/21 (38)	4/11 (36)	4/10 (40)	0.99
Lactate dehydrogenase, ≥250 IU/L	33	28/33 (85)	17/20 (85)	11/13 (85)	0.97
Creatinine, elevated level for age[@]	69	14/69 (20)	5/48 (10)	9/21 (38)	**0.002**

eGFR[*], <90 mL/min/1.73 m^2	42	14/42 (33)	5/26 (19)	9/16 (56)	**0.01**
Troponins, >0.5 ng/dL	27	2/27 (7)	0/13 (0)	2/14 (14)	0.48
Aspartate aminotransferase, >40 U/L	61	29/61 (48)	16/41 (39)	13/20 (65)	0.06
Alanine aminotransferase, >40 U/L	62	13/62 (21)	4/42 (10)	9/20 (45)	**0.002**
Microbiological indices					
Blood culture positive	58	2/58 (3)	0/37 (0)	2/21 (10)	0.13
Urine culture positive	34	2/34 (6)	1/21 (5)	1/13 (8)	0.99
Cerebrospinal fluid culture positive	19	0/19	0/17	0/2	-
Respiratory viral panel positive[&] (except SARS-CoV-2)	47	3/47 (6)	1/32 (3)	2/15 (13)	0.24
Co-infection (bacterial or viral or fungal)	82	12/82 (15)	5/59 (8)	7/23 (30)	**0.01**

[#] All values expressed as x/N (%) where N= number of patients with available data for a variable in that category; x= number of patients; [$] excluding infants <28 days of life; [&] BioFire® FilmArray® respiratory panel (bioMérieux); [@] Normal values range used for 'creatinine for age[19]' in mg/dL: newborn 0.3-1.0, infant 0.2-0.4, 1 to 9 years 0.3-0.7, 10 to 17 years 0.5-1.0, 18 to 21 years 0.9-1.3 (male) 0.6-1.1 (female); * denominator for eGFR (estimated glomerular filtration rate) includes patients ≥ 2 years age, eGFR calculated using 'bedside Schwartz equation[21]' for patients aged 2 to 17 years and 'CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) creatinine equation[20]' for patients aged 18 to 21 years.

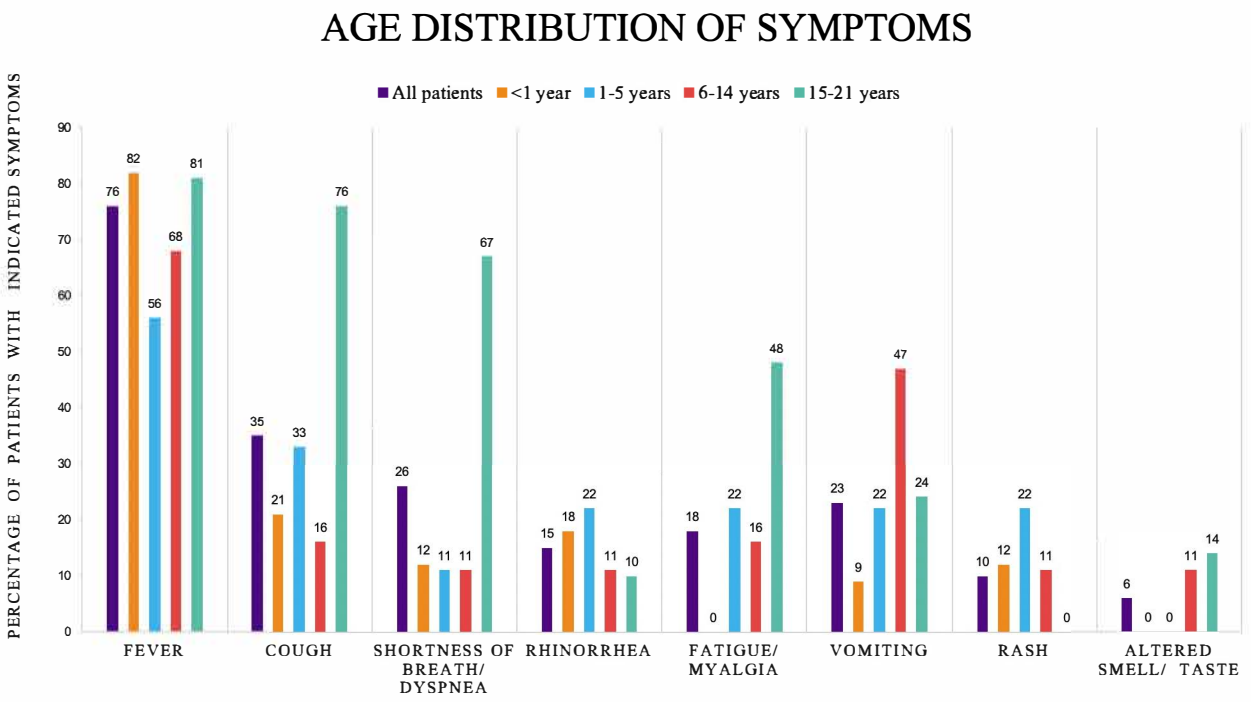

Figure 1. Presenting symptoms for all patients and their age wise distribution. (The percentages of symptoms in an age group for indicated symptom are on y-axis, individual symptoms are on x-axis, and the colors represent various age groups as shown in the figure).

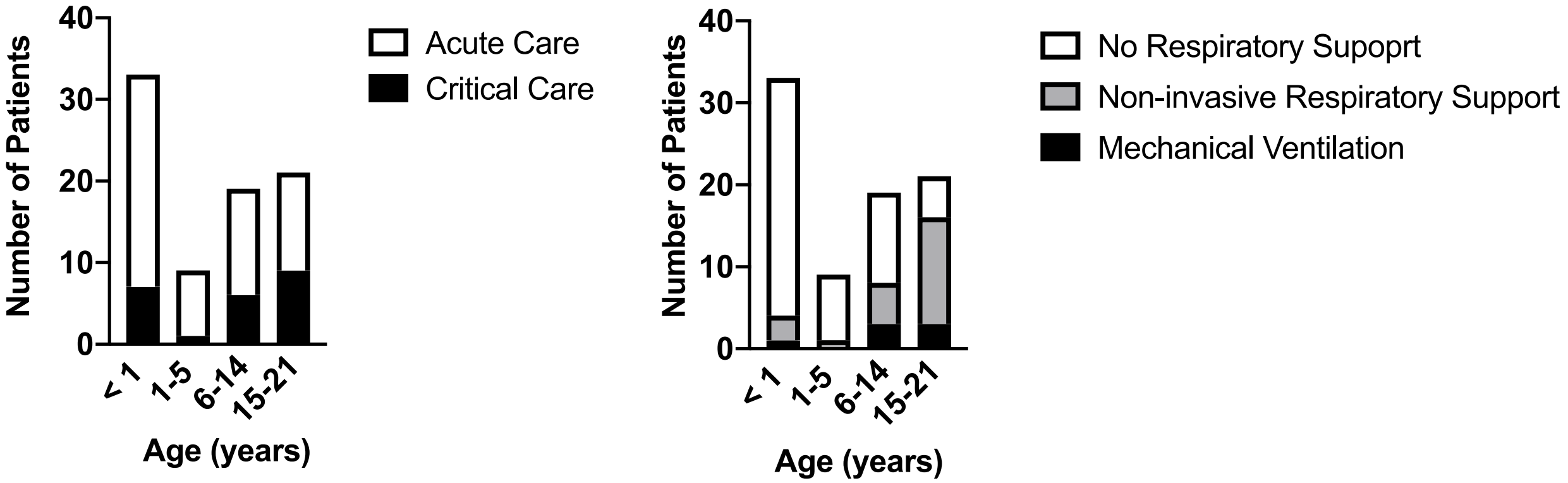

Figure 2. Distribution of pediatric and adolescent patients in various age groups, need for admission to acute vs. critical care units and type of respiratory support required. (The numbers of patients are on y-axis, individual bars represent various age groups and different shades represent support required as shown in the figure).

Supplemental Table 3: Summary of five major case series of hospitalized pediatric and adolescent patients with Coronavirus Disease-2019 from the United States.

Study and Setting	Number of hospitalized patients	Demographics	Acute vs. Critical/ Intensive Care	Respiratory support	Symptoms	Laboratory values	Co-morbidity	Radiographic findings	Outcomes
Zachariah et al.[14] Epidemiology, clinical features, and disease severity in patients with coronavirus disease 2019 (COVID-19) in a children's hospital in New York City, New York	**50 patients** **Still admitted at the time of publication:** 24%	**Inclusion:** ≤21 years **Male:** 54% **Hispanic:** 50% **Black:** N/A **< 1yo:** 28% **15-21 years:** N/A	**Not reported** Two categories: **Severe disease** (requiring mechanical ventilation): 9 (18%) **Not severe disease:** 41 (82%)	**Any respiratory support:** 32% **Mechanical ventilation:** 18% **NIPPV:** 6%	**Fever**: 80% **Cough**: 46% **SOB/Dyspnea:** 34% **Chest pain:** 18% **GI symptoms:** 14% **Sore throat:** 12% **Congestion/runny nose:** 12%	**WBC** (10^3/μL)*: 7.6 (4.6-11.4) **Lymphopenia** (cells/μL)*: 72%, **ALC**: 1201 (600-2084) **CRP** (mg/dL)*: median, 8.978 vs. 0.64, P<0.001 **Procalcitonin** (ng/mL)*: median, 0.31 vs. 0.17, P<0.001	**Obesity:** 32% **Asthma:** 12% **Malignancy/ innumosuppression:** 16% **Neurologic:** 14% **Genetics syndrome:** 10% **Cardiac:** 8%	**ChXR: 72%** **Bilateral patchy/ ground glass opacities:** 69% **Pleural effusion:** 25% **Focal consolidation:** 22% **Pneumothorax:** 5%	**Died:** 1 (2%)
DeBiasi et al.[12] Severe COVID-19 in children and young adults in the Washington DC metropolitan region	**44 patients** **Still admitted at the time of publication:** N/A	**Inclusion:** <1 year to >20 years *(Upper limit not specified, included patients until 34 years)* **Male:** 50% **Ethnicity:** N/A **<1 year:** 32% **>15 years:** 32%	**Non-critically ill:** 35 (80%) **Critically ill:** 9 (20%) Definition of critically ill N/A	**Any respiratory support:** 18% **Mechanical ventilation:** 9% **BiPAP:** 2% **HFNC:** 2%	**Fever:** 77% **Cough:** 37% **SOB:** 26% **Sore throat/ congestion:** 25% **Diarrhea or vomiting:** 15% **Chest Pain:** 14% **Loss of taste/smell:** 5%	**N/A**	**Obesity:** 2% **Asthma:** 16% **Oncologic**: 5% **Neurologic:** 18% **Cardiac:** 9% **Hematologic:** 9% **Diabetes:** 5%	**N/A**	**No deaths reported**
Chao et al.[11]	**46 patients**	**Inclusion:** 1 month- 21 years	**General pediatric unit:** 33 (72%)	**Any respiratory support:** 61%	**Fever:** 61% **Cough:** 63%	**WBC (10^3/uL)#:** 9.7 (6.9-17.1) vs.7 (5.4-11.8)	**Obesity:** 26% **Asthma:** 24%	**ChXR:** 67 % **Normal:** 19%	**Died:** 1 (2%)

Clinical characteristics and outcomes of hospitalized and critically Ill children and adolescents with coronavirus disease 2019 (COVID-19) at a tertiary care medical center in New York City	**Still admitted at the time of publication:** 9%	**Male:** 67% **Hispanic/Latino:** 79% **Black:** 11% **<1 year:** N/A **Median age:** 13.1 years (IQR 0.4-19.3)	**PICU:** 13 (28%)	**Mechanical ventilation:** 13% **HFNC:** 17% **NIV:** 4% **NC:** 28%	**SOB:** 50%	**ALC (cells/uL)[#]:** 1184 (880-2534) vs. 1377 (536-2232) **Platelets (k/uL)[#]:** 194 (138-238) vs. 244 (195-361) (P=0.03) **CRP (mg/dL)[#]:** 6.6 (2-11.8) vs. 1.9 (0.5-4.3) (P=0.02) **Procalcitonin (ng/mL)[#]:** 11.5 (1.4-21.5) vs. 0.1 (0.1-0.2) (P=0.03) **Pro-BNP (pg/mL)[#]:** 1112 (1051-1734) vs. 60 (60-85)	**Immuno suppressed:** 4% **Seizure disorder:** 9% **Malignancy:** 2% **Heart Disease:** 2%	**Bilateral opacities:** 65% **Unilateral opacities:** 16% **Pleural effusion:** 3%	
Shekerdemian et al.[13] Characteristics and Outcomes of Children With Coronavirus Disease 2019 (COVID-19) Infection Admitted to US and Canadian Pediatric Intensive Care Units	**48 patients** **Still admitted at the time of publication:** 38%	**Inclusion:** ≤21 years **Male:** 52% **Race/ ethnicity:** N/A **<1 year:** 17% **11-21 years:** 56%	**All patients: PICU** **Four categories of illness:** Mild (29%) Moderate (2%) Severe (33%) Critical (35%)	**Any respiratory support:** 81% **Endotracheal or tracheostomy ventilation:** 38% **CPAP or BiPAP:** 8% **HFNC:** 23% **Oxygen only:** 13%	**Respiratory:** 73% **Gastrointestinal:** 2% **Neurological:** 4% **Circulatory:** 4% **Other:** 15%	**N/A**	**Medically complex:** 40% **Immune suppression/malignancy:** 23% **Obesity:** 15% **Diabetes:** 8% **Congenital heart ds:** 6% **Seizures:** 6%	**N/A**	**Died:** 2 (4%) **ECMO:** 1(2%)
Kainth et al. [15] Early Experience of COVID-19 in a US Children's Hospital	**65 patients** **Still admitted at the time of publication:** 11%	**Inclusion:** ≤22 years **Male:** 51% **Race/ ethnicity: Hispanic:** 23% **Black:** 26% **White:** 22%	**Intensive care:** 35% **Severity of disease classified as:** Mild (60%) Moderate (26%) Severe (14%)	**Any respiratory support:** 34% **Mechanical Ventilation:** 8% **Non-invasive ventilation (BiPAP, CPAP):** 8%	**Fever (by history or on presentation):** 74% **URI sign/symptoms:** 34% **LRTI signs/symptoms:** 60%	**WBC (10^3/uL)[#]:** 7.8 (5.0-14.5) **Neutropenia, N=62:** 16% **Lymphopenia, N=62:** 44% **Platelets (k/uL)[#]:** 263.5 (199-384) **CRP (mg/dL)[#]:** 20.1 (4.5-87.9) **D-dimer abnormal, N=26:** 81% **Ferritin abnormal, N=27:** 89%	**Obesity:** 29% **Asthma / reactive airway disease:** 15% **Immuno-suppression:** 12% **Immuno - deficiency:** 6%	**ChXR:** 66% **Initial abnormal ChXR:** 41% **Infiltrates:** 32% **Pleural effusion:** 10% **Bilateral findings:** 67%	**Died:** 2 (3%) **ECMO:** 1(2%) **RRT:** 2 (3%)

		<60 days age: 29% **≥12 years:** 48%		**Supplemental O_2 (NC, FM, HFNC)**: 26%	**Gastrointestinal:** 62% **Neurological:** 32% **Myalgia /Fatigue:** 34%	**Lactate dehydrogenase abnormal N=27:** 93%	**Neuromuscular disease/ disorder:** 9% **Cancer:** 8% **Congenital heart disease:** 5% **Diabetes:** 6%		

Majority of terminology (symptoms, clinical units, co-morbidity categories) are used as indicated in the studies. (Abbreviations: N/A: not available, COVID-19: coronavirus disease 2019, NIPPV: non-invasive intermittent positive pressure ventilation, BiPAP: bi-level positive airway pressure, HFNC: high flow nasal cannula, NC: nasal cannula, FM: Face mask, IQR: interquartile range, CRP: C-reactive protein, WBC: white blood cell count, ALC: absolute lymphocyte count, Pro-BNP: pro-brain natriuretic peptide, ChXR: Chest X-ray, PICU: pediatric intensive care unit, N: number of patients with available data, O_2: Oxygen, GI: gastrointestinal, SOB: shortness of breath, URI: upper respiratory infection, LRTI: lower respiratory tract infection, ECMO: extracorporeal membrane oxygenation, RRT: renal replacement therapy) * Laboratory values expressed as medians (interquartile range) except for CRP & procalcitonin (interquartile range not available at admission), comparison between severe vs. not severe ds. # Laboratory values expressed as medians (interquartile range), comparison between general pediatric unit vs. PICU patients

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