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Research paper

COVID-19 hospitalization rate in children across a private hospital network in the United States
COVID-19 hospitalization rate in children

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ABSTRACT

Objectives: There are limited studies with varying results evaluating the rate of hospitalizations of pediatric patients tested for COVID-19 in the United States. More information in the pediatric COVID-19 literature is needed. The objective of this study was to describe the rates of positive tests, hospitalization, severe disease, and mortality for COVID-19 in children.
Material and Methods: We performed a retrospective analysis of data collected from a data warehouse from 184 hospitals across the United States. All cases of pediatric patients who were tested for COVID-19 were analyzed for test positivity, hospitalization, severe disease, and mortality. A separate subgroup analysis for ages < 1 year, 1–4 years, 5–8 years, 9–14 years, and 15–17 years was performed.
Results: Of 24,781 patient encounters, we found a test positivity rate of 11.15% (95% CI: 10.76–11.55). There were 142 admissions out of the 2,709 symptomatic patients, 5.24% (95% CI: 4.43–6.15) admission rate. Of those admitted, we found that 54.93% (78/142) were admitted to the PICU, but only 22 of the 142 admissions, 15.49% (95% CI: 9.97–22.51), were determined to have severe COVID-19 disease. One patient died during the study period giving an overall pediatric mortality rate of 0.04% (95% CI: 0.00–0.21).
Conclusion: In our sample, we found a test positivity rate of 11.15%. We also report a 5.24% hospitalization rate with 15.49% of admitted patients with severe disease. Lastly, we also report a very low mortality rate of 0.04% of all patients who tested positive for COVID-19.

1. Introduction

Since the first reported pediatric case of SARS-CoV-2 (COVID-19) in the United States, there has been a slow but substantial increase in the number of pediatric cases reported. Studies at the start of the COVID-19 pandemic in the United States estimated that less than 2% of the COVID-19-positive cases occurred in children [1], but as of November 12, 2020, the American Academy of Pediatrics (AAP) and the Children's Hospital Association (CHA) report 11.5% (1039,464 of 9037,991) of COVID-19 cases in the United States occurred in children. Of these children, they report up to 6.1% of all pediatric cases resulted in hospitalization and 0.15% of cases resulted in death [2]. Studies to date in pediatric patients with COVID-19 have also shown less severe presentations and lower morbidity/mortality when compared to adults [3,4]. There is still a need for more information on pediatric patients with COVID-19 to better understand the impact of COVID-19 in children. The objective of this study was to describe the rate of positive tests, rate of hospitalization, and the mortality rate for COVID-19 in children across one of the largest nongovernmental healthcare systems in the United States.

2. Materials and methods

A retrospective data analysis was performed utilizing data on pediatric patients who were tested for COVID-19 from January 1, 2020 to July 24, 2020. Data were obtained from a centralized data warehouse that collects daily data from 184 hospitals, mainly community and non-academic centers, in 20 states across the United States. The study data obtained included demographic information, International Classification of Diseases 10th Edition (ICD-10) codes, procedure codes, location of admission, and mortality. The centralized data warehouse also collects clinical data from the patient encounter such as the presenting signs, symptoms, and physical examination findings. We found this clinical data were limited by the reliability and accuracy of extracting this documentation within a specific area of the electronic medical record (EMR), such as physician and nursing notes as well as within the free text areas of the EMR. Due to this limitation of the reliability and the inaccuracy of extracting the history and examination of each patient, we chose not to

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present any information related to the clinical presentation, which limited our ability to classify the severity of disease into mild, moderate, severe, or critical as in other studies [5]. As a surrogate for severity of disease, we classified children as a severe COVID-19 case by using the location of admission matched with the ICD-10 diagnosis and procedure codes. We defined severe COVID-19 disease as patients who required admission to the pediatric intensive care unit (PICU) with either an ICD-10 code of acute respiratory distress syndrome, respiratory failure, acute respiratory failure, acute and chronic respiratory failure, hypotension, cardiogenic shock, septic shock, and/or a procedure code of ventilator management or noninvasive respiratory support.

Inclusion criteria for the final data analysis comprised all symptomatic pediatric patients < 18 years of age who were tested for COVID-19 from the defined dates above from within the hospital network. A patient was considered positive for COVID-19 with any positive test result or a discharge diagnosis of COVID-19 when results were not available in the data warehouse. Examples of patients without results available in the data warehouse include those who may have been transferred from another facility or those with previously known positive results. For patients with multiple visits, we only included one visit by prioritizing the visit that resulted in a positive COVID-19 test with admission. We excluded any patient admitted to the hospital with a positive COVID-19 test who were determined to be asymptomatic. Asymptomatic COVID-19 admissions were patients who were admitted but did not have any COVID-19 symptoms based on review of the ICD-10 or procedure codes during the hospitalization; examples include patients likely screened for COVID-19 who were admitted for appendicitis or depression. We lastly excluded all patients with incomplete data sets.

Data were analyzed to generate descriptive statistics using STATA 14.0 (Stata Corporation, College Station, TX) statistical software. We compared means using *t* tests and categorical data using the chi-square test. A *p* value less than 0.05 was determined to be statistically significant. We report proportions and percentages with 95% CI for our final symptomatic admission encounters. We lastly report subgroup analysis for hospitalizations for age groups; < 1 year, 1–4 years, 5–9 years, 10–14 years, and 15–17 years. This study was determined to be IRB exempt.

3. Results

Of the 184 hospitals, 137 hospitals had positive testing results for COVID-19 in children under the age of 18 years. There were 25,585 COVID-19 tests ordered for pediatric patients from January 1, 2020 to July 24, 2020 from all the facilities. After excluding multiple visits for the same patient, there were 2763 positive tests for 24,781 single patient encounters, 11.15% (95% CI: 10.76–11.55).

Of the 2763 positive tests, 196 patients required admission, 7.09% (95% CI: 6.16–8.12). We excluded five admissions due to an incomplete data set and also excluded 49 asymptomatic admissions that included 17 newborns in the newborn nursery, three newborns with hyperbilirubinemia, one newborn with spina bifida, one patient with a burn injury, one child abuse case, seven patients with appendicitis, one patient with gallstone pancreatitis, one patient with multiple traumatic injuries, two patients with long bone fractures, five patients with suicidal ideation, and 10 pregnant adolescents admitted to labor and delivery. Our final positive COVID-19 group for data analysis included 142 symptomatic admissions (85 male, 59.9%) for 2709 symptomatic COVID-19-positive patient encounters giving a symptomatic admission rate of 5.24% (95% CI: 4.43–6.15). There was a significant difference in the mean age for the admission group, 6.51 years (95% CI: 5.38–7.37), compared to the discharge group, 9.33 years (95% CI: 9.09–9.57), $p \leq 0.01$.

Age subgroup analysis of all hospitalized children showed the highest admission rate in the < 1-year age group, 14.63% (95% CI: 11.21–18.61), and the highest severe disease PICU admission rate in the 5–9-year age group, 1.17% (95% CI: 0.38–2.72), $p = 0.30$ (**Table 1**). We found 78 of the 142 admissions were to the PICU, 54.93% (95% CI: 46.36–63.28). Of those admitted to the PICU, we found that 22 of the 142 admissions, 15.49% (95% CI: 9.97–22.51), met our criteria for severe COVID-19 disease, therefore giving an overall severe COVID-19 diagnosis in 22 of 2709 positive cases, 0.81% (95% CI: 0.51–1.23) (**Table 2**). There were three patients documented with Kawasaki disease (suggestive of the newly described multisystem inflammatory syndrome in Children [MIS-C]) with an age range of 1–14 years. There was one patient who died during the study period who was in the 15–17-year age group giving a mortality rate of 0.04% (95% CI: 0.00–0.21) of all patients testing positive for COVID-19.

4. Discussion

Using a centralized data warehouse for a network of hospitals across the United States, we were able to analyze a large number of pediatric patients who were tested for COVID-19 during the early to mid-months of the pandemic in the country. After adjusting for patients who were tested on more than one occasion, we found a true positive rate of 11.15% among all children tested for COVID-19 during the study period. Although our study sample was mostly from the community and nonacademic centers, the rate of positivity mirrored the pediatric hospitalization results of 11.5% reported by the AAP and CHA on November 12, 2020 [2]. The data on infection rates among the pediatric population have been variable for multiple reasons, including asymptomatic or mild cases predominating among this population, initial testing availability, and testing variability among different sites.

Of the 2709 symptomatic patients who tested positive for COVID-19, 142 (5.24%) were hospitalized. Subgroup analysis showed that the < 1-year age group had the highest rate of symptomatic admissions (14.63%) of all the age categories. These results compare to a survey conducted by the Centers for Disease Control and Prevention (CDC) surveying COVID-19 hospitalization rates among children across 14 states, which also noted that children < 2 years of age had the highest rate of admission at 24.8% [6]. Similarly, an Italian study reported an admission rate of 11.5% in children age < 1 year versus 3.5% in children aged 7–17 years [7]. Futures studies may discover a change in these rates of admission, both because we are able to better predict the course of COVID-19 in different age groups and because of the impact of larger cultural factors such as return to school.

Initial studies during the early period of the pandemic reported an unfavorable prognosis with younger age, presence of comorbidities, and with increased severity of disease [5,8]. A more recent study conducted by Ouldali et al. found that only 3% of children younger than 90 days had severe disease, but children aged 10 years and older were independently associated with severe disease, odds ratio of 3.4 (95% CI: 1.1–10.3) [9]. Our results also differed from initial studies by showing that children classified as having severe COVID-19 disease requiring PICU level of care were primarily the 5–9-year age group and not in the younger age groups. Although our results did not reach statistical significance, there exists the possibility of a type II error due to the

Table 1
Admissions based on age group compared to total tested.

Age group	Total (*n*)	Admission*n* (% of total, 95% CI)	Severe COVID-19 PICU* *n* (% of total, 95% CI)
< 1 year	376	55 (14.63, 11.21–18.61)	4 (1.06, 0.29–2.70)
1–4 years	444	16 (3.60, 2.07– 5.79)	3 (0.68, 0.14–1.96)
5–9 years	426	23 (5.40, 3.45–7.99)	5 (1.17, 0.38–2.72)
10–14 years	657	12 (1.83, 0.95–3.17)	3 (0.46, 0.09–1.33)
15–17 years	806	36 (4.47, 3.15–6.13)	7 (0.87, 0.35–1.78)
TOTAL	2709	142 (5.24, 4.43–6.15)	22 (0.81, 0.51–1.23)

* $p = 0.297$ (chi-square); CI: confidence interval; PICU: pediatric intensive care unit.

Table 2
Severe symptomatic patients requiring PICU level of care.

Age group (total) (*n*,%)	Respiratory distress (%, 95% CI)	Respiratory support (%, 95% CI)	Intubation (%, 95% CI)	Shock (%, 95% CI)	Death (%, 95% CI)
< 1 year (55) (4, 7.27%)	2 (3.64, 0.44–12.53)	1 (1.82, 0.04–9.72)	1 (1.82, 0.04–9.72)	2 (3.64, 0.44–12.53)	0 (0.00)
1–4 years (16) (3, 18.75%)	2 (12.5, 1.55–38.35)	1 (6.25, 0.16–30.23)	1 (6.25, 0.16–30.23)	0 (0.00)	0 (0.00)
5–9 years (23) (5, 21.74%)	4 (17.40, 4.95–38.78)	3 (13.04, 2.78–33.59)	1 (4.35, 0.11–21.95)	2 (8.70, 1.07–28.04)	0 (0.00)
10–14 years (12) (3, 25.00%)	2 (16.67, 2.09–48.41)	0 (0.00)	1 (8.33, 0.21–38.48)	2 (16.67, 2.09–48.41)	0 (0.00)
15–17 years (36) (7, 19.44%)	6 (16.67, 6.37–32.81)	2 (5.56, 0.68–18.66)	1 (2.28, 0.07–14.53)	2 (5.56, 0.68–18.66)	1 (2.28, 0.07–14.53)
TOTAL (142) (22, 15.49%)	16 (11.27, 6.58–17.65)	7 (4.93, 2.00–9.89)	5 (3.52, 1.15–8.03)	8 (5.63, 2.46–10.80)	1 (0.70, 0.02–3.86)

Data are total *n* or *n* (%, 95% confidence interval); PICU: pediatric intensive care unit.

relatively low number of patients admitted to the PICU with severe disease. An early CDC report published in April 2020 reported a PICU admission rate of only 2% (15/745) [1], but a more recent version of the survey published in August 2020 had a PICU admission rate of 33.2% (69/208) [5]. Derespina et al. recently described clinical manifestations in 70 COVID-19 pediatric patients admitted to the PICU and reported a 28.6% rate of invasive mechanical ventilation and 17% rate of severe sepsis [10]. By comparison, we found that of the 22 patients classified as having severe COVID-19 disease, 22.7% required intubation and 36% were classified as having some form of shock.

Pediatric mortality rates related to COVID-19 to date appear to be much lower than in adults. Initial estimates from New York, one of the early epicenters in the United States, reported a 2% mortality rate among the 50 pediatric patients who were hospitalized [11]. More recently, weekly reports from the AAP and CHA reported a mortality rate of up to 0.15% of all pediatric COVID-19 cases [2]. We reported a mortality rate of 0.7% in the children requiring hospitalization, which corresponds to 0.04% of all patients who tested positive for COVID-19.

Conducting this study in conjunction with one of the largest healthcare organizations in the United States has provided numerous advantages including a large sample of pediatric patients. However, there were several limitations linked to the nature of the methodology used for this study. We are limited by the retrospective design of data acquisition. The decision for testing and admission was likely confounded by variables such as social factors (lack of follow-up or primary care), or medical comorbidities for which we were not able to reliably extract from the data warehouse. Therefore, it was not entirely clear whether a patient was being admitted predominantly for COVID-19-related complaints versus other medical reasons. Due to the retrospective nature of the study, we were not able to follow up on any patient discharged from the emergency department who later required admission at another facility, which could underestimate the true admission rate. We also acknowledge that each hospital had policies for testing based on testing availability and we also did not know the testing method for each hospital site. When available, all were PCR positive. Other testing factors such as disparate state regulations and regional infectivity rates may have resulted in over- or under-representation of positivity, therefore impacting the generalizability of our results.

We also did not collect data related to the clinical presentation due to the reliability of extracting these data from the data warehouse. Subsequently, we were not able to categorize the severity of the presentation and other factors that contributed to the decision for admission. While some studies categorized disease as mild, moderate, severe, or critical [7], we categorized severity based on the level of care of the admitting service (PICU vs. non-PICU) and matched to the ICD-10 or procedure codes. This variability of categorizing disease severity between studies emphasizes the need for a standardized classification that will allow us to consistently and uniformly stratify disease severity. This will in turn allow us to develop prognostic data for these patients. Currently the COVID – GRAM Illness Risk Score attempts to prognosticate severe disease in the inpatient population and provide admission criteria, but this study still needs to be externally validated [12]. Future studies regarding explicit risk factors and risk-stratifying guidelines are currently sparse and are therefore warranted.

5. Conclusion

In our sample of pediatric patients across the United States, we found a test positivity rate of 11.15%. Of those patients with symptoms associated with COVID-19, we reported a 5.24% hospitalization rate, with a trend toward younger patients being admitted, and older patients testing positive. Of those hospitalized, 15.49% were diagnosed with severe disease requiring PICU level of care, which results in an overall severe COVID-19 diagnosis rate of 0.81% for all positive cases. Lastly, we also reported a very low mortality rate of 0.04% of all patients who tested positive for COVID-19. As the epidemiology of this disease is more clearly understood in the pediatric population, future studies in the time of better therapeutics and vaccines can focus on risk stratifying for both short term-prognosis and long-term sequelae.

Disclosure of interest

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