RESEARCH ARTICLE

Characteristics of Hospitalized Children Positive for SARS-CoV-2: Experience of a Large Center

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ABSTRACT

OBJECTIVES: Define the spectrum of disease in pediatric inpatients with a positive SARS-CoV-2 test result in a manner relevant to pediatric hospital medicine.

METHODS: Retrospective case series of all patients aged <22 years hospitalized at our institution with a positive severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) polymerase chain reaction test result between May 1, 2020, and September 30, 2020. Demographic, clinical, and outcome data were collected and analyzed.

RESULTS: Three distinct presentations were associated with acute SARS-CoV-2 positivity. Patients had incidental infection (40%), were potentially symptomatic (47%), or were significantly symptomatic (14%). The average length of stay differed between the significantly symptomatic group and the incidental and potentially symptomatic groups (P =.002). Average age differed among these groups, with significantly symptomatic patients older by >2 years. Fifty-five percent of incidental and 47% of potentially symptomatic patients had at least 1 identified comorbidity, whereas 90% of significantly symptomatic patients had at least 1 (P = .01). There was a significant relationship between obesity (P = .001) and asthma (P = .004) and severe disease. Additionally, there was a statistically significant difference between groups with respect to fever, hypoxia, supplemental oxygen use, duration of supplemental oxygen, and ICU admission, with a significantly higher percentage of patients in the significantly symptomatic group meeting each of these criteria (P < .001 for all categories).

CONCLUSIONS: Pediatric patients hospitalized with SARS-CoV-2 fall into distinct categories, which are critical to understanding the true pathology of SARS-Cov-2 as it relates to hospitalized pediatric patients. Most hospitalized patients who test positive for SARS-CoV-2 are asymptomatic or have a reason for hospitalization other than coronavirus disease 2019.

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Drs Webb and Osburn conceptualized and designed the study, designed the data collection instrument, collected and analyzed all data, drafted the initial manuscript, reviewed and revised the manuscript, and approved the final manuscript as submitted.

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During the coronavirus disease 2019 (COVID-19) pandemic, children have been relatively spared of severe respiratory compromise and concomitant morbidity and mortality.[1] Thus far, definitions of severe disease in pediatric patients are variable but generally reflect respiratory symptoms and define severe as a requirement for any respiratory support or oxygen saturations <92%. Most of these classification systems also define the COVID-19 illness as severe if the patient requires hospitalization.[2–4] Because of the novel nature of the virus and universal testing protocols in place at many US hospitals, these broad definitions do not adequately describe the disease spectrum in hospitalized children.

Children are often admitted to the hospital for reasons unrelated to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and found to have incidental or mildly symptomatic infection. Asymptomatic infection, particularly in pediatric patients, has been well documented.[3,5,6] Because COVID-19 in pediatric patients has significant clinical overlap with many common conditions requiring admission in pediatric patients,[7] it can be difficult to determine if a patient has symptomatic COVID-19 infection or incidental infection with SARS-CoV-2 in the presence of another disease process that has similar symptoms. We sought to accurately understand the COVID-19 disease burden in hospitalized pediatric patients at our center.

METHODS

Setting and Patient Population

This study was conducted at a 358-bed tertiary care children's hospital with a catchment area encompassing 1.3 million children across 12 counties in California. The study site is a safety net hospital, with 75% of the patients being funded by a government payer. It is one of the largest children's hospitals in the United States. The region was heavily impacted by COVID-19 in adults during this time, resulting in hospitals transferring pediatric patients to our tertiary care site to accommodate larger volumes of adults.

This study is a retrospective case series of all patients hospitalized at our institution with SARS-CoV-2 positivity between May 1, 2020, and September 30, 2020. It was approved by our organizational institutional review board. The time period reviewed was chosen on the basis of the dates our institution adopted universal testing of inpatients (mid-April 2020) and when our first patient who tested positive for SARS-CoV-2 was admitted (early May 2020), as well as a desire to avoid potential confounding from overlap with typical fall respiratory virus season.

Inclusion criteria were age <22 years (per our organizational age threshold for pediatric patients), by either positive SARS-CoV-2 test results by polymerase chain reaction (PCR) at our institution or documented positive PCR or antigen test result at a referring facility for patients transferred in, and date of hospitalization between May 1, 2020 and September 30, 2020. Exclusion criteria were age ≥22 years at the time of admission, negative results or no documented SARS-CoV-2 PCR or antigen assay, including those with negative SARS-CoV-2 PCR results or antigen and positive SARS-CoV-2 immunoglobulin G (IgG) results, and documentation of false-positive SARS-CoV-2 PCR or antigen test results.

Data Collection

We manually reviewed the electronic medical record of all patients hospitalized at our center with a positive SARS-CoV-2 PCR or antigen test result during the study period for demographic, clinical, laboratory, radiographic, reason for admission and hospitalization outcome data from admission to discharge. The compiled data were maintained electronically on site, adhering to institutional review board protocol. All chart review was conducted by the 2 principal study authors, and a random selection of charts were reviewed independently by each to ensure interrater reliability. There were no discrepancies between the 2 reviewers' independent assessments.

Study Definitions

Self-reported ethnicity was characterized consistent with our electronic health record as Hispanic and non-Hispanic. Patients were categorized as medically complex if they were technology dependent, considered medically fragile (ie, oncologic diagnosis), had comorbidities requiring multiple specialists, or had a severe disability.[8,9] Obesity was defined as BMI (or weight for age if aged <2 years), greater than or equal to the 95th percentile for age.[10]

Reason for admission was determined as the principal clinical diagnosis necessitating hospital admission. As a surrogate for socioeconomic status, payer status was determined as public, private, or uninsured.

Incidental diagnosis was defined as patients with no documentation of fever, respiratory symptoms (cough, shortness of breath, or difficulty breathing), or gastrointestinal (GI) symptoms (nausea, vomiting, or abdominal pain) before admission or during hospitalization. Patients who were admitted with these symptoms but had a clearly documented alternative reason for them were also deemed to have incidental diagnosis. For example, a child presenting with abdominal pain and fever with positive SARS-CoV-2 PCR test results but found to have an intraabdominal abscess requiring drainage and antibiotic therapy would be classified as being incidentally diagnosed.

Potentially symptomatic was defined as patients with fever or respiratory or GI symptoms who did not require respiratory support or intervention but also did not have a clearly documented alternative explanation. Patients with diabetic ketoacidosis (DKA), appendicitis, and neonatal "rule out serious bacterial infection" were classified in this group. COVID-19 was not the primary reason for admission for these patients, and COVID-19 alone did not directly require hospitalization without the concomitant condition (this group includes 3 patients with appendicitis who received supplemental oxygen in documented conjunction with narcotic administration).

Significantly symptomatic was defined as patients with respiratory or cardiac symptoms consistent with COVID-19 requiring respiratory support or ICU-level care (1 child tested positive for SARS-CoV-2 PCR and IgG and presented with chest pain but only had 1 organ system involved and was characterized as having COVID-19 myocarditis).

Patients were identified as having multisystem inflammatory syndrome in children (MIS-C) if that was the discharge diagnosis by the physician who provided the clinical care and if they met Centers for Disease Control and Prevention criteria for MIS-C.[11]

Data Analysis

Descriptive statistics were used to summarize characteristics of patients overall and in each severity category. χ^2 or Fisher's exact test was used to investigate the level of association among categorical variables. The Kruskal-Wallis test was used to analyze continuous variables (age, length of stay [LOS]). A P value of <0.05 was considered statistically significant.

Analyses were conducted by using SPSS version 26 (IBMS SPSS Statistics, IBM Corporation).

RESULTS

Our institutional quality department provided a list of 184 patients admitted with a positive SARS-CoV-2 test result during the study period. This included patients tested via PCR or IgG in our facility as well as patients admitted with a positive PCR or antigen test result at an outside facility before transfer. Three duplicate names were identified, yielding 181 unique patients. Eleven patients on the list had a negative SARS-CoV-2 PCR result and were thus excluded from analysis. During chart review, an additional 7 patients were determined to have had a false-positive SARS-CoV-2 PCR test result. These patients were also excluded from analysis, resulting in inclusion of 163 unique patients. (Fig 1)

Patients were classified according to the categories defined above: those who appeared to have incidentally tested positive for SARS-CoV-2 after presenting without any of the described symptoms and being hospitalized for another reason, those who exhibited some of the described symptoms of COVID-19 but were hospitalized for other reasons and required no interventions related to their COVID-19 diagnosis during their hospitalization, those who appeared significantly symptomatic and for whom COVID-19 was either the reason for admission or the basis of some or all of the treatments or interventions performed, and those identified as having or likely having MIS-C.

Seventeen of 163 patients were diagnosed with MIS-C (see Table 1). These patients were excluded from subsequent analysis because our focus was acute SARS-CoV-2 positivity. Analysis of our complete MIS-C population is planned in a forthcoming article.

Forty percent (58 of 146) of non-MIS-C patients were classified as having incidental infection. Forty-seven percent (68 of 146) of these were classified as potentially symptomatic, and 14% (20 of 146) were classified as significantly symptomatic. Average LOS differed significantly among these groups, with incidental diagnosis (4.8 days) and potentially symptomatic (3.7 days) differing from significantly symptomatic (12.6 days, $P = .002$). The average age differed substantially among these groups (incidental diagnosis 8 years, potentially symptomatic 8.6 years), with the significantly symptomatic patients older (11.1 years); however, this did not reach statistical significance ($P = 0.11$). See Table 2 for statistical analysis.

A majority of patients in all groups were Hispanic, with no significant difference among groups. In total, 125 of 146 (86%) were Hispanic, compared with 66.2% of overall admissions (3831) during the same time period. Similarly, there was no significant difference among groups with respect to primary language spoken, with Spanish the most common after English (34%). This was also higher than the percentage of Spanish-speaking patients admitted to our institution during the same time period (17.8%). Eighty-eight percent of patients were publicly insured or uninsured, compared with 74.8% of overall admissions to our institution during the same time period.

Eighteen percent (26 of 146) of patients presented with acute appendicitis. All but 1 were categorized as potentially symptomatic because of their GI symptoms. One was categorized as significantly symptomatic because of supplemental oxygen use >24 hours not clearly documented as being secondary to narcotics.

Eight percent (11 of 146) of patients presented with an isolated skeletal fracture, all of whom were classified as incidental diagnoses. Nine (6%) presented with seizure, of which, 7 were classified as incidental diagnoses and 2 were classified as potentially symptomatic on the basis of the definitions above. Six percent presented with neonatal fever, all of whom were classified as potentially symptomatic and none of whom required intervention beyond monitoring of cultures and antibiotics. Eight (5%) patients presented with DKA, of which 7 were categorized as potentially symptomatic and 1 as significantly symptomatic because of need for PICU admission. See Table 3 for reason for admission breakdown.

COVID-19 was the reason for admission in 0 of 58 incidental diagnosis patients, compared with 11% of potentially symptomatic patients and 80% of significantly symptomatic patients ($P <$ .001). Forty-five percent of incidental and 47% of potentially symptomatic patients had no identified comorbidities, whereas 10% of significantly symptomatic patients had none ($P = .01$). With specific comorbidities, there was a significant relationship for obesity, with 19% and 22% of incidental and potentially symptomatic patients obese versus 60% of significantly symptomatic patients ($P = .001$). The same relationship was seen with asthma, with 5% and 10% of incidental and potentially symptomatic patients with asthma versus 35% of significantly symptomatic patients ($P = .004$). There was no statistically

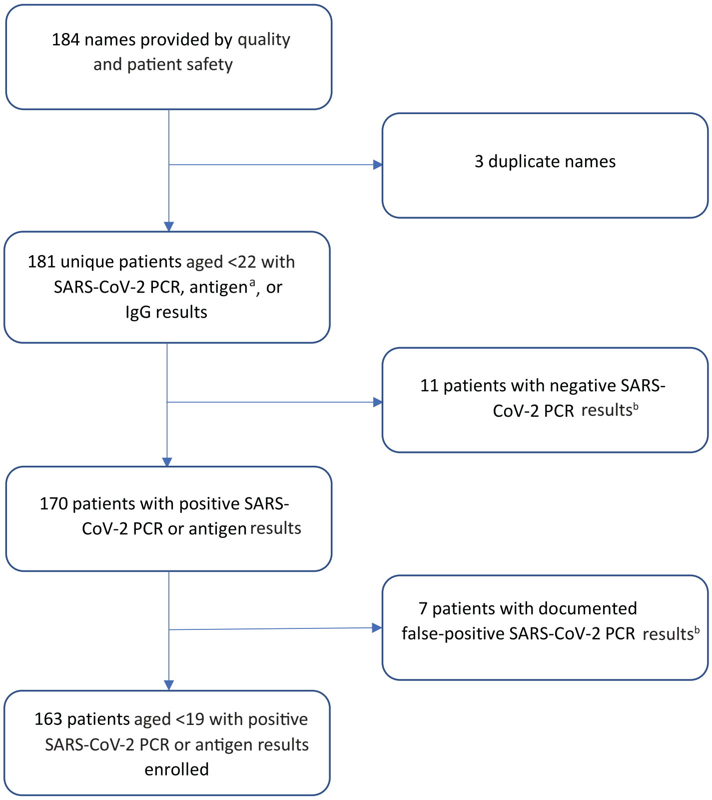

FIGURE 1 Flow diagram of patients included in the study. [a] Patients transferred in from referring centers with positive SARS-CoV-2 test results did not have study repeated. Most of these were PCRs, but some were antigen tests. None were antibody tests. All negative referrals had a confirmatory PCR sent at our institution. [b] The 11 patients with negative SARS-CoV-2 PCR results had positive IgG results, hence inclusion on the list we received. All 11, as well as all 7 of the tests deemed to have false-positive results, were performed at our institution and were PCR tests.

significant relationship among groups for history of diabetes, seizure disorder, or medical complexity.

There were statistically significant relationships among groups with respect to history of fever, respiratory, and GI symptoms. Seventy-five percent of significantly symptomatic versus 51% and 7% of potentially symptomatic and incidental patients presented with history of fever ($P < .001$). Seventy-five percent of potentially symptomatic patients versus 33% and 45% of incidental and significantly symptomatic patients presented with GI symptoms ($P < .001$). Eighty-five percent of significantly symptomatic patients versus 24% of potentially symptomatic patients and none of the incidental diagnosis patients presented with respiratory symptoms ($P < .001$).

There was a statistically significant relationship among groups with respect to documented fever > 38°C, hypoxia < 90%, supplemental oxygen use, duration of supplemental oxygen therapy > 48 hours, and PICU admission, with a significantly higher percentage of patients in the significantly symptomatic group meeting each of these criteria ($P < .001$ for all, see Table 2). Five patients in the incidental diagnosis group required supplemental oxygen; all were intubated. Two were multisystem organ trauma patients admitted for airway protection and 3 were deaths determined to have been unrelated to COVID-19. Apart from these 5, all patients who required more respiratory support than simple nasal cannula were categorized as significantly symptomatic.

There were 4 deaths in our population (see Table 4). One, in a medically complex 16-year-old admitted for respiratory failure, was attributed to COVID-19. The other 3 were determined by our organization and local public health officials as not related to COVID-19 and were thus categorized as incidental diagnoses.

Seven patients received Remdesivir. All of these patients also received Dexamethasone and required PICU admission and substantial respiratory support. Eight patients required intubation, including the 5 discussed above, an extremely premature infant who developed apnea and desaturations and had a positive SARS-CoV-2 PCR test result midway through a prolonged NICU course, and a medically complex 10-year-old with holoprosencephaly, refractory epilepsy, severe malnutrition, and severe chronic lung disease with home oxygen dependence. There was only 1 patient who had a respiratory coinfection: the medically complex 16-year-old who died had coinfection with adenovirus.

DISCUSSION

Currently available disease classification schemes[2–4] that would categorize a patient on substantial positive pressure support in the same category as or minimally different from a patient admitted for appendicitis not requiring oxygen, are neither clinically helpful nor likely meaningful to the patients and families with whom we discuss disease severity.

We offer an alternative classification scheme that would recognize the significance of hospitalization all or in part because of COVID-19 and requiring intervention specifically for that, but we also acknowledge that there is a substantial portion of patients for whom COVID-19 was either incidental or minimally related to hospitalization. In our large population, that percentage was a majority of patients (126 of 146, 86%). As such, we sought to provide a classification that more accurately represents the disease burden for hospitalized pediatric patients.

TABLE 1 Demographics and Clinical Characteristics of the 4 Distinct Groups

Characteristic	All (*N* = 163)	Incidental (*n* = 58)	Potentially (*n* = 68)	Significantly (*n* = 20)	MIS-C (*n* = 17)
Age in y, mean (median)	8.7 (9)	8.0 (8.5)	8.6 (9)	11.1 (15)	8.3 (7)
Sex, female, *n* (%)	69 (42)	28 (48)	26 (38)	10 (50)	5 (29)
LOS in d, mean (median)	5.7 (3)	4.5 (2)	3.7 (2.5)	12.6 (6)	8.9 (8)
Ethnicity, *n* (%)					
Hispanic	138 (85)	51 (88)	56 (82)	18 (90)	13 (77)
Non-Hispanic	25 (9)	7 (12)	12 (18)	2 (10)	4 (24)
Insurance type, *n* (%)					
Public or uninsured	143 (88)	55 (95)	58 (85)	15 (75)	15 (88)
Private	20 (12)	3 (5)	10 (15)	5 (25)	2 (12)
Language, *n* (%)					
English	104 (64)	35 (60)	45 (66)	13 (65)	11 (65)
Spanish	54 (33)	21 (36)	21 (31)	7 (35)	5 (29)
Other	5 (3)	2 (3)	2 (3)	0 (0)	1 (6)
Comorbidities, *n* (%)					
Any	95 (58)	32 (55)	36 (53)	18 (90)	9 (53)
Obesity	44 (27)	11 (19)	15 (22)	12 (60)	6 (35)
Asthma	20 (12)	3 (5)	7 (10)	7 (35)	3 (18)
Diabetes	13 (8)	4 (7)	8 (12)	1 (5)	0 (0)
Seizures	10 (6)	7 (12)	3 (4)	2 (10)	0 (0)
Medically complex, *n* (%)	25 (15)	11 (19)	7 (10)	6 (30)	1 (6)
COVID-19 reason for admission, *n* (%)[a]					
Yes	31 (19)	0 (0)	7 (11)	16 (80)	8 (47)
No	126 (77)	58 (100)	59 (87)	4 (20)	5 (29)
Unclear	6 (4)	0 (0)	2 (3)	0 (0)	4 (24)
Required ICU care, *n* (%)	38 (23)	7 (12)	6 (9)	12 (60)	13 (76)
History, *n* (%)[b]					
Fever	71 (44)	4 (7)	35 (52)	15 (75)	17 (100)
Respiratory symptoms	36 (22)	4 (7)	16 (24)	17 (85)	3 (18)
GI symptoms	91 (56)	0 (0)	51 (75)	9 (45)	13 (77)
Documented, *n* (%)					
Fever	56 (34)	4 (7)	26 (38)	13 (65)	13 (77)
Hypoxia	18 (11)	3 (5)[c]	1 (2)[d]	11 (55)	3 (18)
Supplemental oxygen	27 (19)	5 (9)	3 (4)	19 (95)	9 (53)

[a] For patients with MIS-C as reason for admission, COVID-19 as reason for admission was "yes" answer.
[b] There were 4 patients, all categorized as incidental diagnosis, admitted for multisystem trauma in which there was no documented review of systems and thus historical symptoms were categorized as "unclear." The total of the "yes" and "no" fields for historical symptoms is thus 54.
[c] Three deaths not attributed to COVID-19.
[d] Patient with congenital heart disease with documented baseline statistics <90%.

Similar to previous studies,[12,13] we had a substantial proportion of patients who were classified as having incidental diagnosis (40%). Furthermore, the 47% of patients in the potentially symptomatic category did not manifest COVID-19 disease that would otherwise require hospitalization. There was notable similarity between these 2 categories with respect to age, LOS, comorbidities, historical symptoms, and lack of interventions related to COVID-19. This serves to further highlight the lower degree of morbidity that pediatric patients experience from SARS-CoV-2.

During this time, our institution was the only facility caring for hospitalized pediatric patients who tested positive for SARS-CoV-2 within our large catchment area, and, thus, our population of these patients represents a comprehensive and accurate assessment of the disease burden of COVID-19 in children requiring hospitalization during the time period of interest.

The patient population with significantly symptomatic disease fits the description of adults[14] and children[15] who are also at higher risk of more severe disease, with significantly longer LOS, greater

TABLE 2 Characteristics and Statistical Analysis of 3 Subgroups

Variable	Diagnosis Group			P
	Incidental Diagnosis (n = 58)	Potentially Symptomatic (n = 68)	Significantly Symptomatic (n = 20)	
Age, mean (SD), y	8.0 (6.1)	8.6 (6.0)	11.1 (6.6)	.11
LOS, mean (SD), d	4.8 (9.7)	3.7 (3.5)	12.6 (24.1)	.002
Sex, n (%)				
Female	28 (48)	26 (38)	10 (50)	—
Male	30 (52)	42 (62)	10 (50)	—
Ethnicity, n (%)				.61
Hispanic	51 (88)	56 (82)	18 (90)	
Non-Hispanic	7 (12)	12 (18)	2 (10)	
Primary language, n (%)				.96
English	35 (60)	45 (66)	13 (65)	
Spanish	21 (36)	21 (31)	7 (35)	
Other	2 (3)	2 (3)	0 (0)	
Insurance type, n (%)				.03
Private	3 (5)	10 (15)	5 (25)	
Public	55 (95)	55 (81)	15 (75)	
Uninsured	0 (0.0)	3 (4)	0 (0)	
COVID-19 reason for admission, n (%)				<.001
No	58 (100)	59 (89)	4 (20)	
Yes	0 (0)	7 (11)	16 (80)	
Comorbidity: any, n (%)				.01
No	26 (45)	32 (47)	2 (10)	
Yes	32 (55)	36 (53)	18 (90)	
Comorbidity: obesity, n (%)				.001
No	47 (81)	53 (78)	8 (40)	
Yes	11 (19)	15 (22)	12 (60)	
Comorbidity: asthma, n (%)				.004
No	55 (95)	61 (90)	13 (65)	
Yes	3 (5)	7 (10)	7 (35)	
Medically complex, n (%)				.09
No	47 (81)	61 (90)	14 (70)	
Yes	11 (19)	7 (10)	6 (30)	
History of respiratory symptoms, n (%)[a]				<.001
No	54 (100)	52 (76)	3 (15)	
Yes	0 (0)	16 (24)	17 (85)	
History of fever, n (%)[a]				<.001
No	50 (93)	33 (49)	5 (25)	
Yes	4 (7)	35 (51)	15 (75)	
History of GI symptoms, n (%)[a]				<.001
No	36 (67)	17 (25)	11 (55)	
Yes	18 (33)	51 (75)	9 (45)	
Maximum temperature, n (%)				<.001
>38°C	4 (7)	26 (38)	13 (65)	
≤38°C	54 (93)	42 (62)	7 (35)	

TABLE 2 Continued

Variable	Diagnosis Group			P
	Incidental Diagnosis (n = 58)	Potentially Symptomatic (n = 68)	Significantly Symptomatic (n = 20)	
Lowest oxygen saturation, n (%)				<.001
<90%	3 (5)	1 (1)	11 (55)	
90%–92%	1 (2)	2 (3)	3 (15)	
>92%	54 (93)	65 (96)	6 (30)	
Supplemental oxygen, n (%)[b]				<.001
No	53 (91)	65 (96)	1 (5)	
Yes	5 (9)	3 (4)	19 (95)	
Respiratory support, n (%)				<.001
CPAP or BiPAP	0 (0)	0 (0)	2 (10)	
High-flow nasal cannula	0 (0)	0 (0)	7 (35)	
Intubated	5 (9)	0 (0)	3 (15)	
Simple nasal cannula	0 (0)	3 (4)	7 (35)	
None	53 (91)	65 (96)	1 (5)	
Duration of oxygen use, n (%)				<.001
≤24 h	1 (2)	2 (3)	2 (10)	
24–48 h	0 (0)	0 (0)	6 (30)	
>48 h	4 (7)	1 (1)	11 (55)	
None	53 (91)	65 (96)	1 (5)	
PICU, n (%)[c]				<.001
No	51 (88)	62 (91)	8 (40)	
Yes	7 (12)	6 (9)	12 (60)	

BiPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure; —, not applicable.
[a] Four patients in the incidental diagnosis group had no documented review of systems and were excluded from analysis of historical symptoms.
[b] Includes 3 deaths deemed not related to COVID, and 2 multisystem trauma patients intubated for airway protection.
[c] Includes 5 patients above plus another multisystem trauma and a patient with ingestion and altered mental status.

proportion of obesity and asthma, and older age (the latter clinically if not statistically significant). With inclusion of children in vaccine trials as well as evaluation of high-risk populations for monoclonal antibody therapy, this delineation of patients at higher risk for significantly symptomatic disease is critical.[13]

In our potentially symptomatic category, 37% of patients had appendicitis. It has been hypothesized that SARS-CoV-2 can make patients more susceptible to developing appendicitis[16–18]; however, no mechanism for this has been described. Given the fact that patients with appendicitis universally have abdominal pain, it seems likely that a positive SARS-CoV-2 test result in this instance is coincidental rather than causative.

Our region has a high number of frontline workers, particularly those working in agriculture, which likely contributed to the local impact of COVID-19 in adults. We found similar trends in socioeconomic status and ethnicity to previously published studies.[19,20] Specifically, even accounting for a high percentage of admissions of Hispanic, Spanish-speaking, and publicly insured children during the same time period, these populations were substantially overrepresented in our SARS-CoV-2 patients (86% vs 66.2% Hispanic, 34% vs 17.8% Spanish-speaking, and 88% vs 74.8% publicly insured or uninsured). Current available data reveal that vaccination rates among Hispanic/Latinx individuals lag substantially behind non-Hispanic white individuals, despite this population being heavily represented in essential industries.[21] This further highlights the need to focus education and mitigation efforts on these groups, as well as to effectively prioritize them for vaccination.

Because decisions regarding school reopening continue to be linked largely to community transmission rates,[12,22] an accurate understanding of the true disease burden of COVID-19 in children is crucial. The same ethnic and socioeconomic disparities seen in those testing positive for SARS-CoV-2 are seen in the industries deemed essential, leading to a population of parents simultaneously most vulnerable to COVID-19 and to the potentially devastating economic and safety consequences of lack of child care.[23] Although our study does not directly address these, it does highlight that the burden of physiologically significant COVID-19 disease in an ethnically and socioeconomically vulnerable pediatric population during a time of high community transmission was overall low, and this is an important consideration in the broader context of public health and policy making.

TABLE 3 Reason for Admission by Subgroup

Reason for Admission	n (%)		
	Incidental (n = 58)	Potentially (n = 68)	Significantly (n = 20)
Respiratory distress	0 (0)	2 (3)	10 (50)
Appendicitis	0 (0)	25 (37)	1 (5)
LRTI or pneumonia	0 (0)	0 (0)	5 (25)
Fracture	11 (19)	0 (0)	0 (0)
Neonatal fever or ROS	0 (0)	9 (13)	0 (0)
Seizure	7 (12)	2 (3)	0 (0)
DKA	0 (0)	7 (10)	0 (0)
Trauma	5 (9)	0 (0)	0 (0)
Dehydration	0 (0)	5 (7)	0 (0)
Skin or soft tissue infection	3 (5)	2 (3)	0 (0)
Scheduled admission	3 (5)	0 (0)	0 (0)
Abdominal pain	2 (3)	1 (2)	1 (5)
Asthma	0 (0)	0 (0)	1 (5)
Ingestion	2 (3)	0 (0)	0 (0)
Intussusception	2 (3)	0 (0)	0 (0)
Feeding intolerance or poor feeding	1 (2)	1 (2)	0 (0)
GI bleed	1 (2)	1 (2)	0 (0)
Other	22 (38)	13 (19)	2 (10)

LRTI, lower respiratory tract infection; ROS, rule out sepsis.

Our study has several limitations. Our data were obtained from a single center. The time frame was limited to avoid overlap with respiratory virus season, which ultimately has had minimal impact this year. We intentionally excluded MIS-C patients from our final analysis, given the fact that our inclusion criteria would have missed some of them; however, it is certainly important to include MIS-C in the consideration of COVID-19 disease burden in children. We had 4 incidental diagnosis patients for whom review of systems data were lacking; however, the likelihood of missing clinically significant COVID-19 disease in these patients is low, given lack of intervention required while hospitalized.

Our study adds meaningfully to what is currently known about COVID-19 in children by highlighting that, although a positive SARS-CoV-2 test result may be relatively common in hospitalized children during the COVID-19 pandemic, true need of hospital-level intervention for COVID-19 disease itself occurs in a minority of hospitalized patients. Despite a minority of patients who tested positive for SARS-CoV-2 having COVID-19 illness, our study underscores patients with asthma and obesity are at highest risk for severe disease.

Our classification scheme offers a clinically, as well as epidemiologically, useful tool for clinicians and particularly pediatric hospitalists to conceptualize pediatric SARS-CoV-2 hospitalizations and COVID-19 risk. Despite our using a conservative threshold in defining “potentially symptomatic,” there was virtually no statistically or clinically meaningful difference between “incidental diagnosis” and this group. Given the similarity between incidentally and potentially or minimally symptomatic patients, prospective application of our classification criteria would provide a practical, safe means of identifying and prioritizing hospitalized pediatric patients at risk for severe disease.

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REFERENCES

1. Sisk B, Cull W, Harris JM, Rothenburger A, Olson L. National trends of cases of COVID-19 in children based on US State Health Department data. *Pediatrics*. 2020;146(6):e2020027425

2. Parri N, Magistà AM, Marchetti F, et al; CONFIDENCE and COVID-19 Italian Pediatric Study Networks. Characteristic of COVID-19 infection in pediatric

TABLE 4 Deaths in Our Population

Deaths	Age, y	Clinical Details	Attributed to COVID-19[a]
1	16	Medically complex patient admitted for respiratory failure	Yes
2	7	Previously healthy patient admitted after a submersion in a local body of water. SARS-CoV-2 PCR test results were positive. The patient died within 48 h of admission.	No
3	17	Medically complex patient who presented to the ED with a small bowel obstruction and died within 24 h. The patient had GI symptoms but no other history consistent with or concerning for SARS-CoV-2.	No
4	13	Oncology patient who had a prolonged hospitalization and ultimately died of sepsis. At admission, the patient tested positive for SARS-CoV-2 but was asymptomatic. The patient died almost 6 wk after the positive test result.	No

ED, emergency department.
[a] COVID-19 attribution was determined by our organization in conjunction with the local public health department.

patients: early findings from two Italian pediatric research networks. *Eur J Pediatr.* 2020;179(8):1315–1323

3. Dong Y, Mo X, Hu Y, et al. Epidemiology of COVID -19 among children in China. *Pediatrics.* 2020;145(6):e20200702
4. Bailey LC, Razzaghi H, Burrows EK, et al. Assessment of 135 794 pediatric patients tested for severe acute respiratory syndrome coronavirus 2 across the United States. *JAMA Pediatr.* 2021;175(2):176–184
5. Otto WR, Geoghegan S, Posch LC, et al. The epidemiology of severe acute respiratory syndrome coronavirus 2 in a pediatric healthcare network in the United States. *J Pediatric Infect Dis Soc.* 2020;9(5):523–529
6. Hoang A, Chorath K, Moreira A, et al. COVID-19 in 7780 pediatric patients: a systematic review. *EClinicalMedicine.* 2020;24:100433
7. Song X, Delaney M, Shah RK, Campos JM, Wessel DL, DeBiasi RL. Comparison of clinical features of COVID-19 vs seasonal influenza A and B in US Children. *JAMA Netw Open.* 2020;3(9):e2020495
8. Kuo DZ, Houtrow AJ; Council on Children With Disabilities. Recognition and management of medical complexity. *Pediatrics.* 2016;138(6):e20163021
9. Cohen E, Kuo DZ, Agrawal R, et al. Children with medical complexity: an emerging population for clinical and research initiatives. *Pediatrics.* 2011;127(3):529–538
10. Centers for Disease Control and Prevention. Defining childhood obesity. 2019. Available at: https://www.cdc.gov/obesity/childhood/defining.html. Accessed November 25, 2020
11. Centers for Disease Control and Prevention. Multisystem inflammatory syndrome in children (MIS-C) associated with coronavirus disease 2019 (COVID-19). 2020. Available at: https://emergency.cdc.gov/han/2020/han00432.asp. Accessed December 1, 2020
12. Shane AL, Sato AI, Kao C, et al. A pediatric infectious diseases perspective of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and novel coronavirus disease 2019 (COVID-19) in children. *J Pediatric Infect Dis Soc.* 2020;9(5):596–608
13. Zachariah P, Johnson CL, Halabi KC, et al; Columbia Pediatric COVID-19 Management Group. 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. *JAMA Pediatr.* 2020;174(10):e202430
14. Hu J, Wang Y. The clinical characteristics and risk factors of severe COVID-19. *Gerontology.* 2021;67(3):255–266
15. Verma S, Lumba R, Dapul HM, et al. Characteristics of hospitalized children with SARS-CoV-2 in the New York City metropolitan area. *Hosp Pediatr.* 2021;11(1):71–78
16. Gerall CD, DeFazio JR, Kahan AM, et al. Delayed presentation and sub-optimal outcomes of pediatric patients with acute appendicitis during the COVID-19 pandemic. *J Pediatr Surg.* 2021;56(5):905–910
17. Malhotra A, Sturgill M, Whitley-Williams P, et al. Pediatric COVID-19 and appendicitis: a gut reaction to SARS-CoV-2? *Pediatr Infect Dis J.* 2021;40(2):e49–e55
18. Fisher JC, Tomita SS, Ginsburg HB, Gordon A, Walker D, Kuenzler KA. Increase in pediatric perforated appendicitis in the New York City metropolitan region at the epicenter of the COVID-19 outbreak. *Ann Surg.* 2021;273(3):410–415
19. Hawkins RB, Charles EJ, Mehaffey JH. Socio-economic status and COVID-19-related cases and fatalities. *Public Health.* 2020;189:129–134
20. Bhavsar SM, Clouser KN, Gadhavi J, et al. COVID-19 in Pediatrics: Characteristics of Hospitalized Children in New Jersey. *Hosp Pediatr.* 2021;11(1):79–87
21. CalMatters. Who's vaccinated in California: a county-by-county look at racial data. Available at: https://calmatters.org/health/coronavirus/2021/02/whos-vaccinated-california-by-county/. Accessed February 23, 2021
22. COVID-19 and Reopening In-Person Instruction Framework & Public Health Guidance for K-12 Schools in California, 2020-2021 School Year. Available at: https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/COVID-19/COVID19-K12-Schools-InPerson-Instruction.aspx#School%20Reopening%20Guidance. Accessed February 23, 2021
23. Robert Wood Johnson Foundation. Parents are struggling to provide for their families during the pandemic. Available at: https://www.rwjf.org/en/library/research/2020/05/parents-are-struggling-to-provide-for-their-families-during-the-pandemic.html. Accessed February 23, 2021

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