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SHORT COMMUNICATION

Demographic predictors of hospitalization and mortality in US children with COVID-19

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Abstract

Understanding which children are at increased risk for poor outcome with COVID-19 is critical. In this study, we link pediatric population–based data from the US Center for Disease Control and Prevention to COVID-19 hospitalization and in-hospital death. In 27,045 US children with confirmed COVID-19, we demonstrate that African American [OR 2.28 (95% CI: 1.93, 2.70)] or mixed race [OR 2.95 (95% CI: 2.28, 3.82)] and an underlying medical condition [OR 3.55 (95% CI: 3.14, 4.01)] are strong predictors for hospitalization. Death occurred in 39 (0.19%) of 20,096 hospitalized children; children with a prior medical condition had an increased odd for death [OR 8.8 (95% CI: 3.7, 21.1)].

Conclusion: Hospitalization and in-hospital death are rare in children diagnosed with COVID-19. However, children at higher risk for these outcomes include those with an underlying medical condition, as well as those of African American descent.

What is Known:
• *Demographic factors are independent prognosticators of poor outcome in children with COVID-19.*

What is New:
• *Children with an underlying medical condition and those from an African American or mixed race/ethnicity are at high risk for COVID-19 hospitalization.*
• *History of a comorbidity supersedes age, gender, and race/ethnicity as a risk factor for in-hospital pediatric COVID-19 death.*

Keywords COVID-19 · SARS-CoV-2 · Pediatric · Children · COVID-NET

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Abbreviations

CDC	Centers for Disease Control and Prevention
CI	Confidence interval
COVID-19	Coronavirus disease 2019
COVID-NET	COVID-19-Associated Hospitalization Surveillance Network
MIS-C	Multisystem inflammatory syndrome in children
NH	Non-Hispanic
OR	Odds ratio

Introduction

As of January 19, 2021, more than 23M cases of COVID-19 have been confirmed in the USA [1]. A recent report from the American Academy of Pediatrics and the Children's Hospital

Association estimates nearly 2.5M total COVID-19 cases in US children [2]. Previous studies have shown that age, gender, race/ethnicity, and underlying medical conditions are independent risk factors for poor outcome in COVID-19 [3–6]. Understanding the role these factors play in severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) may inform clinicians, researchers, and governing agencies which children are at highest risk for severe COVID-19. Thus, our goal was to quantify the relationship between demographic factors and US pediatric COVID-19 hospitalization and death.

Methods

The Centers for Disease Control and Prevention COVID-19-associated hospitalization surveillance network (CDC COVID-NET) is a population-based system that captures laboratory-confirmed COVID-19 cases in over 250 US acute-care hospitals [7]. s -. The CDC COVID-NET is comprised of demographic variables (e.g., gender, age group, race and ethnicity, medical conditions) and date of positive SARS-CoV-2 test, as well as outcomes, including hospitalization and mortality. Evidence of COVID-19 cases were evaluated for a postive detection of SARS-CoV-2 via nasopharyngeal/throat swabs or serologic testing.The database stratifies the variables as follows:

- Age group: stratified to 0–9 years or 10–19 years
- Gender: male or female
- Race and ethnicity: White, Non-Hispanic (NH); Black, NH; Hispanic/Latino; Asian, NH; Multiple/other, NH, Hawaiian/Pacific Islander, NH; Alaskan/American Indian, NH
- Medical condition: yes or no
- Hospitalization: yes or no
- Death: yes or no

Our primary outcomes were hospitalization and in-hospital mortality. The data from the CDC COVID-NET was downloaded on August 17, 2020, and captured pediatric COVID-19 rates in the USA between March 2, 2020, and July 16, 2020. Although the database included a total of 229,052 children, we only included children that had complete information (e.g., no missing data). We examined the association of age, gender, race and ethnicity, and medical condition on hospitalization, followed by in-hospital mortality. The following underlying illnesses yielded a "yes" answer on the "medical condition" field: asthma, autoimmune disease, cardiovascular disease, chronic lung disease, gastrointestinal/liver disease, hypertension, immune suppression, metabolic disease, neurologic disease, obesity, pregnancy, renal disease, or other disease.

All demographic variables were included in the multivariable logistic regression model. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. A p value < 5% was considered statistically significant. Analyses were performed in STATA (version 13, College Station, TX). Since the data is publicly available and reported in a de-identified fashion, ethical approval to analyze the data was not warranted by local authorities.

Results

Hospitalization

A total of 27,045 US children with COVID-19 were included in this report. The majority (n = 18,924; 70.0%) of children were between the ages of 10 and 19 years with a similar gender distribution (please refer to Table 1). Hispanic/Latino, White, non-Hispanic, and Black, non-Hispanic totaled 90.3% of the population. Thirty-nine percent (n = 10,438) of the children had an underlying medical condition.

Of the 27,045 children, 1,274 (4.7%) required hospitalization. Multivariate analysis demonstrated that age, race/ethnicity, and medical conditions were significant features for hospitalization. Specifically, COVID-19-positive children < 10 years of age [OR 1.5 (95% CI 1.3, 1.7)] who were Black or of mixed race/ethnicity, and with a medical condition [OR 3.6 (95% CI 3.1, 4.0)] associated with a higher odd for hospitalization (see Table 2).

Mortality

Mortality data was available for 20,096 (74.3%) individuals that were hospitalized (refer to Table 3). Death occurred in 39 (0.19%) hospitalized children. Demographic differences observed between survivors and non-survivors included race and an underlying medical condition. Children who were black, non-Hispanic [OR 3.0 (95% CI 1.3, 6.7)], and those with an underlying medical condition [OR 8.8 (95% CI 3.7, 21.1)] had an increased odd for death. Please see Table 4 for more details.

Discussion

In a large US cohort of confirmed COVID-19 children, we found that hospitalization occurred 4.7% of the time with an in-hospital mortality rate of 0.19%. Cases of COVID-19 were more frequently observed in children older than 10 years of age and those of Hispanic/Latino and White, non-Hispanic race/ethnicity. However, children more likely to be hospitalized or die were Black, non-Hispanic and children with an

Table 1 Demographic characteristics of hospitalized US children with COVID-19

Variable	Total (n=27,045)	Non-hospitalized (n=25,771)	Hospitalized (n=1,274)	p value
Age				< 0.01
0–9 years	8,121	7,639 (94.1%)	482 (5.9%)	
10–19 years	18,924	18,132 (95.8%)	792 (4.2%)	
Sex				0.99
Female	13,959	13,299 (95.3%)	660 (4.7%)	
Male	13,086	12,472 (95.3%)	614 (4.7%)	
Race/ethnicity				< 0.01
White, NH	7,974	7,717 (96.8%)	257 (3.2%)	
Black, NH	4,224	3,876 (91.8%)	348 (8.2%)	
Hispanic/Latino	12,236	11,697 (95.6%)	539 (4.4%)	
Asian, NH	972	936 (96.3%)	36 (3.7%)	
Multiple/other, NH	980	894 (91.2%)	86 (8.8%)	
Hawaiian/Pacific Islander, NH	478	471 (98.5%)	7 (1.5%)	
Alaskan/American Indian, NH	181	180 (99.4%)	1 (0.6%)	
Comorbidity				< 0.01
No	16,607	16,195 (97.5%)	412 (2.5%)	
Yes	10,438	9,576 (91.7%)	862 (8.3%)	

NH non-Hispanic

underlying health condition. Interestingly, medical condition was the strongest risk factor for a poor outcome.

Table 2 Multivariable logistic regression evaluating risk factors associated with US pediatric COVID-19 hospitalization (n = 27,045)

Variable	Odds ratio	95% CI	p value
Age			
0–9 years	1.48	1.31–1.67	< 0.01
10–19 years	1 (reference)	–	–
Sex			
Female	1.03	0.92–1.16	0.56
Male	1 (reference)	–	–
Race/ethnicity			
White, NH	1 (reference)	–	–
Black, NH	2.28	1.93–2.70	< 0.01
Hispanic/Latino	1.38	1.19–1.61	< 0.01
Asian, NH	1.11	0.78–1.61	0.56
Multiple/other, NH	2.95	2.28–3.82	< 0.01
Hawaiian/Pacific Islander, NH	0.25	0.12–0.54	< 0.01
Alaskan/American Indian, NH	0.20	0.03–1.42	0.11
Comorbidity			
No	1 (reference)	–	–
Yes	3.55	3.14–4.01	< 0.01

CI confidence interval, *NH* non-Hispanic

Our data showed that Black, non-Hispanic and Hispanic children were 2.5 times more likely than White children to be hospitalized and 5 times more likely to die after infection with SARS-CoV-2. Several reasons exist for this continued pattern of disproportionate impact of COVID-19 in minorities. First, parents are among the greatest vector of the disease to children [6]. As such, parents who work in high "viral-contact" jobs are more likely to be minorities. For example, Williams et al. [8] described that many of the industries (e.g., gyms, hair salons, restaurants) that remained open during the pandemic are driven by workers who are predominantly minority. Second, poverty is more common among minority groups. A study by Adhikari and colleagues [9] concluded that counties with higher rates of poverty and those with more diverse populations had significantly higher infection and death rates compared to counties with a substantial White population. Next, lower socioeconomic status is intricately linked to larger household sizes, crowding, and therefore more cross-infection [10]. This emphasized the needed to untangle the differences in immunologic response to SARS-CoV-2 based on race/ethnicity [11].

A past medical history of an underlying condition was the strongest risk factor for poor outcome in US children with COVID-19. An earlier report in *Morbidity and Mortality Weekly Report* noted that Hispanic and non-Hispanic Black children had a higher prevalence of underlying conditions when compared to White children (45.7% vs. 29.8% vs. 14.9%, respectively) [5]. Similarly, our analysis of 27,045 pediatric cases of COVID-19 found that Black, non-

Table 3 Demographic characteristics of COVID-19-positive children with in-hospital death

Variable	Total (n= 20,096)	Survivors (n= 20,057)	Non-survivor (n= 39)	p value
Age				0.69
0–9 years	6,104	6,091 (99.8%)	13 (0.2%)	
10–19 years	13,992	13,966 (99.8%)	26 (0.2%)	
Sex				0.95
Female	10,415	10,395 (99.8%)	20 (0.2%)	
Male	9,681	9,662 (99.8%)	19 (0.2%)	
Race/ethnicity				< 0.01
White, NH	6,231	6,222 (99.9%)	9 (0.1%)	
Black, NH	3,182	3,166 (99.5%)	16 (0.5%)	
Hispanic/Latino	8976	8,965 (99.9%)	11 (0.1%)	
Asian, NH	645	645 (100%)	0 (0%)	
Multiple/other, NH	677	674 (99.6%)	3 (0.4%)	
Hawaiian/Pacific Islander, NH	273	273 (100%)	0 (0%)	
Alaskan/American Indian, NH	112	112 (100%)	0 (0%)	
Comorbidity				< 0.01
No	12,581	12,575 (99.95%)	6 (0.05%)	
Yes	7,515	7,482 (99.6%)	33 (0.4%)	

NH non-Hispanic

Hispanic children had a higher proportion of comorbidities when compared to White children (49.6% vs. 37.3%). Our findings that comorbidity and minority populations are at increased risk for COVID-19 death is reiterated in a study by Ahmed et al. [12]. Another recent meta-analysis examined the association of pediatric comorbidities with COVID-19 infection. In 42 studies, encompassing 275,661 children, Tsankov et al. summarized that children with comorbidities had a relative risk ratio of 1.79 for severe COVID-19 infection and 2.81 for COVID-19-related mortality.

Table 4 Multivariable logistic regression evaluating risk factors associated with pediatric COVID-19 in-hospital death (n = 20,096)

Variable	Odds ratio	95% CI	p value
Age			
0–9 years	1.24	0.63–2.43	0.53
10–19 years	1 (reference)	–	–
Sex			
Female	0.98	0.52–1.85	0.96
Male	1 (reference)	–	–
Race/ethnicity			
White, NH	1 (reference)	–	–
Black, NH	2.96	1.30–6.73	0.01
Hispanic/Latino	0.88	0.36–2.13	0.78
Asian, NH	1	–	–
Multiple/other, NH	3.33	0.90–12.37	0.07
Hawaiian/Pacific Islander, NH	1	–	–
Alaskan/American Indian, NH	1	–	–
Comorbidity			
No	1 (reference)	–	–
Yes	8.82	3.68–21.1	< 0.01

CI confidence interval, *NH* non-Hispanic

There are limitations to our study. First, although the data is derived from 14 states, it only represents 10% of the US population. Second, missing data was common in the database which decreased our overall sample size from 229,052 children to 27,045 pediatric cases. In particular, medical conditions had more than 50% of the data unknown or missing. Despite finding that a history of medical conditions impacts the trajectory of childhood COVID-19, the database is not granular in providing the specific conditions for each patient.

To our knowledge, this is the largest pediatric evaluation investigating demographic information as risk factors of COVID-19 hospitalization and death. Implications from our study are threefold: (i) gender may not play a significant role in childhood COVID-19 severity, (ii) race and ethnicity, and underlying medical conditions, are vital risk factors for COVID-19 hospitalization or death, and (iii) younger age increases hospitalization risk, but not death. Future studies should focus on unraveling the mechanisms underpinning poor COVID-19 outcomes in Black, non-Hispanic children, as well as those with medical conditions.

Authors' Contributions Drs. Alvaro and Axel Moreira conceptualized and designed the study, drafted sections of the initial manuscript, carried out the analyses, and supervised the project.

Dr. Ahmed assisted with conceptualization, wrote sections of the initial manuscript, and critically reviewed and revised the manuscript.

Drs. Chorath and Rajasekaran and Ms. Burmeister assisted with conceptualization and 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.

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Data availability Publicly available data.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Conflict of interest The authors declare no conflict of interest.

Code availability Not applicable.

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