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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 inde pendent risk factors for poor outcome in COVID 19 [3 6]. Understanding the role these factors play in severe acute re spiratory 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 com prised 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 associ ation of age, gender, race and ethnicity, and medical condition on hospitalization, followed by in hospital mortality. The fol lowing underlying illnesses yielded a "yes" answer on the "medical condition" field: asthma, autoimmune disease, car diovascular 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 multivari able logistic regression model. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. A p value < 5% was considered statistically significant. Analyses were per formed 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 hospitaliza tion. Multivariate analysis demonstrated that age, race/ethnicity, and medical conditions were significant fea tures 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%) individ uals 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 med ical condition. Children who were black, non Hispanic [OR 3.0 (95% CI 1.3, 6.7)], and those with an under lying 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 hospital ized 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 con tact" 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 dur ing the pandemic are driven by workers who are predominant ly minority. Second, poverty is more common among minor ity 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 in fection. 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 pop ulation. Second, missing data was common in the database which decreased our overall sample size from 229,052 chil dren to 27,045 pediatric cases. In particular, medical condi tions 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 in creases 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 ini tial manuscript, and critically reviewed and revised the manuscript.

Drs. Chorath and Rajasekaran and Ms. Burmeister assisted with con ceptualization 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.

References

1. COVID Data Tracker. Centers for Disease Control and Prevention. Covid.cdc.gov/covid data tracker/#cases_totalcases. Accessed 19 Jan 2021
2. Children and COVID 19: State Level Data Report. American Academy of Pediatrics. Services.aap.org/en/pages/2019 novel coronavirus covid 19 infections/children and covid 19 state level data report. Accessed 19 Jan 2021
3. Götzinger F, Santiago García B, Noguera Julián A, Lanaspa M, Lancella L, Calò Carducci FI, Gabrovska N, Velizarova S, Prunk P, Osterman V, Krivec U, Lo Vecchio A, Shingadia D, Soriano Arandes A, Melendo S, Lanari M, Pierantoni L, Wagner N, L'Huillier AG, Heininger U, Ritz N, Bandi S, Krajcar N, Roglić S, Santos M, Christiaens C, Creuven M, Buonsenso D, Welch SB, Bogyi M, Brinkmann F, Tebruegge M, Pfefferle J, Zacharasiewicz A, Berger A, Berger R, Strenger V, Kohlfürst DS, Zschocke A, Bernar B, Simma B, Haberlandt E, Thir C, Biebl A, vanden Driessche K, Boiy T, van Brusselen D, Bael A, Debulpaep S, Schelstraete P, Pavic I, Nygaard U, Glenthoej JP, Heilmann Jensen L, Lind I, Tistsenko M, Uustalu Ü, Buchtala L, Thee S, Kobbe R, Rau C, Schwerk N, Barker M, Tsolia M, Eleftheriou I, Gavin P, Kozdoba O, Zsigmond B, Valentini P, Ivaškeviciene I, Ivaškevicius R, Vilc V, Schölvinck E, Rojahn A, Smyrnaios A, Klingenberg C, Carvalho I, Ribeiro A, Starshinova A, Solovic I, Falcón L, Neth O, Minguell L, Bustillo M, Gutiérrez Sánchez AM, Guarch Ibáñez B, Ripoll F, Soto B, Kötz K, Zimmermann P, Schmid H, Zucol F, Niederer A, Buettcher M, Cetin BS, Bilogortseva O, Chechenyeva V, Demirjian A, Shackley F, McFetridge L, Speirs L, Doherty C, Jones L, McMaster P, Murray C, Child F, Beuvink Y, Makwana N, Whittaker E, Williams A, Fidler K, Bernatoniene J, Song R, Oliver Z, Riordan A (2020) COVID 19 in children and adolescents in Europe: a mul tinational, multicentre cohort study. Lancet Child Adolesc Health 4(9):653 661
4. Shekerdemian LS, Mahmood NR, Wolfe KK et al (2020) Characteristics and outcomes of children with coronavirus disease 2019 (COVID 19) infection admitted to us and canadian pediatric intensive care units [published online ahead of print, 2020 May 11]. JAMA Pediatr. https://doi.org/10.1001/jamapediatrics.2020.1948
5. Kim L, Whitaker M, O'Halloran A, Kambhampati A., Chai S.J., Reingold A., Armistead I., Kawasaki B., Meek J., Yousey Hindes K., Anderson E.J., Openo K.P., Weigel A., Ryan P., Monroe M.L., Fox K., Kim S., Lynfield R., Bye E., Shrum Davis S., Smelser C., Barney G., Spina N.L., Bennett N.M., Felsen C.B., Billing L.M., Shiltz J., Sutton M., West N., Talbot H.K., Schaffner W., Risk I., Price A., Brammer L., Fry A.M., Hall A.J., Langley G.E., Garg S., COVID NET Surveillance Team, COVID NET Surveillance Team, Coates A., Daily Kirley P., Libby T., Roland J., Alden N., Herlihy R., McLafferty S., Clogher P., Kayalioglu H., Maslar A., Misiorski A., Niccolai L., Olson D., Parisi C., Fawcett E., Gretzinger S., Lengacher K., Williams J., Blythe D., Brooks A., Park R., Wilson M., Como Sabetti K., Danila R., Cline C., Angeles K., Eisenberg N., Flores K., Habrun C., Hancock E., Khanlian S., Novi M., Phipps E., Salazar Sanchez Y., Dufort E., Muse A., Bushey S., Gaitan M., Kurtz R.A., Owusu Dommey A., Snyder L., Michaelis K., Seeley K., Markus T., Chatelain R., George A., Hill M., McCullough L., Spencer M., Swain A., McCaffrey K., Holstein R., Meador S., Wortham J. Hospitalization rates and characteristics of children aged <18 years hospitalized with laboratory confirmed COVID 19 COVID NET, 14 states, March 1 July 25, 2020. MMWR Morb Mortal Wkly Rep 2020;69:1081 1088
6. Hoang A, Chorath K, Moreira A et al (2020) COVID 19 in 7780 pediatric patients: a systematic review. EClinicalMedicine 24: 100433
7. Coronavirus disease 2019 associated hospitalization surveillance network (COVID NET). Centers for Disease Control and Prevention. Cdc.gov/coronavirus/2019 ncov/covid datacovid net/ purpose methods.html. Last accessed on 9.17.2020
8. Williams JC, Anderson N, Holloway T, Samford E 3rd, Eugene J, Isom J. Reopening the United States: Black and Hispanic workers are essential and expendable again [published correction appears in Am J Public Health. 2021 Jan;111(1):e2]. Am J Public Health 2020;110(10):1506 1508. https://doi.org/10.2105/AJPH.2020.305879
9. Adhikari S, Pantaleo NP, Feldman JM, Ogedegbe O, Thorpe L, Troxel AB (2020) Assessment of community level disparities in coronavirus disease 2019 (COVID 19) infections and deaths in large US metropolitan areas. JAMA Netw Open 3(7):e2016938. https://doi.org/10.1001/jamanetworkopen.2020.16938
10. Sze S, Pan D, Nevill CR, Gray LJ, Martin CA, Nazareth J, Minhas JS, Divall P, Khunti K, Abrams KR, Nellums LB, Pareek M (2020) Ethnicity and clinical outcomes in COVID 19: a systematic review and meta analysis. EClinicalMedicine. 29:100630. https://doi.org/10.1016/j.eclinm.2020.100630
11. Tal Y, Adini A, Eran A, Adini I (2020) Racial disparity in Covid 19 mortality rates a plausible explanation. Clin Immunol 217: 108481. https://doi.org/10.1016/j.clim.2020.108481
12. Ahmed M, Advani S, Moreira A, Zoretic S, Martinez J, Chorath K, Acosta S, Naqvi R, Burmeister Morton F, Burmeister F, Tarriela A, Petershack M, Evans M, Hoang A, Rajasekaran K, Ahuja S, Moreira A (2020) Multisystem inflammatory syndrome in children: a systematic review. EClinicalMedicine. 26:100527. https://doi.org/10.1016/j.eclinm.2020.100527