Black-White Risk Differentials in Pediatric COVID-19 Hospitalization and Intensive Care Unit Admissions in the USA

Laurens Holmes Jr.[1,7,8] · Colin Wu[2] · Rakinya Hinson[1,3] · Emanuelle Dias[1,4] · Carlin Nelson[1,5] · Lavisha Pelaez[1] · Kirk Dabney[1,6] · Kayla Whaley[1,6] · Justin Williams[1]

Abstract

Purpose The COVID-19 morbidity with SARS-CoV-2 as a causative pathogenic microbe remains a pandemic with children experiencing less mortality but with severe manifestations. The current study aimed to assess SARS-CoV-2 cumulative incidence, COVID-19 hospitalization, and ICU admission with respect to racial differentials.

Materials and Methods A cross-sectional nonexperimental epidemiologic design was used to examine pediatric COVID-19 data from CDC during 2020. The variables assessed were ICU admissions, hospitalization, sex, race, and region. The Chi-Square (X^2) statistic was used to examine the independence of the variables by race, while the binomial regression model was used to predict racial risk differentials in hospitalization and ICU admissions.

Results The pediatric COVID-19 data observed the cumulative incidence of hospitalization to be 96,376, while ICU admission was 12,448. Racial differences were observed in hospitalization, ICU admissions, sex, and region. With respect to COVID-19 hospitalization, Black/African American (AA) children were two times as likely to be hospitalized compared to their White counterparts, prevalence risk ratio (pRR) = 2.20, 99% confidence interval (CI = 2.12–2.28). Similarly, Asians were 45% more likely to be hospitalized relative to their White counterparts, pRR = 1.45, 99% CI = 1.32–1.60. Regarding ICU admission, there was a disproportionate racial burden, implying excess ICU admission among Black/AA children relative to their White counterparts, pRR = 5.18, 99% CI = 4.44–6.04. Likewise, Asian children were 3 times as likely to be admitted to the ICU compared to their White counterparts, pRR = 3.36, 99% CI = 2.37–4.77. Additionally, American Indians/Alaska Natives were 2 times as likely to be admitted to ICU, pRR = 2.54, 99% CI = 0.82–7.85.

Conclusion Racial disparities were observed in COVID-19 hospitalization and ICU admission among the US children, with Black/AA children being disproportionately affected, implying health equity transformation.

Abbreviations

ICU	Intensive care unit
CDC	Center of Disease Control and Prevention
AA	African American
AI/AN	American Indians/Alaska Natives
NH/PI	Native Hawaiians/Pacific Islanders
PRR	Prevalence risk ratio
CI	Confidence interval
CCSPUD	COVID-19 Case Surveillance Public Use Dataset

✉ Laurens Holmes Jr.
drlholmesjr@gmail.com

1 Office of Health Equity and Inclusion (OHEI), Nemours Children's Healthcare System, Wilmington, DE, USA

2 Biology Department, Tufts University, Medford, MA, USA

3 Department of Epidemiology and Biostatistics, Florida A&M University Institute of Public Health, Tallahassee, FL, USA

4 Department of Health Promotion and Behavioral Sciences, University of Texas Health Science Center School of Public Health, Houston, TX, USA

5 College of Health Professions, Walden University, Minneapolis, MN, USA

6 Rollins School of Public Health, Emory University, Atlanta, GA, USA

7 Biological Sciences Departmenmt, University of Delaware, DE, Newark, USA

8 Global Epigenomic Research & Analytics, DE, Wilmington, USA

NK   Natural killer cells
COVID-19   Coronavirus disease 2019
SARS-CoV-2 Severe acute respiratory syndrome corona-
            virus 2

Introduction

COVID-19 is a clinical manifestation due to SARS-CoV-2 microscopic pathogen. The replication, transmissibility, case fatality, hospitalization, ICU admission, prognosis, and mortality have been observed in both children and adult populations to vary [1]. The observed variability in pathogenic spread, replication, prognosis, mortality, and survival has been shown to be caused by population density which affects social distancing, mask utilization, and hand hygiene [2]. SARS-CoV-2 and COVID 19 have been associated with comorbidities, nutritional insufficiencies, immunosuppression, organ transplants, obesity, and pregnancy [3]. Epidemiologic and population-based data have clearly observed racial and ethnic differences with respect to adult case mortality among subpopulations, with Blacks/AA reflecting excess case fatality and mortality [4–6]. Besides population density, social distancing, face mask utilization, and rigorous hygiene in order to prevent pathogenic spread especially in some subpopulations, there is a need for rigorous tracing, tracking, and testing. The inability to apply these prospective preventing practices in some subpopulations renders infectivity disproportionate in that population, namely, Blacks/AAs, and Hispanics [5].

Viral replication mitigation depends on applying appropriate, reliable, and interrelated universal control and preventive measures with respect to COVID-19 which is caused by SARS-CoV-2 and in this case the alpha and beta variance among children in the USA [7]. It remains relevant to understand the viral replication as well as infectivity and the complications. SARS-CoV-2 (variants A and B) are not living organisms but genetic material that requires a host system for replication and infectivity. Regardless of exposure, viral transmission remains a prospective implying that not every individual exposed to a given pathogen will develop the disease [8]. The transmissibility of a viral pathogen depends on the host's immune system responsiveness [9]. With respect to SARS-CoV-2, there is a requirement of the spike protein that affects the host cell response, and with this binding, there is a viral replication. The observed binding results in viral replication, leading to subclinical and clinical manifestations as well as complications, poor prognosis, and mortality if there are no adequate therapeutics in addressing these clinical manifestations. The observed immune system responsiveness variance is explained by glycoprotein differences based on nutrients, stress reduction, healthy lifestyle, and physical exercise [10]. Available data in the USA have observed some populations with unbalanced diet, lack of exercise, excessive alcohol, smoking, and sleep deprivation that tends to affect immune system responsiveness [11].

With the available data on the adult population with respect to COVID-19 hospitalization, ICU admission complication, and mortality, there are limited data in the population that address racial variances in hospitalization, ICU admission, and mortality. Additionally, the understanding of prognosis and mortality requires the application of data on hospitalization and ICU admissions, especially in this context of children with immune system incompetency, as well as immunosuppression. The utilization of these data allows for subpopulation differentials such as race in assessing survival and mortality in pediatric COVID 19 pandemic. With the observed insufficiencies, this study aimed to assess COVID-19 related hospitalization and ICU admission among children in the USA and to determine the role of race.

Methods

This study was based on secondary data implying preexisting information from the Center of Disease Control and Prevention (CDC) that required an approval for data extraction as well as an Institutional Review Board (IRB) approval for this study conduct. Prior to study conduct upon data acquisition approval from CDC, a study conduct approval from an IRB was obtained as well.

Data Source

To determine whether racial disparities of COVID-19 exist in the pediatric population, the publicly available COVID-19 Case Surveillance Public Use Dataset (CCSPUD) was obtained from the CDC database. A cross-sectional study design implying a non-experimental epidemiologic design was utilized to assess the exposure function of race in children with COVID-19 with respect to hospitalization and ICU admission. This design is appropriate, given the preexisting data that allowed for a simultaneous assessment of exposure implying race and the outcomes, namely, hospitalization and ICU admission. The CCSPUD detailed over 25 million cases of COVID-19 in the USA, which encapsulated approximately 86% of all reported cases. The CDC defined the pediatric population as children aged 0 to 17 years, which yielded a total of 3,302,618 pediatric cases. The dataset also contained 19 different variables which included race, ethnicity, hospitalization, ICU admission, state of residence, and county of residence.

Sample Size and Power Estimations

Due to the preexisting nature of the data and the sample size implying the scientific power estimation to estimate the power, we utilized type 1 zero tolerance of 1% (0.01), effect size of 20%, and sample size of 1,048,575 as well as the subpopulation sample sizes, Whites (258,609), Blacks/AA (123,738), Asians (20,030), American Indians/Alaska

Natives AI/AN (8,052), Native Hawaiians/Pacific Islanders NH/PI (2,463), Multiracial/Others (27,245), and Unknown (430,554).

Variable Ascertainment

The outcome variables were COVID-19 hospitalization and ICU admission. These variables were measured on a dichotomous scale (implying "hospitalization and ICU admission" = 1 and "non-hospitalization and non-ICU admission" = 2). The rationale behind this transformation was the binary outcome variable, which required a binomial regression model utilized in this assessment. The main independent variable in exposure was race measured on a nominal scale. This race variable identified the following: (a) as Whites, (b) as Asians, (c) as American Indian/Alaska Natives AI/AN, (d) as Blacks/AA, (e) as Native Hawaiians/Pacific Islanders NH/PI, (f) as Multiracial, and (g) as Others. Other variables utilized in this study included sex which was measured on a dichotomous scale (where male = 1 and female = 2). The region of residence was measured on a nominal scale (namely, Northeast, Midwest, South, and West).

Statistical Analysis

Descriptive statistics were first performed to determine the percentages of each race or ethnicity that were hospitalized and/or admitted into the ICU in order to discern the presence of any disproportionate rates and trends among the data. The Chi-Square (X^2) test was then performed to summarize the study population (with respect to race). The binomial regression model was utilized to assess the risk for hospitalization and ICU admission by race and subpopulation, with Whites as the reference group. Prior to the descriptive analysis implying summary statistics, this data was assessed for missing variables and outliers. The discrete variables which are the variables in this data were summarized using frequency and percentages.

This approach allowed for the estimation of the Chi-Square (X^2) value, the degree of freedom, and the probability value. This stratification (Chi-Square (X^2)) model allows for the estimation of the prevalence risk ratio based on the nature of the data and the design applied in this study. The hypothesis-driven association between race and hospitalization, as well as ICU admission, was performed using binomial regression models. In this analysis, a White subpopulation was used as a reference group in assessing the risk associated with other subpopulations, namely, Black/AA with respect to hospitalization and ICU admission.

All tests were two-tailed and the type 1 error tolerance was placed at 1% as well as the 99% confidence interval as the measure of precision. All analyses were performed using STATA version 17.0 (STATA Corporation, College Station Texas).

Results

Although not in the table, there were 17,016 children diagnosed with COVID-19 and hospitalized as well as being placed in ICU admission during this period. There were 96,376 children with hospitalization and 12,448 children with respect to ICU admission.

Table 1 demonstrates the frequency and racial differences of children diagnosed with COVID-19 with respect to hospitalization, ICU admission, sex, and region of residence. Their hospitalization rate was the highest among Blacks/AA (3.3%) and intermediate among Asians (2.2%) and American Indians/Alaska Natives AI/AN (2.3%), but the lowest among Whites (1.5%) and Native Hawaiian/Pacific Islanders NH/PI (0.8%), X^2 ((df=5) 1,839.8, $p < 0.001$). Similarly, the ICU admission reflected the highest prevalence among Blacks/AA (2.2%) and moderate among American Indians/Alaska Natives AI/AN (1.1%) and Asians (1.5%), but the lowest among Whites (0.4%) and Native Hawaiians/Pacific Islanders NH/PI (0.4%), X^2 ((df=5) 551.5, $p < 0.001$).

With respect to the sex distribution in children, COVID 19 cases contained the worst racial differential. With respect to the male sex, there were more males diagnosed with COVID-19 among Asians (53.2%) and Native Hawaiian/Pacific Islanders NH/PI (53.3%). Among Asians (50.8%) and Blacks/AA (50.3%), more females were diagnosed relative to males, X^2 ((df=5) 493.6, $p < 0.001$). Furthermore, racial differences were observed in the distribution of children with COVID-19 by region. Furthermore, Blacks/AA were more diagnosed in the South (50.4%), while in the West, more American Indians/Alaska Natives AI/AN (62.9%) and Asians (41.9%) were diagnosed, X^2 ((df=20) 361,116.1, $p < 0.001$).

Relative to Whites in Table 2, in their observed association, American Indians/Alaska Natives AI/AN were 53% more likely than their White counterparts to be hospitalized with COVID-19 during this period, (pRR=1.53, 99% CI=1.36–1.73). Similarly, there was a 45% increased risk of hospitalization among Asians relative to their White counterparts (pRR=1.45, 99% CI=1.32–1.60). Furthermore, the risk of hospitalization was the highest among Blacks/AA and compared to their White counterparts, Blacks/AA were two times as likely to be hospitalized with COVID-19 (pRR=2.20, 99% CI=2.12–2.18).

Figure 1 exhibits the risk of hospitalization by margins plot which is a predictive model in assessing the generalized linear modeling in this hospitalization and race nexus. However, between Asians and American Indians/Alaska Natives AI/AN,

Table 1 Study characteristics of children with SARS-CoV-2 and COVID-19 clinical experience stratified by race, CDC's Case Surveillance Public Use Dataset, 2021

Variables	Whites	AI/AN	Asians	Black/AA	Multiracial	NH/PI	x2 (df)	p
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)		
Hospitalization							1,839.8 (5)	<0.001
Yes	10,042 (1.5)	266 (2.3)	418 (2.2)	3,628 (3.3)	1,744 (2.2)	22 (0.8)		
No	667,063 (98.5)	11,454 (97.7)	19,003 (97.9)	107,720 (96.7)	79,458 (97.9)	2,813 (99.2)		
ICU							551.5 (5)	<0.001
Yes	502 (0.4)	3 (1.1)	33 (1.5)	234 (2.2)	120 (0.9)	4 (0.4)		
No	115,440 (99.6)	270 (98.9)	2,234 (98.5)	10,208 (97.8)	13,298 (99.1)	1,126 (99.7)		
Sex								
Male	649,589 (50.1)	14,328 (49.2)	26,500 (53.2)	119,510 (49.7)	90,402 (52.2)	2,186 (53.3)		
Female	647,549 (49.9)	14,813 (50.8)	23,338 (46.8)	120,824 (50.3)	82,885 (47.8)	1,912 (46.7)		
Region of Residence							361,116.1 (20)	<0.001
Northeast	239,394 (18.4)	1,340 (4.6)	15,326 (30.6)	50,305 (21.2)	29,305 (16.8)	0 (0.0)		
Midwest	385,736 (29.6)	3,011 (10.3)	8,729 (17.4)	46,525 (19.3)	33,935 (19.5)	12 (0.3)		
South	376,062 (28.9)	6,469 (22.2)	4,971 (9.9	121,494 (50.4)	36,065 (20.7)	562 (13.7)		
West	300,068 (23.1)	18,344 (62.9)	21,031 (41.9)	21,839 (9.1)	74,671 (42.9)	2,860 (69.8)		
Other	71 (0.01)	0 (0.0)	85 (0.2)	69 (0.03)	23 (0.01)	664 (16.2)		

CDC, United State Department of Disease Control and Prevention; *AI/AN*, American Indian/Alaska Native; *AA*, African American; *NH/PI*, Native Hawaiian Pacific Islander; *n*, frequency, implying number; *%*, percentage; x^2, Chi-Square; *df*, degree of freedom; *p*, probability value, implying random error quantifications as sampling variability; *ICU*, intensive care unit; other, people living in the US territories (Guam, Puerto Rico, US Virgin Islands); *SARS-CoV-2*, the causative pathogen for COVID-19, classified as Corona virus; *COVID-19*, a disease caused by SARS-cov2, diagnosed in 2019; total sample size ($n = 1,793,836$)
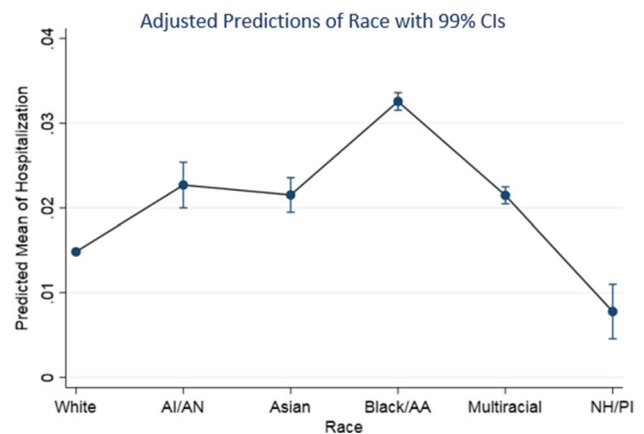
Table 2 Association between hospitalization risk and race among children with COVID-19 in the USA, CDC Surveillance Public Use Dataset, 2021

Variables	pRR	99% CI	p
Race			
White	1.00	Referent	Referent
AI/AN	1.53	1.36–1.73	<0.001
Asian	1.45	1.32–1.60	<0.001
Black/AA	2.20	2.12–2.28	<0.001
Multiracial	1.45	1.38–1.52	<0.001
NH/PI	0.52	0.34–0.79	0.002

Notes & Abbreviations: CDC, United State Department of Disease Control and Prevention; *AI/AN*, American Indian/Alaska Native; *AA*, African American; *NH/PI*, Native Hawaiian Pacific Islander; *PRR*, prevalence risk ratio; *99% CI*, 99% confidence interval, implying lower and upper CI limits; *p*, probability value, implying random error quantifications as sampling variability; *COVID-19*, a disease caused by SARS-CoV-2, diagnosed in 2019

Notes/Abbreviations: AI/AN = American Indian/Alaska Native; AA = African American; NH/PI = Native Hawaiian/Pacific Islander; 99% CI = 99% confidence interval, implying lower and upper CI limits; Margins Plot - the prediction of hospitalization based on race categorization in this generalized linear model

Fig. 1 The nexus between race and hospitalization of children with COVID-19 in the USA by margins plot

despite differences in the parameter estimates, there was an overlapping in the confidence intervals.

Compared to White children in Table 3, Black/AA children were 5 times as likely to be admitted into the ICU following the diagnosis and care provisions, ($pRR = 5.18$, 99% $CI = 4.44–6.04$). Similarly, Asians and American Indians/Alaska Natives AI/AN experienced the same ICU admission risk. Relative to their White counterparts, American Indians/Alaska Natives AI/AN were two times as likely to be admitted into the ICU ($pRR = 2.54$, 99% $CI = 0.82–7.85$), while Asians were three times as likely to be admitted into the ICU ($pRR = 3.36$, 99% $CI = 2.47–4.77$).

Table 3 Association between icu admission risk and race among children with COVID-19 in the USA, CDC Surveillance Public Use Dataset, 2021

Variables	*pRR*	99% CI	*p*
Race			
White	1.00	Referent	Referent
AI/AN	2.54	0.82–7.85	0.11
Asian	3.36	2.37-4.77	<0.001
Black/AA	5.18	4.44-6.04	<0.001
Multiracial	2.07	1.67-2.52	<0.001
NH/PI	0.82	0.31-2.18	0.69

Notes & Abbreviations: CDC, United State Department of Disease Control and Prevention; *ICU*, intensive care unit; *AI/AN*, American Indian/Alaska Native; *AA*, African American; *NH/PI*, Native Hawaiian Pacific Islander; *PRR*, prevalence risk ratio; *99% CI*, 99% confidence interval, implying lower and upper CI limits; *p*, probability value, implying random error quantifications as sampling variability; *COVID-19*, a disease caused by SARS-CoV-2, diagnosed in 2019

Discussion

As the result of the growing number of children with the Delta variant of SARS-CoV-2 (COVID-19), this study reflects the assessment of hospitalization as well as intensive care unit (ICU) admission by sub-population variance. The cross-sectional design was utilized to assess the prevalence risk ratio in comparing these subpopulations with respect to the proportionate burden of hospitalization and ICU admission. There are a few relevant findings. First, racial variances were observed in the main independent variables (i.e., sex and region), as well as the response variables (i.e., ICU admission and hospitalization). Secondly, hospitalization was the highest among Blacks/African American (hereafter denoted as AA) children and intermediate among Asians and American Indians/Alaska Natives (hereafter known as AI/AN), but the lowest among Whites. ICU admission was the highest among AA, and intermediate among Asians and AI/AN, but the lowest among Whites. Additionally, the illustration of these subpopulation variances by margins plot clearly confirms the observed variances (Fig. 2). The current data reflects the alpha and beta variants of SARS-CoV-2 (COVID-19). This study observed racial variability with respect to COVID-19 hospitalization among children in the United States (US). The indicated disparities have been observed in previous studies [5, 12–15].

With this large sample implying a representative sample of the US children, this finding supports observed previous data implicated in viral pathogenic spread and hospitalization among children. Regarding ICU admission, racial variability was observed which is supported by previous findings in viral manifestations and admission among children. The ICU admission variability was driven by the severity of COVID-19 among children, which explains why some
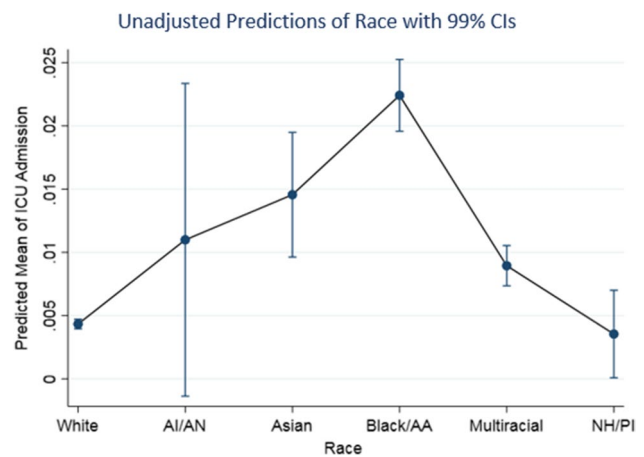
Fig. 2 The nexus between race and ICU admission of children with COVID-19 in the USA by margins plot

subpopulations were associated with the disproportionate burden of ICU admission with respect to COVID-19. The variability in comorbidity by race was observed, which is indicative of the increasing pathogenic spread and replication as well as hospitalization and ICU admission in subpopulations with marginalized access and utilization of care [16]. Sex differences as observed in this data indicate the variability of the immune responsiveness given that XX and XY chromosomes and other factors such as hormonal differences do impact COVID-19 transmissibility and severity [17]. The differences in the regions by race were also observed in this data, implying environmental differences in the replication of COVID-19 as well as hospitalization and ICU admission [18]. Increased viral risk is dependent on the environment of exposure including (though not limited to) population density as well as healthy nutrients, imbalanced diet, physical inactivity, and lifestyle variables [4, 19].

We have demonstrated the increased risk of hospitalization among Black/AA children that have been diagnosed with COVID-19 and treated for the disease. The observed disproportionate burden of COVID-19 hospitalization among this population has been exhibited elsewhere [12]. The observed variance can be explained by the proximity of Black/AA children as well as the inability for the immune system to produce antibodies that is driven by balanced nutrients, exercise, and healthy physical environment [3]. With the observed increase in hospitalization of Black/AA children, the risk and need to evaluate health inequity in the process of access to care in this population may be driven by comorbidities that lower the immune responsiveness and therefore increase the risk of COVID-19 among this population [16].

This study has also illustrated the increased risk of ICU admission among Black/AA children compared to their White counterparts diagnosed with and treated for COVID-19. Previous studies have observed comparable ICU admission with respect to other viral pathogens such as flu driven by the influenza virus [20]. ICU admission with respect to subpopulations remains higher if the immune system responsiveness is marginalized. The immune system is dependent on the availability of glycoproteins in the enhancement of immunoglobulins implying antibody generation [21]. In the absence of antibody generation, the T-cells remain inactivated implying the inability of the Natural Killer (NK) cells to enhance the immune responsiveness in destroying the viral pathogen. The availability of glycoproteins as the building blocks of immunoglobulins depends on healthy nutrients, including micronutrients such as vitamins and minerals as well as macronutrients, mainly proteins and carbohydrates with low glycemic index. With this observed lack of social and economic resources in this subpopulation, AA children are less likely to be exposed to healthy nutrients, thus, resulting in a compromised immune system and implying increased SARS-CoV-2 transmissibility, infectivity, severity, hospitalization, and ICU admission as well as mortality [4].

Despite the contribution and strength of this study, in order to understand racial variances in COVID-19 hospitalization and ICU admission among children, there are some limitations. First, this study was based on a cross-sectional design that tends to reflect restricted causal inference which indicates the ability of a given variable to produce an effect as a response. In this study, race was and remains the independent variable with an exposure function in determining the hospitalization and ICU admissions by subpopulations. However, the findings of Black/AA children with the highest prevalence of hospitalization and ICU admission are not driven by a restricted causal inference since race existed prior to the COVID-19 infectivity in this population. Secondly, the findings in this study may be driven by unmeasured confoundings as well as residual confoundings. Because of the unavailability of potentially confounding variables such as insurance, income poverty level, education, and specific environments, it is possible that the observed increase in hospitalization and ICU admission among Blacks/AA may be driven by unmeasured confoundings. However, it is highly unlikely that this disproportionate burden of hospitalization and ICU admission among Black/AA children with COVID-19 is driven solely by these unmeasured confoundings.

Therefore, in the process of assessing reliable and valid findings, there is a need to address both measured and unmeasured confoundings. Furthermore, the pediatric COVID-19 mortality was not addressed in these findings due to the in-availability of mortality data. In effect, the availability of these data could have provided information on the case mortality and mortality burden of this manifestation as well as the racial disparities they are in. This observation although limited is not a result of insufficient data but the initial and the Delta variant that did not present clinical severity, complication, and mortality among children in the USA (variants A and B). Despite adjusting for confounding in the reliable and valid evidence discovery, there are unmeasured confoundings [22]. However, the observed excess and ICU hospitalization are not driven solely by the unmeasured confounding. Additionally, with respect to residual confoundings regardless of the statistical software utilized in addressing confounding, residual confounding persists [23].

Conclusion

In summary, racial disparities were observed in pediatric COVID-19 hospitalization and ICU admission, with Blacks/AA indicated with the disproportionate burden of hospitalization and ICU admission in the USA. Additionally, compared to their White counterparts, Asian Americans and American Indians/Alaska Natives AI/AN experienced excess burden of ICU admission relative to their White counterparts. These findings are suggestive of the need to assess the factors associated with increasing SARS-Cov-2 transmissibility, disease severity, hospitalization, and ICU admission among children in the USA. Therefore, based on these data or information, this study recommends policy formulation, implementation, and evaluation in addressing health equity transformation with respect to infectious disease, viral pandemics, and health care management system, thus increasing access, care utilization, and quality care in COVID-19 pandemic.

Recommendations

Furthermore, these findings are suggestive of the need to allocate equitable resources to Blacks/AA and encourage health care services and public health integration in addressing subpopulations disparities in future pandemics.

by Colin Wu and Justin Williams. Examination of the data, assistance in the analysis, and substantial enhancement of the primary draft preparation were performed by Justin Williams. Facilitation of interpretation was provided by Rakinya Hinson and Justin Williams. Interpretation of data was performed by Prof. Laurens Holmes Jr., Carlind Nelson, and Emmanuelle Dias. Data acquisition, analysis, and data tabulation were provided by Lavisha Pelaez. Review of abstract and contributed comments was provided by Kayla Whaley. Consultation, recommendations, and the review of the entire manuscript were facilitated and provided by Dr. Kirk Dabney.

Declarations

Ethics Approval This study was approved by the Institutional Review Board (IRB) prior to conduct, analysis, and interpretation.

Consent to Participate Due to all the material consisting of secondary data no consent was necessary.

Consent to Publication Due to secondary data utilized in this study, there was no informed consent was required in this study. Prof. Laurens Holmes Jr.—author identification.

Competing Interests The authors declare no competing interests.

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