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# Association Between Race and COVID-19 Outcomes Among 2.6 Million Children in England

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**IMPORTANCE** Although children mainly experience mild COVID-19 disease, hospitalization rates are increasing, with limited understanding of underlying factors. There is an established association between race and severe COVID-19 outcomes in adults in England; however, whether a similar association exists in children is unclear.

**OBJECTIVE** To investigate the association between race and childhood COVID-19 testing and hospital outcomes.

**DESIGN, SETTING, PARTICIPANTS** In this cohort study, children (0-18 years of age) from participating family practices in England were identified in the QResearch database between January 24 and November 30, 2020. The QResearch database has individually linked patients with national SARS-CoV-2 testing, hospital admission, and mortality data.

**EXPOSURES** The main characteristic of interest is self-reported race. Other exposures were age, sex, deprivation level, geographic region, household size, and comorbidities (asthma; diabetes; and cardiac, neurologic, and hematologic conditions).

**MAIN OUTCOMES AND MEASURES** The primary outcome was hospital admission with confirmed COVID-19. Secondary outcomes were SARS-CoV-2–positive test result and any hospital attendance with confirmed COVID-19 and intensive care admission.

**RESULTS** Of 2 576 353 children (mean [SD] age, 9.23 [5.24] years; 48.8% female), 410 726 (15.9%) were tested for SARS-CoV-2 and 26 322 (6.4%) tested positive. A total of 1853 children (0.07%) with confirmed COVID-19 attended hospital, 343 (0.01%) were admitted to the hospital, and 73 (0.002%) required intensive care. Testing varied across race. White children had the highest proportion of SARS-CoV-2 tests (223 701/1 311 041 [17.1%]), whereas Asian children (33 213/243 545 [13.6%]), Black children (7727/93 620 [8.3%]), and children of mixed or other races (18 971/147 529 [12.9%]) had lower proportions. Compared with White children, Asian children were more likely to have COVID-19 hospital admissions (adjusted odds ratio [OR], 1.62; 95% CI, 1.12-2.36), whereas Black children (adjusted OR, 1.44; 95% CI, 0.90-2.31) and children of mixed or other races (adjusted OR, 1.40; 95% CI, 0.93-2.10) had comparable hospital admissions. Asian children were more likely to be admitted to intensive care (adjusted OR, 2.11; 95% CI, 1.07-4.14), and Black children (adjusted OR, 2.31; 95% CI, 1.08-4.94) and children of mixed or other races (adjusted OR, 2.14; 95% CI, 1.25-3.65) had longer hospital admissions (≥36 hours).

**CONCLUSIONS AND RELEVANCE** In this large population-based study exploring the association between race and childhood COVID-19 testing and hospital outcomes, several race-specific disparities were observed in severe COVID-19 outcomes. However, ascertainment bias and residual confounding in this cohort study should be considered before drawing any further conclusions. Overall, findings of this study have important public health implications internationally.

Editorial

Supplemental content

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Approximately 10% of COVID-19 cases involve children up to the age of 18 years.[1,2] Although children with COVID-19 largely experience mild disease, hospitalization rates are steadily increasing,[3] and the underlying factors associated with severe outcomes have not been comprehensively explored. Only a small number of observational studies[4-12] have focused on children with COVID-19, and these studies[4-12] have mainly concentrated on age, sex, and preexisting comorbidities.

There is an established association between race/ethnicity and severe COVID-19 outcomes in adults, including hospitalizations and mortality.[13-16] Disentangling the factors associated with these differences in adults is challenging. A combination of clinical factors, including higher prevalence of underlying chronic diseases in racial/ethnic minorities, and sociodemographic factors, including deprivation, key worker status, housing, and household size, are thought to play important roles.[17] Whether a similar association between race/ethnicity and severe COVID-19 exists in children is not well established. To our knowledge, no population-based studies to date have directly explored race and SARS-CoV-2 infection and COVID-19 hospitalization risk in children, while accounting for important clinical and sociodemographic factors.

Current insight into the association between race and COVID-19 outcomes in children is based on descriptive observational studies from the UK[4,18] and the US.[5] In the UK, 2 studies, a case series of 5 children[18] and a cohort of 651 children,[4] reported on differences according to ethnicity and race, respectively, in COVID-19 outcomes, but both were limited to the first wave of the pandemic and hospitalized children. In the US, a descriptive cohort of 135 794 children tested for SARS-CoV-2 from a network of 7 US pediatric health systems[5] reported race/ethnicity-specific differences in outcomes, however, without directly accounting for other potential mediating factors, such as family demographics. We aimed to investigate the association between race and childhood (0-18 years of age) COVID-19 testing and hospital outcomes, while accounting for sociodemographic and clinical factors, using linked electronic health record data.

### Key Points

**Question** Is race associated with COVID-19 testing and hospital outcomes in children in England?

**Findings** In this cohort study of 2 576 353 children (0-18 years of age) in England with COVID-19 disease, children who were Black, Asian, or of mixed race had lower proportions of SARS-CoV-2 tests and had higher positive results and COVID-19 hospitalizations compared with White children. These results held after key demographic factors and selected comorbidities were accounted for.

**Meaning** These findings suggest that race may play an important role in childhood COVID-19 outcomes, which reinforces the continued need for a race-tailored focus on health system performance and targeted public health interventions.

## Methods

### Data Sources

The QResearch database (version 45) is a national, integrated database that consists of 35 million anonymized health records across all ages from approximately 1300 family practices across England,[19] representing 20% of the UK population. Established in 2002, it is a not-for-profit collaboration between the University of Oxford and Egton Medical Information Systems, the leading clinical computer supplier for family practices in the UK.[20] The database has ethical approval from the East Midlands-Derby Research Ethics Committee and has been extensively used for epidemiologic research, including COVID-19 research.[15,21-24] QResearch only has anonymized data, and there is no requirement under the ethics approval for individual consent. Our study was conducted and findings reported in line with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline and the Reporting of Studies Conducted Using Observational Routinely Collected Data (RECORD) guidelines.[25,26]

Primary care medical records consist of patient-level demographic information, including sex, self- or parent-assigned race, deprivation score, and household size, as well as clinical data, including clinical measurements and diagnoses. These records in QResearch are linked to the following: (1) hospital admission data (including intensive care unit [ICU] admissions) via Hospital Episode Statistics,[27] a database that contains details for admissions and emergency attendances to all National Health Service (NHS) hospitals in England; (2) civil registration (including mortality) data through the Office for National Statistics[28]; and (3) positive and negative SARS-CoV-2 real-time reverse transcriptase–polymerase chain reaction (RT-PCR) test results undertaken in hospital and community settings in England through the National Infectious Disease Surveillance System provided by Public Health England.[29,30]

Data are linked at individual patient level using an anonymized identifier based on the NHS number. The NHS number is valid and complete in 99.8% of primary care and civil registry data as well as 98% of hospital admissions data.[19,31]

### Study Population and Outcomes

The study population was a closed cohort of children from birth up through 18 years of age, registered with participating family practices in the QResearch database between January 24, 2020 (ie, the date of the first confirmed case of COVID-19 in the UK), until the latest date for which data were available (October 31, 2020, for hospital admissions and November 30, 2020, for test results).

The primary outcome of interest was hospital admission for confirmed COVID-19 infection. The NHS England definition of hospital admission was used (ie, any COVID-19 admission with a confirmed positive COVID-19 RT-PCR test result in last 14 days[32] or an *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)* diagnosis code of U07.1 or U07.2). Secondary outcomes included the following: (1) COVID-19 ICU admission via Hospital Episode Statistics; (2) SARS-CoV-2 tests (duplicate tests removed); (3) COVID-19 RT-PCR–positive disease in those tested

from community and in-hospital testing available through Public Health England[30]; (4) any hospital attendance with confirmed COVID-19 infection, including any COVID-19 RT-PCR-positive disease via in-hospital testing as well as COVID-19-confirmed hospital admission data; (5) duration of hospitalization with confirmed COVID-19 (no admission vs <36 or ≥36 hours admission to hospital; previous studies[33,34] estimate that 36 hours is the mean length of stay in pediatric admissions in the UK and longer admissions are categorized as prolonged); (6) mortality data via the Office for National Statistics; and (7) a diagnosis of multisystem inflammatory syndrome in children (MIS-C) using *ICD-10* diagnosis code U07.5. Outcomes were reported from January 24 to October 31, 2020, for hospital admissions or November 30, 2020, for test results.

### Exposures

The main characteristic of interest was self- or parent-reported race, identified through primary care health records. Racial groups were recorded based on the 2011 Census of England and Wales in 4 broad categories (White, Asian, Black, and mixed or other).[35]

Explanatory variables with existing evidence of association with childhood COVID-19 outcomes were identified through primary care records. These variables include the following: (1) age at cohort entry (categorized as 0-<3 months, 3 months-1 year, 2-5 years, 6-10 years, 11-15 years, and 16-18 years); (2) sex (male or female); (3) level of deprivation assessed through the Townsend deprivation score,[36] which is an area-level continuous score based on an individual's postcode; factors that included unemployment, non-car ownership, non-home ownership, and household overcrowding, are measured for a given area of approximately 120 households, via the 2011 Census of England and Wales[35] and combined to give a Townsend score for that area, with the first quintile representing the lowest deprivation level and the fifth quintile representing the highest deprivation level; (4) geographic region (10 regions across England); (5) household size (categorized into 2 people, 3-5 people, 6-9 people, or ≥10 people in a household), with single-occupant households reclassified as missing and imputed; and (6) only relevant comorbidities previously observed to be associated with severe childhood COVID-19 outcomes and with differing prevalence across racial or ethnic groups were included (asthma,[37] type 1 diabetes,[38] obesity,[4,39] congenital heart disease,[40] neurologic disorders [cerebral palsy and epilepsy],[41] and sickle cell disease).[42]

### Statistical Analysis

Logistic regression was used to investigate the associations between race and each of the COVID-19 outcomes in 3 separate models. Model A consisted of unadjusted analyses. Model B adjusted for demographic factors only (age, sex, deprivation, household size, and geographic region). Model C adjusted for the aforementioned demographic factors and relevant comorbidities (asthma, type 1 diabetes, congenital heart disease, cerebral palsy, epilepsy, and sickle cell disease). All models accounted for the correlation because of clustering of children within practices through a robust variance estimator.

Regression analyses for hospital contact and admission included the full cohort of children. Analyses for testing positive for SARS-CoV-2 were restricted to those tested, and analyses for hospitalization duration were restricted to those with confirmed SARS-CoV-2 infection.

Multiple imputation with chained equations was used to replace missing data for household size (14% missing), race (30% missing), and Townsend deprivation score quintile (0.8% missing). Ten imputations were performed (eTable 12 in the Supplement). Imputation models included race, all explanatory variables, and the primary outcome variables; statistical models were developed on each of the 10 imputed data sets and the estimates pooled using the Rubin rules.

All analyses were performed using Stata statistical software, version 16 (StataCorp LLC).[43] A 2-sided $P < .05$ was considered to be statistically significant.

## Results

### Study Population and Characteristics

The cohort included 2 576 353 children (mean [SD] age, 9.23 [5.24] years; 48.8% female). **Table 1** summarizes the baseline characteristics of the cohort. A total of 1 827 809 of the 2 576 353 children (70.9%) were school aged (>5 years). Race was recorded for 1 795 735 participants (69.7%) (eTable 2 in the Supplement). A total of 484 694 of the 2 576 353 patients (18.8 %) comprised individuals who identified as Asian, Black, and mixed or other racial categories, which is largely representative of the UK population.[44] A total of 361 509 of the 2 576 353 children (14.0%) were classified into single-person households.

Overall, 410 726 children (15.9%) underwent SARS-CoV-2 testing, with positive results in 26 322 (6.4%). During the study period, 1853 children (0.07%) in the cohort had a recorded hospital contact and 343 (0.01%) were admitted to the hospital (**Table 2**). Of those admitted, 184 of 343 (53.6%) remained in the hospital for less than 36 hours and 159 of 343 (46.4%) remained in the hospital for 36 hours or longer.

A total of 73 of 343 patients (21.3%) were admitted to the ICU. Of these admitted patients, 22 (30.1%) were infants (0-<3 months of age), 45 (62.6%) were male, and 26 (36.1%) were from the most deprived level. Of 159 prolonged hospitals stays (≥36 hours), 50 (31.4%) were ICU admissions. There was only 1 recorded death during the study period (case fatality rate, 0.003%).

### COVID-19 Testing

Testing patterns across different races varied (Table 1; eTable 1 in the Supplement). White children had the highest percentage of SARS-CoV-2 tests (223 701/1 311 041 [17.1%]), whereas children of all other races had lower percentages (Asian: 33 213/243 545 [13.6%]; mixed or other: 18 971/147 529 [12.9%]; and Black: 7727/93 620 [8.3%]). In children who were tested, those from Asian (3576/33 213 [10.8%]), Black (601/7727 [7.8%]), and mixed or other (1197/18 971 [6.3%]) backgrounds had higher proportions of positive test results, whereas White children had lower proportions (13 043/223 701 [5.8%]) (Table 2).

Table 1. Baseline and Clinical Characteristics of Children Registered With QResearch Practices Between January 24, 2020, and November 30, 2020[a]

| Characteristic | Total population | No. of SARS-CoV-2 tests | Tested for SARS-CoV-2 per total population, % |
|---|---|---|---|
| Total | 2 576 353 | 410 726 | 15.9 |
| Sex | | | |
| Male | 1 318 747 (51.2) | 213 157 (51.9) | 16.1 |
| Female | 1 257 606 (48.8) | 197 569 (48.1) | 15.7 |
| Age, mean (SD), y | 9.23 (5.24) | 9.28 (5.41) | NA |
| Age categories | | | |
| 0-3 mo | 61 116 (2.4) | 8348 (2.0) | 13.7 |
| 3-12 mo | 130 110 (5.1) | 23 984 (5.8) | 18.4 |
| 2-5 y | 557 318 (21.6) | 93 316 (22.7) | 16.7 |
| 6-10 y | 725 819 (28.2) | 106 440 (25.9) | 14.7 |
| 11-15 y | 707 095 (27.5) | 108 575 (26.4) | 15.4 |
| 16-18 y | 394 895 (15.3) | 70 063 (17.1) | 17.7 |
| Race | | | |
| White | 1 311 041 (50.9) | 223 701 (78.9) | 17.1 |
| Asian | 243 545 (9.5) | 33 213 (11.7) | 13.6 |
| Black | 93 620 (3.6) | 7727 (2.7) | 8.3 |
| Mixed or other | 147 529 (5.7) | 18 971 (6.7) | 12.9 |
| Not recorded | 780 618 (30.3) | 127 114 (30.9) | 16.3 |
| Townsend deprivation quintile | | | |
| 1 (Least deprived) | 527 452 (20.5) | 95 949 (23.6) | 18.2 |
| 2 | 547 532 (21.3) | 96 475 (23.7) | 17.5 |
| 3 | 542 116 (21.0) | 88 858 (21.8) | 16.4 |
| 4 | 509 671 (19.8) | 74 096 (18.2) | 14.5 |
| 5 (Most deprived) | 429 060 (16.7) | 51 598 (12.7) | 12.0 |
| Not recorded | 20 522 (0.8) | 3750 (0.9) | 18.3 |
| Geographic region of England | | | |
| East Midlands | 48 887 (1.9) | 7977 (1.9) | 16.3 |
| East of England | 98 280 (3.8) | 14 980 (3.7) | 15.2 |
| London | 669 444 (26.0) | 82 965 (20.2) | 12.4 |
| North East | 51 775 (2.0) | 10 087 (2.5) | 19.5 |
| North West | 473 994 (18.4) | 95 702 (23.3) | 20.2 |
| South Central | 341 774 (13.3) | 54 145 (13.2) | 15.8 |
| South East | 283 721 (11.0) | 33 246 (10.8) | 11.7 |
| South West | 242 585 (9.4) | 38 114 (9.3) | 15.7 |
| West Midlands | 284 207 (11.0) | 48 147 (11.7) | 16.9 |
| Yorkshire and Humber | 81 686 (3.2) | 14 363 (3.5) | 17.6 |
| Household size (No. of people) | | | |
| 2 | 383 616 (14.9) | 64 635 (15.7) | 16.8 |
| 3-5 | 1 549 068 (60.1) | 253 123 (61.6) | 16.3 |
| 6-9 | 246 764 (9.6) | 30 806 (7.5) | 12.5 |
| ≥10 | 35 396 (1.4) | 3950 (1.0) | 11.2 |
| Not recorded[b] | 361 509 (14.0) | 58 212 (14.2) | 16.1 |
| Comorbidities | | | |
| No relevant comorbidities | 2 348 326 (91.1) | 362 649 (88.3) | 15.4 |
| Asthma | 183 089 (7.1) | 37 519 (9.1) | 20.5 |
| Diabetes (type 1) | 4916 (0.2) | 1166 (0.3) | 23.7 |
| Cerebral palsy | 3927 (0.2) | 1153 (0.3) | 29.4 |
| Epilepsy | 12 972 (0.5) | 3213 (0.8) | 24.8 |
| Congenital heart disease | 21 523 (0.8) | 4694 (1.1) | 21.8 |
| Sickle cell disease | 1600 (0.1) | 332 (0.1) | 20.8 |

Abbreviation: IQR, interquartile range.

[a] Data are presented as number (percentage) unless otherwise indicated.

[b] Household size 1 (single occupant) was reclassified as not recorded.

Table 2. COVID-19 Testing and Hospital Outcomes of Children Between January 24 and October 31 (for Hospital Data) and November 30, 2020 (for Testing Data)[a]

| Outcome | Total population | Tested positive | Hospital contact | Hospital admission | | | ICU admission |
|---|---|---|---|---|---|---|---|
| | | | | <36 h | ≥36 h | Total admissions | |
| Total population | 2 576 353 | 26 322 (1.0) | 1853 (0.07) | 184 (0.007) | 159 (0.006) | 343 (0.01) | 73 (0.002) |
| Sex | | | | | | | |
| Male | 1 318 747 | 12 959 (1.0) | 934 (0.07) | 109 (0.008) | 83 (0.006) | 192 (0.01) | 45 (0.003) |
| Female | 1 257 606 | 13 363 (1.1) | 919 (0.07) | 75 (0.006) | 76 (0.006) | 151 (0.01) | 28 (0.002) |
| Age, median (IQR), y | | 14 (9-17) | 13 (7-16) | 3 (1-12) | 8 (1-15) | 5 (1-13) | 4 (0-12) |
| Age categories | | | | | | | |
| 0-<3 mo | 61 116 | 330 (0.53) | 96 (0.15) | 35 (0.06) | 30 (0.05) | 65 (0.1) | 22 (0.03) |
| 3-12 mo | 130 110 | 580 (0.44) | 113 (0.09) | 36 (0.03) | 18 (0.01) | 54 (0.04) | 6 (0.005) |
| 2-5 y | 557 318 | 2334 (0.42) | 204 (0.04) | 39 (0.007) | 21 (0.004) | 60 (0.01) | 12 (0.002) |
| 6-10 y | 725 819 | 4750 (0.65) | 318 (0.04) | 22 (0.003) | 26 (0.004) | 48 (0.006) | 12 (0.002) |
| 11-15 y | 707 095 | 9000 (1.27) | 535 (0.08) | 28 (0.004) | 33 (0.005) | 61 (0.009) | 15 (0.002) |
| 16-18 y | 394 895 | 9328 (2.36) | 587 (0.15) | 24 (0.006) | 31 (0.008) | 55 (0.01) | 6 (0.002) |
| Race | | | | | | | |
| White | 1 311 041 | 13 043 (1.0) | 839 (0.06) | 62 (0.004) | 63 (0.004) | 125 (0.009) | 24 (0.002) |
| Asian | 243 545 | 3576 (1.47) | 236 (0.09) | 24 (0.01) | 23 (0.009) | 47 (0.02) | 15 (0.006) |
| Black | 93 620 | 601 (0.64) | 67 (0.07) | 10 (0.01) | 10 (0.01) | 20 (0.02) | 5 (0.005) |
| Mixed/other | 147 529 | 1197 (0.81) | 108 (0.07) | 11 (0.007) | 19 (0.01) | 30 (0.02) | 6 (0.004) |
| Townsend deprivation quintile | | | | | | | |
| 1 (Least deprived) | 527 452 | 6239 (1.0) | 433 (0.08) | 30 (0.005) | 17 (0.003) | 47 (0.009) | 7 (0.001) |
| 2 | 547 532 | 5762 (1.1) | 395 (0.07) | 31 (0.006) | 23 (0.004) | 54 (0.01) | 10 (0.002) |
| 3 | 542 116 | 5562 (1.0) | 408 (0.08) | 44 (0.008) | 29 (0.005) | 73 (0.01) | 17 (0.003) |
| 4 | 509 671 | 4916 (1.0) | 326 (0.06) | 38 (0.007) | 37 (0.007) | 75 (0.01) | 12 (0.002) |
| 5 (Most deprived) | 429 060 | 3694 (0.86) | 271 (0.06) | 41 (0.009) | 51 (0.01) | 92 (0.02) | 26 (0.006) |
| Household size (No. of people) | | | | | | | |
| 2 | 383 616 | 3427 (0.90) | 257 (0.07) | 33 (0.009) | 27 (0.007) | 60 (0.02) | 9 (0.002) |
| 3-5 | 1 549 068 | 16 760 (1.12) | 1156 (0.07) | 93 (0.006) | 75 (0.005) | 168 (0.01) | 38 (0.002) |
| 6-9 | 246 764 | 2739 (1.83) | 160 (0.06) | 14 (0.006) | 25 (0.01) | 39 (0.02) | 6 (0.002) |
| ≥10 | 35 396 | 573 (1.61) | 42 (2.3) | <5[b] | <5 | <5 | <5 |
| Comorbidities | | | | | | | |
| No relevant comorbidities | 2 348 326 | 22 747 (1.0) | 1584 (0.07) | 288 (0.01) | 157 (0.007) | 131 (0.006) | 55 (0.002) |
| Asthma | 183 089 | 2962 (1.6) | 188 (0.1) | 15 (0.008) | 10 (0.005) | 25 (0.01) | <5 |
| Diabetes (type 1) | 4916 | 98 (2.0) | 16 (0.3) | <5 | <5 | <5 | <5 |
| Cerebral palsy | 3927 | 57 (1.5) | 13 (0.3) | <5 | <5 | 7 (0.2) | 5 (0.1) |
| Epilepsy | 12 972 | 205 (1.6) | 35 (0.3) | 5 (0.04) | 7 (0.05) | 12 (0.09) | 5 (0.04) |
| Congenital heart disease | 21 523 | 244 (1.1) | 28 (0.1) | <5 | <5 | 7 (0.03) | 5 (0.02) |
| Sickle cell disease | 1600 | 9 (0.6) | <5 | <5 | <5 | <5 | <5 |

Abbreviations: ICU, intensive care unit; IQR, interquartile range.

[a] Data are presented as number (percentage) unless otherwise indicated.

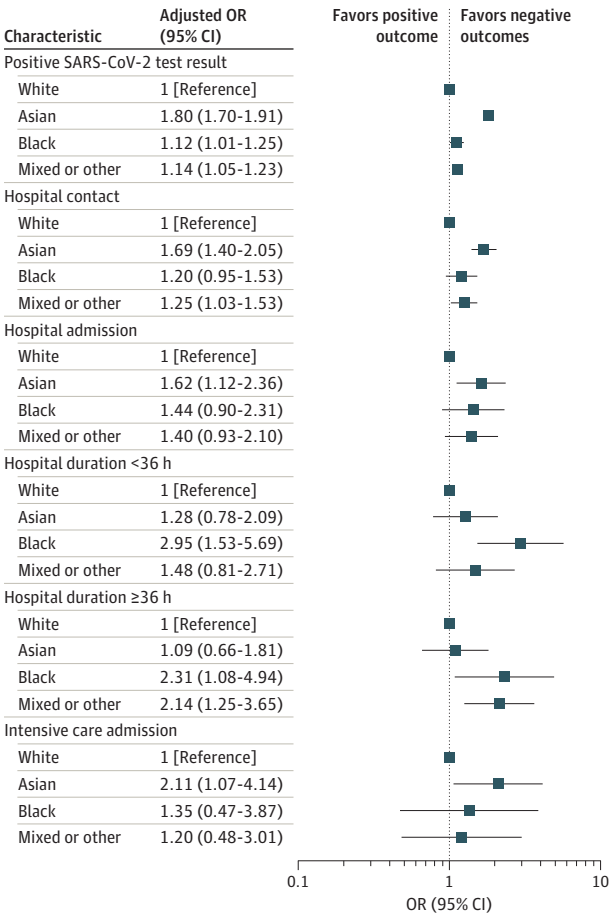
[b] Values less than 5 were suppressed to maintain confidentiality.

In maximally adjusted estimates, children of Asian (adjusted OR, 1.80; 95% CI, 1.70-1.91; $P < .001$), Black (adjusted OR, 1.12; 95% CI, 1.01-1.25; $P = .04$), and mixed or other (adjusted OR, 1.14; 95% CI, 1.05-1.23; $P = .002$) backgrounds had significantly higher odds of positive test results compared with White children (**Figure 1**; eFigure 1 and eTables 3 and 8 in the Supplement). Older children (16-18 years of age) were also more likely to have a positive test result for SARS-CoV-2 compared with infants (0-3 months of age) (adjusted OR, 3.62; 95% CI, 3.23-4.05; $P < .001$) (**Figure 2**).

## COVID-19 Hospital Contact and Admission

Race was significantly associated with hospital admission (Figure 1 and **Figure 3**; eFigure 3 and eTables 5 and 10 in the Supplement) and any hospital contact (Figure 1; eFigure 2 and eTables 4 and 9 in the Supplement). In maximally adjusted es-

Figure 1. Maximally Adjusted Regression Analysis Exploring the Association Between Race and Outcomes of Interest




Outcomes of interest included SARS-CoV-2 testing, hospital contact (admission or attendance), hospital admission, hospitalization duration, and intensive care admission. Adjustments were made for demographic characteristics (age, sex, deprivation level, region, and household size) and all relevant comorbidities (asthma, type 1 diabetes, cerebral palsy, congenital heart disease, epilepsy, and sickle cell disease). OR indicates odds ratio.

timates, children of Asian (adjusted OR, 1.69; 95% CI, 1.40-2.05; $P < .001$) and mixed or other (adjusted OR, 1.25; 95% CI, 1.03-1.53; $P = .03$) backgrounds had significantly higher ORs for hospital contact. Asian children were also more likely to be admitted to the hospital for confirmed COVID-19 (adjusted OR, 1.62; 95% CI, 1.12-2.36; $P = .01$) compared with White children, whereas the ORs for Black children (adjusted OR, 1.44; 95% CI, 0.90-2.31) and children of mixed or other races (adjusted OR, 1.40; 95% CI, 0.93-2.10) were comparable.

Hospitalization duration also varied across races (Figure 1; eFigure 4 and eTable 6 in the Supplement). In adjusted estimates, Black children (adjusted OR, 2.31; 95% CI, 1.08-4.94; $P = .03$) and children of mixed or other races (adjusted OR, 2.14; 95% CI, 1.25-3.65; $P = .006$) had significantly more hospitalizations that were 36 hours or longer compared with White children. Because of small numbers of children with comorbidities, adjusted estimates for hospitalization duration included only demographic variables.

### COVID-19 ICU Admissions

Race was also associated with ICU admissions (Figure 1; eFigure 5 and eTables 7 and 11 in the Supplement). In maximally adjusted estimates, Asian children had a significantly higher odds ratio for COVID-19 ICU admissions (adjusted OR, 2.11; 95% CI, 1.07-4.14; $P = .03$) compared with White children. The OR for COVID-19 ICU admission in Black children (adjusted OR, 1.36; 95% CI, 0.47-3.87) and children of mixed or other races (adjusted OR, 1.20; 95% CI, 0.48-3.01) was not significantly different compared with White children.

## Discussion

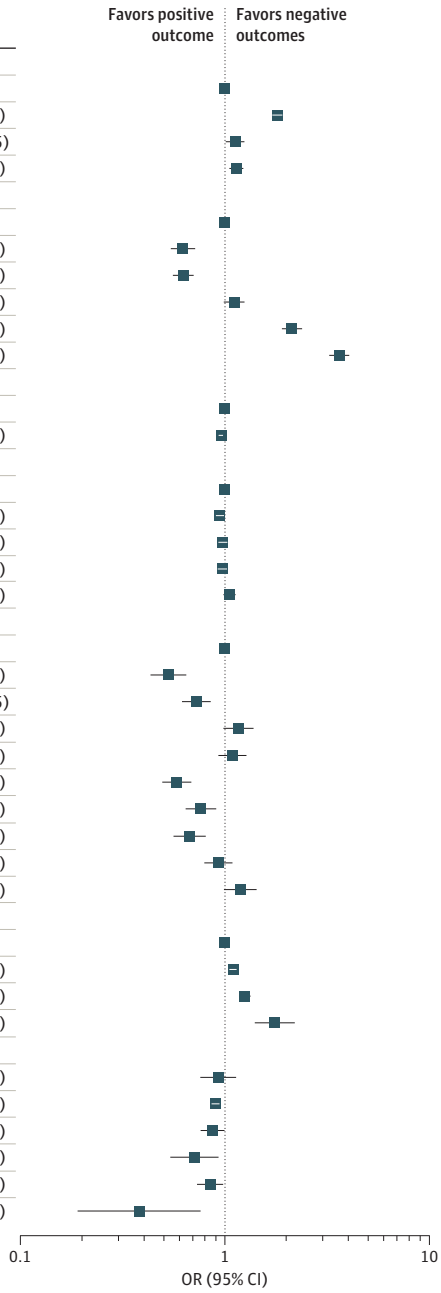
This cohort study used a nationally representative cohort of 2 576 353 children (0-18 years of age) to investigate the association between race and pediatric COVID-19 outcomes in the UK. Results of this study indicate that race-specific disparities in SARS-CoV-2 testing and COVID-19 hospital outcomes seen in adults also exist among children, after accounting for several clinical and sociodemographic factors thought to play a role in the disease. First, unequal SARS-CoV-2 testing across racial minority children was identified, with the highest proportion of tests seen in White children. Second, in children who received a test, racial minority children were more likely to test positive compared with White children. Third, Asian children were significantly more likely to have COVID-19 hospital and ICU admissions compared with White children. Fourth, although Black children and children of mixed or other races had comparable risks of hospital admission, when admitted, they were more likely to remain in the hospital for 36 hours or longer compared with White children.

Differing testing rates across racial/ethnic minorities during the pandemic have previously been reported in studies[45,46] that focused on adults. This disparity has also been observed more generally in other health contexts in adults, such as cancer screening,[47] HIV screening,[48] and vaccination uptake.[49,50] Structural discrimination, distrust of health care establishments, and the wider social determinants of health are all thought to contribute to this observed inequity.[51] The findings of this study support similar pediatric reports from the US[5] and suggest that this disparity is not limited to adults. These findings highlight the need for a more international focus on prioritization of testing access and uptake among children from different race. Testing remains particularly important for children, while waiting for vaccination programs to roll out to younger age groups.

The finding that racial minority children are more likely to test positive for SARS-CoV-2 compared with White children, after accounting for key sociodemographic and clinical factors, builds on a previous report[5] from the US-based pediatric cohort study and is in keeping with several other studies[52,53] focused on adult racial/ethnic minorities. A recent meta-analysis[17] of 50 studies in adults from the US and the UK found that racial/ethnic minorities were at higher risk for SARS-CoV-2 infection. The underlying reasons for these findings are likely to be multifactorial and complex. Higher infection rates observed among adult racial minorities have

Figure 2. Maximally Adjusted Regression Analysis Exploring the Association Between Race and Having a SARS-CoV-2 Positive Test Result

| Characteristic | Adjusted OR (95% CI) |
|---|---|
| Race/ethnicity | |
| White | 1 [Reference] |
| Asian | 1.80 (1.70-1.91) |
| Black | 1.12 (1.01- 1.25) |
| Mixed or other | 1.14 (1.05-1.23) |
| Age category | |
| 0-3 mo | 1 [Reference] |
| 3 mo to 1 y | 0.62 (0.54-0.71) |
| 2-5 y | 0.63 (0.56-0.70) |
| 6-10 y | 1.11 (0.99-1.25) |
| 11-15 y | 2.12 (1.90-2.38) |
| 16-18 y | 3.62 (3.23-4.05) |
| Sex | |
| Female | 1 [Reference] |
| Male | 0.96 (0.93-0.98) |
| Townsend deprivation quintile | |
| 1 (Least deprived) | 1 [Reference] |
| 2 | 0.94 (0.90-0.99) |
| 3 | 0.98 (0.93-1.03) |
| 4 | 0.97 (0.92-1.02) |
| 5 (Most deprived) | 1.05 (0.98-1.13) |
| Region | |
| East Midlands | 1 [Reference] |
| East Anglia | 0.53 (0.43-0.65) |
| London | 0.72 (0.62 -0.85) |
| North East | 1.16 (0.98-1.38) |
| North West | 1.09 (0.93-1.27) |
| South Central | 0.58 (0.49-0.68) |
| South East | 0.76 (0.64-0.91) |
| South West | 0.67 (0.56-0.81) |
| West Midlands | 0.93 (0.79-1.09) |
| Yorkshire and Humber | 1.19 (0.99-1.43) |
| Household size (No. of people) | |
| 2 | 1 [Reference] |
| 3-5 | 1.09 (1.05-1.14) |
| 6-9 | 1.25 (1.17-1.33) |
| ≥10 | 1.75 (1.40-2.19) |
| Comorbidities | |
| Type 1 diabetes | 0.93 (0.76-1.13) |
| Asthma | 0.90 (0.86-0.94) |
| Congenital heart disease | 0.87 (0.76-0.99) |
| Cerebral palsy | 0.71 (0.54-0.93) |
| Epilepsy | 0.85 (0.73-0.98) |
| Sickle cell disease | 0.38 (0.19-0.76) |



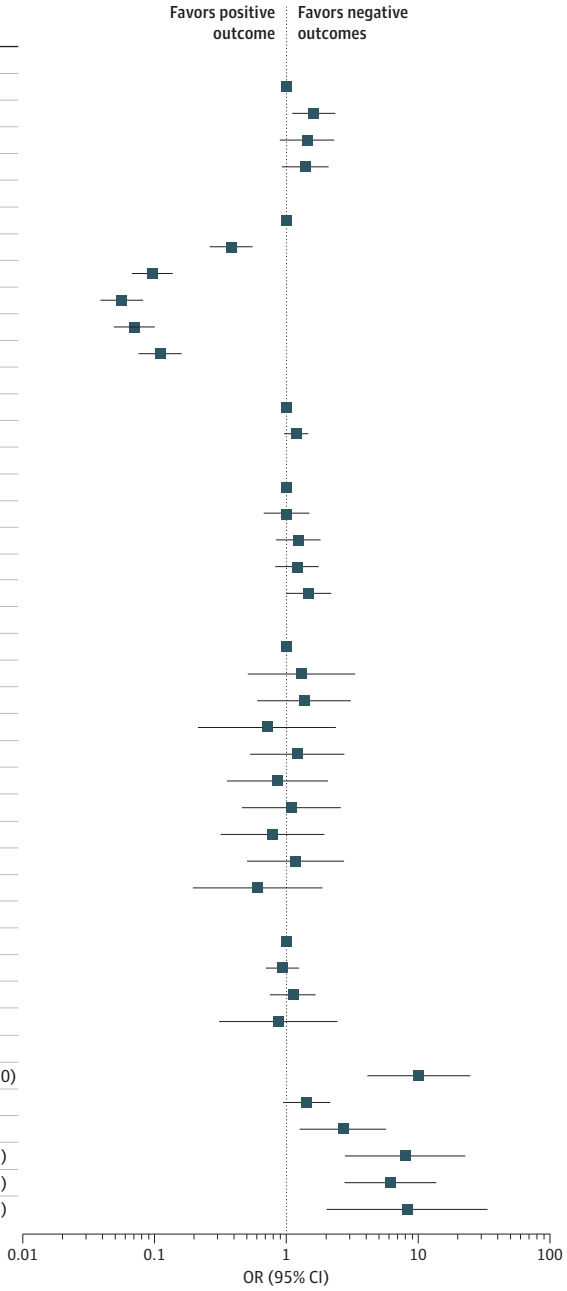

Adjustments were made for demographic characteristics (age, sex, deprivation level, region, and household size) and relevant comorbidities (asthma, type 1 diabetes, congenital heart disease, cerebral palsy, epilepsy, and sickle cell disease). OR indicates odds ratio.

largely been attributed to sociodemographic factors that we were unable to account for in our study.[17,45] These factors include living in multigenerational households and being part of families with members who are considered essential workers.[42]

This study further found race-specific differences in hospital outcomes in children with COVID-19. Compared with White children, Asian children were more likely to have COVID-19 hospital and ICU admissions, whereas Black children and children of mixed or other races were more likely to remain in the hospital for longer than or equal to 36 hours. These results suggest that racial minority children may have a more severe course of COVID-19. These findings are in line with studies[4,54,55] based on cohorts of hospitalized children with COVID-19: (1) a UK-based descriptive study[4] that reported an increased risk of COVID-19 critical care admissions in children of Black backgrounds and (2) US-based studies[54,55] on MIS-C that identified a higher risk in children of Black race in MIS-C–related hospitalizations. The underlying mechanisms for these findings are likely to be complex. The lower percentage of tests seen in racial minority children may result in the biased selection of more severe COVID-19 cases and

Figure 3. Adjusted Regression Analysis Exploring the Association Between Race and Hospital Admission

| Characteristic | Adjusted OR (95% CI) |
|---|---|
| Race/ethnicity | |
| White | 1 [Reference] |
| Asian | 1.62 (1.12-2.36) |
| Black | 1.44 (0.90-2.31) |
| Mixed or other | 1.40 (0.93-2.10) |
| Age category | |
| 0-3 mo | 1 [Reference] |
| 3 mo to 1 y | 0.38 (0.26-0.56) |
| 2-5 y | 0.10 (0.07-0.14) |
| 6-10 y | 0.06 (0.04-0.08) |
| 11-15 y | 0.07 (0.05-0.10) |
| 16-18 y | 0.11 (0.08-0.16) |
| Sex | |
| Female | 1 [Reference] |
| Male | 1.19 (0.97-1.47) |
| Townsend deprivation quintile | |
| 1 (Least deprived) | 1 [Reference] |
| 2 | 1.01 (0.68-1.50) |
| 3 | 1.24 (0.84-1.83) |
| 4 | 1.21 (0.83-1.77) |
| 5 (Most deprived) | 1.48 (1.00-2.20) |
| Region | |
| East Midlands | 1 [Reference] |
| East Anglia | 1.31 (0.51-3.33) |
| London | 1.37 (0.60-3.09) |
| North East | 0.72 (0.22-2.38) |
| North West | 1.21 (0.53-2.76) |
| South Central | 0.86 (0.36-2.08) |
| South East | 1.10 (0.46-2.60) |
| South West | 0.79 (0.32-1.95) |
| West Midlands | 1.18 (0.51-2.75) |
| Yorkshire and Humber | 0.61 (0.20-1.88) |
| Household size (No. of people) | |
| 2 | 1 [Reference] |
| 3-5 | 0.94 (0.70-1.26) |
| 6-9 | 1.12 (0.76-1.67) |
| ≥10 | 0.87 (0.31-2.45) |
| Comorbidities | |
| Type 1 diabetes | 10.11 (4.12-24.80) |
| Asthma | 1.43 (0.95-2.16) |
| Congenital heart disease | 2.69 (1.27-5.71) |
| Cerebral palsy | 7.96 (2.79-22.76) |
| Epilepsy | 6.17 (2.77-13.73) |
| Sickle cell disease | 8.24 (2.02-33.51) |




Adjustments were made for demographic characteristics (age, sex, deprivation level, region, and household size) and any relevant comorbidity (asthma, type 1 diabetes, congenital heart disease, cerebral palsy, epilepsy, and sickle cell disease). OR indicates odds ratio.

underestimate the mild and asymptomatic cases in these groups. These study findings do not allow further extrapolation of underlying etiologic mechanisms. More granular assessment of individual ethnicities within Asian and Black groups, as well as other ethnicities, such as Hispanic, are required before any further interpretation.

This study also identified other potential factors associated with severe childhood COVID-19 outcomes, such as young age, preexisting comorbidities, and higher deprivation levels. Infants (0-3 months of age) were more likely to have hospital admissions, longer hospital stays, and more ICU admissions. Higher ORs of these outcomes were also observed in children with preexisting comorbidities, specifically neurologic disorders (cerebral palsy and epilepsy), type 1 diabetes, congenital heart disease, and sickle cell disease. This finding could be a result of the lower admission thresholds for observation in infants and children with preexisting comorbidities but could also indicate a more severe disease course. The findings of this study are in line with results of several other pediatric cohort studies[4,5,11] that have explored COVID-19. This study also observed a higher proportion of ICU admissions in male patients, which has been reported in a previous pediatric, multicohort study[11] in Europe and is an established risk factor for poor outcomes in adults with COVID-19.[17] Male sex has previously been reported to be associated with more severe outcomes

in several other childhood infectious diseases, such as influenza and respiratory syncytial virus,[56] although the mechanisms underlying this difference is unclear.

### Strengths and Limitations

This study has a number of strengths. Overall, the main strengths include the use of a large, nationally representative sample covering approximately 20% of the population of England. The population-based approach overcomes the potential selection bias observed in previous studies,[54,57] which have been restricted to hospital admissions, and reduces the risk of collider bias. Detailed consideration and inclusion of clinical and sociodemographic confounders in the analyses provide a rigorous investigation of the association between race and pediatric COVID-19 outcomes.

This study also has some important limitations. First, the numbers of ICU admissions and deaths were small. Although the findings provide crucial insights into the association of race with COVID-19 outcomes, further studies are required to explore the most severe cases (ie, ICU admissions and mortality) and longer-term outcomes, such as long-term COVID-19. Second, because of the absence of a code for MIS-C in the UK, it was not possible to separately investigate the association between race and MIS-C. Third, although obesity has been associated with more severe COVID-19 outcomes in children as well as adults and has different prevalence rates across racial/ethnic minority groups in the UK,[5,39,58] body mass index was not consistently recorded across the data set (only 15.8% of cohort) and therefore could not be included in analyses. This inconsistency is attributable to childhood weight measurements not routinely being conducted in primary care. Fourth, schools were open for part of the study period (September to November 2020), which may impact test rates, although schooling is compulsory for all children in the UK. Fifth, 14.0% of the study cohort was misclassified into single-occupant households, which is likely because of family members registering at different nearby family practices. Because only 2.1% of the 16- to 24-year-olds in the UK are reported to live alone,[59] we reclassified single-occupant households as missing and imputed it in our analyses. Sixth, because this study is an observational study based on linked data sets, there is the possibility of selection bias from missing data, information bias from misclassification of test results (particularly with limited community testing at the beginning of the pandemic, which may underestimate the numbers of patients with COVID-19 disease), and residual confounding from unaccounted confounders, such as parental occupation.

## Conclusions

After accounting for important sociodemographic and clinical factors that are associated with COVID-19 disease, this population-based cohort study provides, to our knowledge, the most evidence to date of race-specific disparities across SARS-CoV-2 testing and COVID-19 hospitalizations in children in the UK. Disparities in testing, infection rates, and hospitalization linked to racial minority children have important implications for families, practitioners, and policymakers internationally. Raising awareness of race/ethnic group–specific patterns of presentation to hospital and potential differences in disease course may support families in their decisions to seek medical advice early and aid practitioners in tailoring their inpatient and ambulatory management. This study reinforces the continued need for race/ethnicity-tailored focus on health system performance and targeted public health interventions in children, not only during the ongoing COVID-19 pandemic but also in the event of future public health threats.

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**Additional Contributions:** EMIS Practices contributed to QResearch, and EMIS Health, the

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**Additional Information:** This project involves data derived from patient-level information collected by the NHS as part of the care and support of patients with cancer. The COVID-19 test data are collated, maintained, and quality assured by Public Health England (PHE). Access to the data was facilitated by the PHE Office for Data Release. The Hospital Episode Statistics and mortality data used in this analysis are reused with permission of NHS Digital, which retains copyright of those data. NHS Digital and PHE bear no responsibility for the analysis or interpretation of the data.

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