*Open Forum Infectious Diseases*

MAJOR ARTICLE

# Severe Acute Respiratory Syndrome Coronavirus 2 Seroprevalence and Reported Coronavirus Disease 2019 Cases in US Children, August 2020–May 2021

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***Background.*** Case-based surveillance of pediatric coronavirus disease 2019 (COVID-19) cases underestimates the prevalence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections among children and adolescents. Our objectives were to estimate monthly SARS-CoV-2 antibody seroprevalence and calculate ratios of SARS-CoV-2 infections to reported COVID-19 cases among children and adolescents in 8 US states.

***Methods.*** Using data from the Nationwide Commercial Laboratory Seroprevalence Survey, we estimated monthly SARS-CoV-2 antibody seroprevalence among children aged 0–17 years from August 2020 through May 2021. We calculated and compared cumulative incidence of SARS-CoV-2 infection extrapolated from population-standardized seroprevalence of antibodies to SARS-CoV-2, cumulative COVID-19 case reports since March 2020, and infection-to-case ratios among persons of all ages and children aged 0–17 years for each state.

***Results.*** Of 41 583 residual serum specimens tested, children aged 0–4, 5–11, and 12–17 years accounted for 1619 (3.9%), 10 507 (25.3%), and 29 457 (70.8%), respectively. Median SARS-CoV-2 antibody seroprevalence among children increased from 8% (range, 6%–20%) in August 2020 to 37% (range, 26%–44%) in May 2021. Estimated ratios of SARS-CoV-2 infections to reported COVID-19 cases in May 2021 ranged by state from 4.7–8.9 among children and adolescents to 2.2–3.9 for all ages combined.

***Conclusions.*** Through May 2021 in selected states, the majority of children with serum specimens included in serosurveys did not have evidence of prior SARS-CoV-2 infection. Case-based surveillance underestimated the number of children infected with SARS-CoV-2 more than among all ages. Continued monitoring of pediatric SARS-CoV-2 antibody seroprevalence should inform prevention and vaccination strategies.

**Keywords.** COVID-19; infection; pediatric; SARS-CoV-2; seroprevalence; surveillance.

As of January 2022, children and adolescents aged 0–17 years accounted for 16% of >45 million individual confirmed and probable cases of coronavirus disease 2019 (COVID-19) reported since January 2020 by jurisdictional health departments to the United States (US) Centers for Disease Control and Prevention (CDC) [1]. Although children and adolescents experienced lower risk of severe COVID-19 and COVID-19–related mortality than older adults, children remain at risk of severe complications of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection including hospitalization, multisystem inflammatory syndrome in children, post–COVID-19 conditions, and death [2–6]. Furthermore, as a result of COVID-19 vaccination of older persons, children and adolescents account for an increasing proportion of reported COVID-19 cases and SARS-CoV-2 testing [7]. Comirnaty (COVID-19 messenger RNA [mRNA] vaccine), produced by Pfizer-BioNTech, was granted Emergency Use Authorization (EUA) by the US Food and Drug Administration (FDA) and recommended for persons aged ≥16 years by the Advisory Committee on Immunization Practices (ACIP) in December 2020 [8]. Following early vaccination of priority groups and high-risk individuals [9], uptake of COVID-19 vaccines among adolescents aged 16–17 years increased during March–April 2021 once widespread community vaccination became

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available [10]. After the Pfizer-BioNTech COVID-19 vaccine was approved for adolescents aged 12–15 years in May 2021 and children aged 5–11 years in November 2021, ACIP recommended vaccination for these age groups [11, 12]. As of January 2022, >16 million 12- to 17-year-olds and 7 million 5- to 11-year-olds had received at least 1 dose of COVID-19 vaccine, reaching an estimated 64% of 16- to 17-year-olds and 26% of 12- to 15-year-olds in the US [10].

Analyses of case surveillance data from health departments have used different age groups in the case definitions for estimating COVID-19 incidence among children and adolescents [7]. Estimates of SARS-CoV-2 infections among children and adolescents based on case-based surveillance data may be less reliable than those for older age groups because children may be less likely to present with symptoms and be tested for SARS-CoV-2 infection. Since July 2020, CDC has partnered with commercial laboratories to conduct repeated cross-sectional seroprevalence studies using residual clinical serum specimens to test for the presence of SARS-CoV-2 antibodies [13, 14]. In unvaccinated individuals, detection of specific antibodies to SARS-CoV-2 proteins in serum indicates previous infection [15]. Laboratory assays that detect nucleocapsid (N) antibodies identify individuals with a history of SARS-CoV-2 infection regardless of immunization status because currently approved or authorized vaccines in the US elicit antibodies to SARS-CoV-2 spike protein [14].

While commercial laboratory serosurveillance has provided seroprevalence estimates across the age spectrum, including persons aged 0–17 years [13], differences in seroprevalence among pediatric age groups have not been evaluated. This study looked at data from early in the pandemic through May 2021 to estimate numbers of children and adolescents who had been infected with SARS-CoV-2 prior to widespread COVID-19 vaccination among children aged 5–15 years. To investigate trends in estimated SARS-CoV-2 infections among children and adolescents, we analyzed commercial laboratory serosurvey data from 8 US states and compared cumulative incidence of SARS-CoV-2 infection inferred from seroprevalence with total confirmed and probable COVID-19 cases reported during the same period among pediatric age groups. The objectives of this analysis were to estimate pediatric SARS-CoV-2 antibody seroprevalence monthly from August 2020 through May 2021 in selected states and to estimate ratios of SARS-CoV-2 infections to COVID-19 cases among children and adolescents reported through case-based surveillance.

## METHODS

Methods for the Nationwide Commercial Laboratory Seroprevalence Survey have been previously described [13, 14]. In brief, CDC partnered with 3 commercial laboratories to test for the presence of SARS-CoV-2 antibodies in convenience samples of residual sera submitted for routine clinical testing, including but not limited to lipid testing, sodium level testing, and hormone testing. Serum specimens submitted for COVID-19 or SARS-CoV-2 antibody testing were excluded. Commercial laboratories assigned patient identifiers to de-duplicate serum specimens within each serosurvey round; de-identified laboratory results were provided to CDC with patient demographics (age in years, sex, and residential zip code). Patient race and ethnicity were not provided.

Commercial laboratories used 1 of 3 immunoassays authorized under EUA: Elecsys Anti-SARS-CoV-2 assay (Roche, Indianapolis, Indiana) and ARCHITECT SARS-CoV-2 immunoglobulin G (IgG) assay (Abbott, Chicago, Illinois), both targeting the viral N protein; and VITROS Anti-SARS-CoV-2 IgG Assay (Ortho-Clinical Diagnostics, Raritan, New Jersey) targeting the viral spike protein. Proportions of sera tested by each immunoassay varied by state and calendar month (Figure 1). From August to October 2020, evidence of prior SARS-CoV-2 infection was defined as a positive test by any immunoassay, according to interim guidelines for COVID-19 antibody testing for public health serosurveillance [16]. To compare trends in pediatric seroprevalence after COVID-19 vaccination was recommended for adolescents aged ≥16 years, we restricted analysis to states in which commercial laboratories tested all sera collected after November 2020 using a single anti-nucleocapsid antibody immunoassay (Elecsys, Roche). We also restricted analysis to states in which commercial laboratories tested ≥100 residual specimens from individuals aged 0–17 years for each month from August 2020 to May 2021 for estimates of pediatric seroprevalence by month.

Using de-identified patient data from the commercial laboratory serosurvey, we estimated SARS-CoV-2 seroprevalence among persons of all ages, children and adolescents aged 0–17 years, and for 3 pediatric age groups: 0–4, 5–11, and 12–17 years. We calculated weighted estimates of seropositivity for each state and month of specimen collection, using individual weights to account for differences in distributions of age, sex, and metropolitan vs rural residence among patients included in serosurveys compared to the state population aged 0–17 years [13]. As previously described, we estimated population-weighted seroprevalence and 95% confidence intervals (CIs) accounting for sensitivity and specificity of the assays using an iterative poststratification process known as raking and layered bootstrapping, with adjusted seroprevalence defined as the mean of the bootstrap distribution and upper and lower confidence limits set at the 2.5th and 97.5th percentiles [17]. We estimated cumulative SARS-CoV-2 infections among persons of all ages and children aged 0–17 years, as well as by pediatric age groups, by multiplying monthly mean seroprevalence estimates, and upper and lower confidence limits, by the respective age-specific population in each state [18].

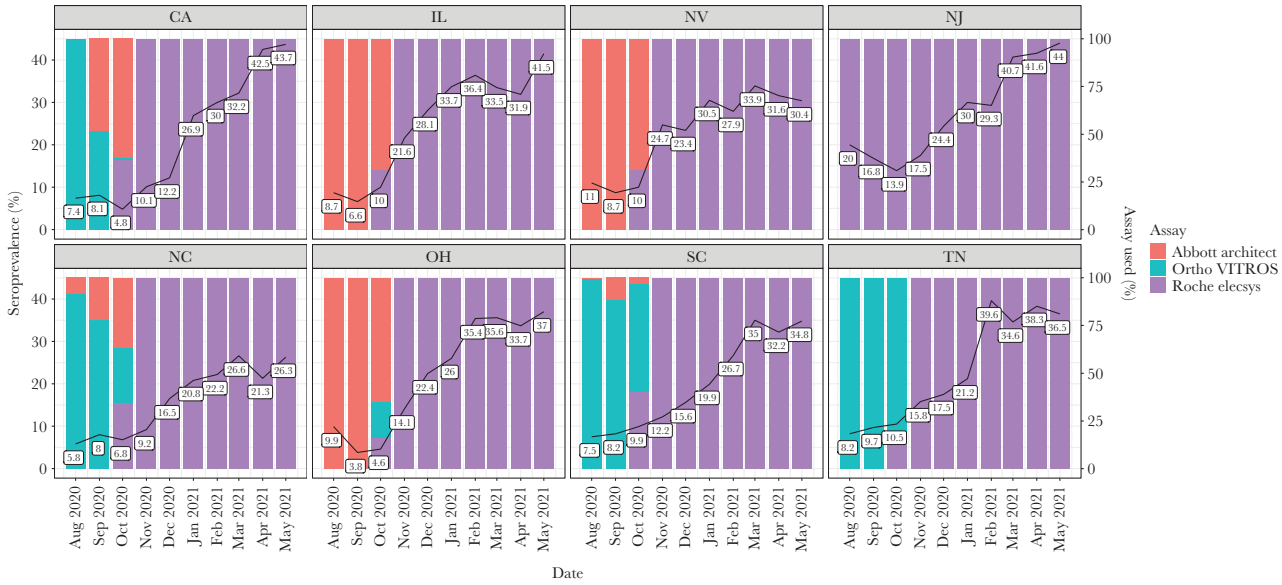


**Figure 1.** Monthly population-weighted seroprevalence among children and adolescents aged 0–17 years in 8 US states included in analysis, with proportions of pediatric serum specimens tested monthly by each commercial immunoassay. Commercial laboratories tested randomly selected, de-duplicated residual sera for the presence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) antibodies using 1 of 3 US Food and Drug Administration–approved commercial immunoassays under Emergency Use Authorization: Roche Elecsys Anti-SARS-CoV-2 pan-immunoglobulin immunoassay, Abbott ARCHITECT SARS-CoV-2 immunoglobulin G (IgG) immunoassay, and Ortho-Clinical Diagnostics VITROS SARS-CoV-2 IgG immunoassay. Abbreviations: CA, California; IL, Illinois; NC, North Carolina; NJ, New Jersey; NV, Nevada; OH, Ohio; SC, South Carolina; TN, Tennessee.

For COVID-19 case-based surveillance, CDC receives individual-level data (including age, sex, date of illness onset, and specimen collection) for probable and laboratory-confirmed COVID-19 cases from jurisdictional health departments through the COVID-19 Case Report Form and the National Notifiable Diseases Surveillance System [19, 20]. For each reported case patient, date of illness was defined as either symptom onset (if reported), the earliest clinical date on case report forms, or date reported to CDC. For this analysis, we included individual-level case data from 8 states (California, Illinois, Nevada, New Jersey, North Carolina, Ohio, South Carolina, and Tennessee) with ≥90% concordance between daily aggregate COVID-19 case counts and cumulative individual case reports from March 2020 through May 2021 and case patient age recorded for >90% of individual case reports.

To calculate ratios of cumulative infections to reported cases, we divided estimated infections (with upper and lower confidence limits) for each month by the number of confirmed and probable COVID-19 cases in persons of all ages and children aged 0–17 years reported by each state health department since January 2020. To allow for delayed antibody response to SARS-CoV-2 infection, cumulative numbers of infections estimated from monthly seroprevalence were divided by COVID-19 cases reported through the 15th of the corresponding month from 15 August 2020 through 15 May 2021. Analyses were conducted in SAS software, version 9.4 (SAS Institute) and R software, version 3.6.3 (R Core Team).

## RESULTS

For the 8 states included in the analysis, a total of 41 583 residual serum specimens were tested from persons aged 0–17 years during August 2020 through May 2021. By state, total numbers of specimens tested from individuals aged 0–17 years ranged from 3235 for Nevada to 7750 for Illinois (Table 1). Fewer specimens were tested each month from August to October 2020 (range, 2644–3734) compared to November 2020 through May 2021 (range, 4246–4932). Overall, the age groups 0–4, 5–11, and 12–17 years accounted for 3.9%, 25.3%, and 70.8% of specimens tested, respectively. In total, 23 542 (56.6%) specimens tested were from females and 18 041 (43.4%) from males. Higher proportions of pediatric serum specimens tested were obtained from females than males for all states (range, 53.1%–59.2% female) and calendar months (range, 54.2%–58.8% female). Proportions of pediatric specimens tested by each of the 3 serologic assays varied by state and calendar month (Figure 1).

Figure 1 shows weighted seroprevalence estimates based on residual serum specimens from children aged 0–17 years. In August 2020, median seroprevalence in the 8 states was 8%, ranging from 6% in North Carolina to 20% in New Jersey. Overall, estimated seroprevalence was <10% in 6 of 8 states. By May 2021, all 8 states had estimated pediatric seroprevalence >25%. Median seroprevalence in May 2021 was 37%, ranging from 26% in North Carolina to 44% in New Jersey.

In Figure 2, population-weighted pediatric seroprevalence estimates from August 2020 through May 2021 are presented with cumulative incidence of reported COVID-19 cases per 100 000

**Table 1. Distribution by State, Month of Collection, and Pediatric Age Group of Residual Clinical Serum Specimens Tested for Severe Acute Respiratory Syndrome Coronavirus 2 Antibodies Among Persons Aged 0–17 years in 8 US States From August 2020 to May 2021**

| | | 0–4 Years | 5–11 Years | 12–17 Years |
|---|---|---|---|---|
| Characteristic | Total No. of Specimens | No. of Specimens (%) | | |
| Overall | 41 583 | 1619 (3.9) | 10 507 (25.3) | 29 457 (70.8) |
| States | | | | |
| California | 5703 | 232 (4.1) | 1599 (28.0) | 3872 (67.9) |
| Illinois | 7750 | 252 (3.3) | 2259 (29.1) | 5239 (67.6) |
| Nevada | 3235 | 202 (6.2) | 878 (27.1) | 2155 (66.6) |
| New Jersey | 4088 | 324 (7.9) | 1385 (33.9) | 2379 (58.2) |
| North Carolina | 6518 | 203 (3.1) | 1453 (22.3) | 4862 (74.6) |
| Ohio | 4564 | 108 (2.4) | 793 (17.4) | 3663 (80.3) |
| South Carolina | 5708 | 128 (2.2) | 1130 (19.8) | 4450 (78.0) |
| Tennessee | 4017 | 170 (4.2) | 1010 (25.1) | 2837 (70.6) |
| Dates of specimen collection | | | | |
| 1–31 Aug 2020 | 3734 | 231 (6.2) | 1020 (27.3) | 2483 (66.5) |
| 1–30 Sep 2020 | 3290 | 261 (7.9) | 988 (30) | 2041 (62) |
| 1–31 Oct 2020 | 2644 | 133 (5) | 719 (27.2) | 1792 (67.8) |
| 1–30 Nov 2020 | 4799 | 129 (2.7) | 1214 (25.3) | 3456 (72) |
| 1–31 Dec 2020 | 4424 | 133 (3) | 1115 (25.2) | 3176 (71.8) |
| 1–31 Jan 2021 | 4643 | 152 (3.3) | 1111 (23.9) | 3380 (72.8) |
| 1–28 Feb 2021 | 4246 | 129 (3) | 1042 (24.5) | 3075 (72.4) |
| 1–31 Mar 2021 | 4932 | 146 (3) | 1182 (24) | 3604 (73.1) |
| 1–30 Apr 2021 | 4563 | 146 (3.2) | 1071 (23.5) | 3346 (73.3) |
| 1–31 May 2021 | 4308 | 159 (3.7) | 1045 (24.3) | 3104 (72.1) |

children aged 0–17 years for the 8 states. From October 2020 through February 2021, increasing seroprevalence followed pandemic waves observed in the daily number of reported COVID-19 in children. However, estimated seroprevalence appeared to plateau from February to May 2021, including in several states (Illinois and New Jersey) with high numbers of pediatric COVID-19 cases reported during March to May 2021 compared to earlier pandemic waves.

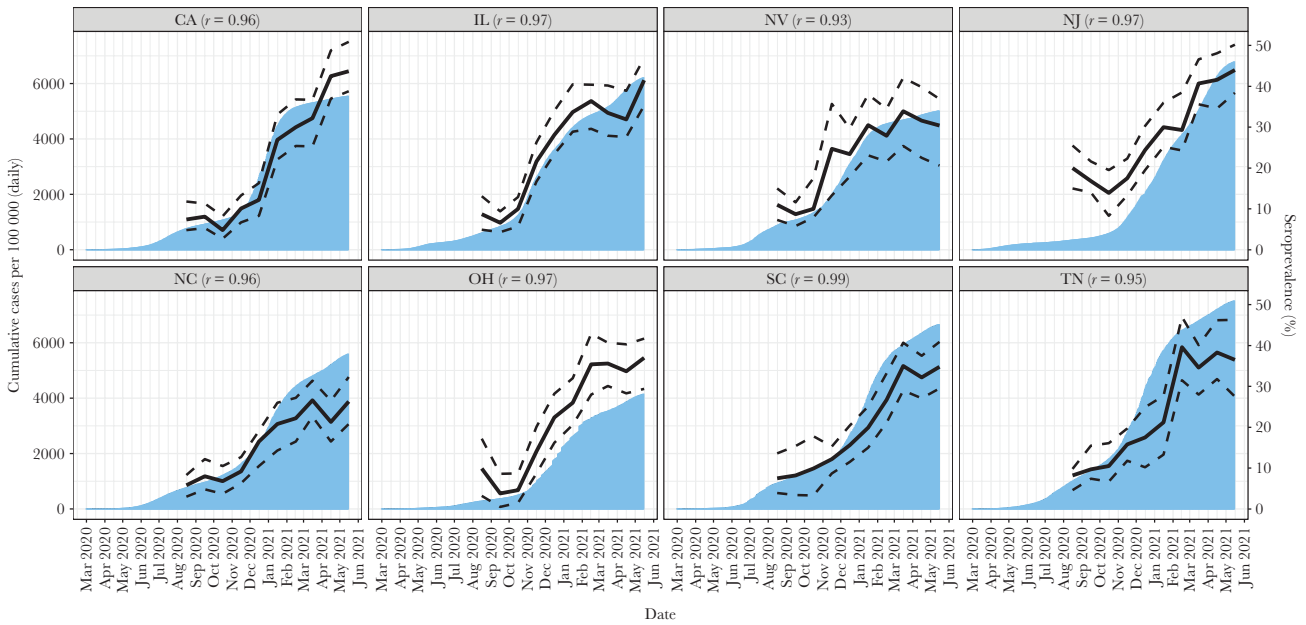


**Figure 2.** Monthly population-weighted seroprevalence among persons 0–17 years of age and cumulative incidence of reported coronavirus disease 2019 (COVID-19) cases (confirmed and probable) per 100 000 children aged 0–17 years in 8 US states, March 2020–May 2021. Each panel represents data from 1 state. Cumulative incidence of reported COVID-19 cases among persons aged 0–17 years is shown in blue, with population-weighted seroprevalence shown as a solid black line with 95% confidence intervals (dotted lines). Abbreviations: CA, California; IL, Illinois; NC, North Carolina; NJ, New Jersey; NV, Nevada; OH, Ohio; SC, South Carolina; TN, Tennessee.

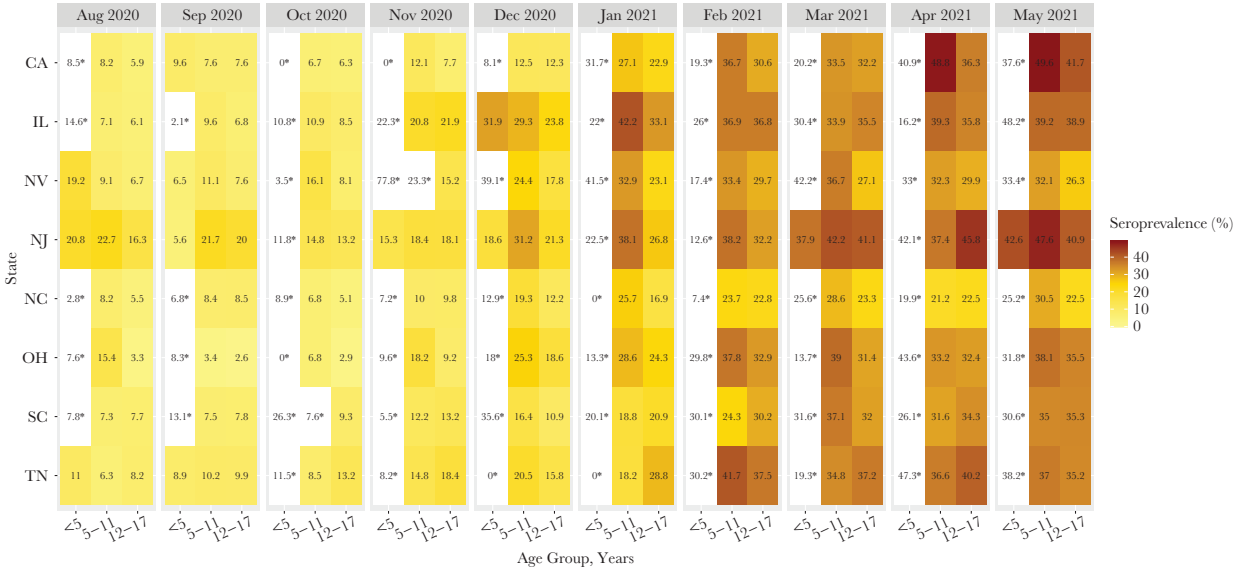


**Figure 3.** Age-stratified severe acute respiratory syndrome coronavirus 2 seroprevalence estimates for 8 US states during August 2020–May 2021. Range of seroprevalence is 0–49.6%. The darkest colors are 40% and above. *White shading indicates <30 specimens in age group, month, state sample. Abbreviations: CA, California; IL, Illinois; NC, North Carolina; NJ, New Jersey; NV, Nevada; OH, Ohio; SC, South Carolina; TN, Tennessee.

Seroprevalence estimates by pediatric age group are shown in Figure 3. Comparisons between age groups were limited by small numbers of specimens from children aged 0–4 years, but seroprevalence increased from August 2020 to May 2021 among all pediatric age groups ($P < .005$ from nonparametric test for all).

Table 2 compares estimated numbers of SARS-CoV-2 infections based on population-weighted seroprevalence estimates in May 2021 from the commercial laboratory serosurvey with cumulative numbers of COVID-19 cases (confirmed and probable) reported by each state health department among persons of all ages and children aged 0–17 years. Compared to ratios in the total population (ranging from 2.2 in South Carolina and Tennessee to 3.9 in Ohio), estimated ratios of SARS-CoV-2 infections to reported cases in all states were higher among persons aged 0–17 years (ranging from 4.7 in North Carolina to 8.9 in Ohio). Pediatric infection-to-case ratios varied between states. Overall, pediatric age-specific infection-to-case ratios

**Table 2. Comparisons of Population-Weighted Seroprevalence, Estimated Severe Acute Respiratory Syndrome Coronavirus 2 Infections, Cumulative Reported Coronavirus Disease 2019 Cases, and Infection-to-Case Ratio Among Persons of All Ages and Children Aged 0–17 Years for 8 US States in May 2021**

| State | Age Group | No. of Specimens | Weighted Seroprevalence (95% CI) | Cumulative Infections, No. (Range) | Cumulative Reported Cases[a] | Infection/Reported Case Ratio (Range) |
|---|---|---|---|---|---|---|
| California | All ages | 2623 | 24.6 (22.8–27.1) | 9 700 454 (9 005 434–10 712 968) | 3 822 702 | 2.5 (2.4–2.8) |
| | 0–17 years | 651 | 43.7 (38.8–50.9) | 3 886 190 (3 454 304–4 523 276) | 492 688 | 7.9 (7.0–9.2) |
| Illinois | All ages | 2752 | 33.8 (31.2–36.3) | 4 279 935 (3 956 394–4 596 830) | 1 378 032 | 3.1 (2.9–3.3) |
| | 0–17 years | 942 | 41.5 (35.3–46.9) | 1 168 883 (994 907–1 321 003) | 174 860 | 6.7 (5.7–7.6) |
| Nevada | All ages | 2623 | 26.4 (24.4–29.0) | 814 258 (753 049–893 062) | 304 603 | 2.7 (2.5–2.9) |
| | 0–17 years | 237 | 30.4 (20.6–36.9) | 210 259 (142 732–255 764) | 34 677 | 6.1 (4.1–7.4) |
| New Jersey | All ages | 2371 | 30.6 (28.5–33.0) | 2 722 198 (2 532 829–2 933 023) | 1 032 402 | 2.6 (2.5–2.8) |
| | 0–17 years | 393 | 44.0 (38.4–50.2) | 852 186 (745 274–973 982) | 131 449 | 6.4 (5.6–7.4) |
| North Carolina | All ages | 2579 | 23.8 (22.0–26.0) | 2 498 128 (2 310 267–2 725 950) | 990 314 | 2.5 (2.3–2.8) |
| | 0–17 years | 648 | 26.3 (20.8–32.3) | 605 738 (477 890–743 315) | 128 567 | 4.7 (3.7–5.8) |
| Ohio | All ages | 2855 | 36.7 (34.6–38.8) | 4 285 138 (4 040 856–4 530 794) | 1 096 385 | 3.9 (3.7–4.1) |
| | 0–17 years | 627 | 37.0 (29.4–41.7) | 953 898 (757 903–1 074 796) | 106 736 | 8.9 (7.1–10.1) |
| South Carolina | All ages | 2566 | 25.8 (23.4–27.8) | 1 330 607 (1 205 479–1 432 816) | 594 999 | 2.2 (2.0–2.4) |
| | 0–17 years | 618 | 34.8 (29.5–40.9) | 386 949 (327 805–454 451) | 73 936 | 5.2 (4.4–6.2) |
| Tennessee | All ages | 2980 | 27.6 (25.4–30.0) | 1 885 715 (1 731 849–2 049 676) | 858 658 | 2.2 (2.0–2.4) |
| | 0–17 years | 192 | 36.5 (27.5–46.3) | 550 904 (415 517–699 893) | 113 355 | 4.9 (3.7–6.2) |

Abbreviation: CI, confidence interval.

[a]Cumulative coronavirus disease 2019 cases (confirmed and probable) reported by state health departments from January 2020 through 15 May 2021.

of SARS-CoV-2 infections to reported COVID-19 cases were highest during August to October 2020. From November 2020 through May 2021, infection-to-case ratios remained relatively stable (Supplementary Figure 1).

Ratios of infections to reported cases tended to be higher in children aged 0–11 years than in those aged 12–17 years. Infection-to-case ratios were similar among children aged 0–4 years and 5–11 years in months when ≥30 specimens from children aged 0–4 years were tested (Supplementary Figure 2). Infection-to-case ratios varied more across states than between pediatric age groups in the same state. In August 2020, we observed the highest ratios in New Jersey for all pediatric age groups (0–4 years: 87.0; 5–11 years: 98.2; 12–17 years: 30.0). In May 2021, we observed the highest ratios in Ohio among children aged 0–4 and 5–11 years (14.3 and 13.1, respectively) and in California among adolescents aged 12–17 years (5.6).

## DISCUSSION

As of May 2021, monthly aggregated commercial laboratory seroprevalence survey data from 8 US states indicated that less than half, 26%–44% depending on the state, of children and adolescents were seropositive for SARS-CoV-2 antibodies against the viral nucleocapsid protein, a marker of prior infection rather than COVID-19 vaccination. In most states, we estimated from 5 to 9 times more SARS-CoV-2 infections in children and adolescents during the COVID-19 pandemic than reported through case-based surveillance, with substantial state-to-state variability. Underestimation of SARS-CoV-2 infections in children was greater than in the total population, with an estimated 2–4 infections for each reported COVID-19 case among persons of all ages [14]. Estimating cumulative incidence of COVID-19 among children and adolescents from case-based surveillance alone would substantially underestimate the proportion of children infected with SARS-CoV-2. Children and adolescents remain at risk of SARS-CoV-2 infection and COVID-19–related complications. Continued SARS-CoV-2 testing and reporting of pediatric COVID-19 cases are important for evaluation of COVID-19 vaccine effectiveness among adolescents and documenting burden of disease in younger children. Ongoing serosurveys with pediatric specimens will be needed in addition to case-based surveillance to monitor trends in SARS-CoV-2 infections in children and adolescents.

The national commercial laboratory seroprevalence survey has provided population-based, cross-sectional data from July 2020 to July 2021 to monitor changes in seroprevalence over time that can be used to estimate cumulative incidence of SARS-CoV-2 infection [13–15]. Results from seroprevalence surveys conducted in 10 geographic locations during March to May 2020 indicated substantial underestimation of SARS-CoV-2 infections and COVID-19 cases early in the pandemic, highlighting the importance of repeated serosampling [15]. In early seroprevalence surveys, ratios of estimated numbers of people infected to reported COVID-19 cases varied widely by state and geography, suggesting not only differences in COVID-19 epidemiology and timing of pandemic waves, but also differences in access to SARS-CoV-2 diagnostic testing and healthcare seeking [21]. Comparisons of SARS-CoV-2 infection rates between population age groups may also reflect differential exposure risks by age and differences in prevalence of asymptomatic infections [21–24]. Our analyses identified fewer differences when comparing seroprevalence by pediatric age group within a state than between states. In the nationwide commercial laboratory serosurvey [13, 14], residual serum specimens from persons aged 0–17 years made up a smaller proportion of specimens tested than specimens from older age groups, limiting comparisons of seroprevalence among children vs adults in the same state. While aggregation of individual-level data for this analysis by month of specimen collection provided seroprevalence estimates for pediatric age groups, smaller numbers of specimens from children aged <5 years resulted in less precise estimates for this important age group.

National commercial laboratory serosurveys have also contributed substantially to our understanding of the COVID-19 pandemic by providing comparable estimates of cumulative rates of SARS-CoV-2 infection by age group and across geographic areas. Seroprevalence data add to case-based surveillance data [7, 25], which are subject to differences in SARS-CoV-2 testing, healthcare seeking, and reporting practices. In general, while timing of SARS-CoV-2 infection of seropositive individuals is unknown, individual-level data on patient age, sex, and urban/rural residence for specimens randomly sampled for testing allows for analyses of trends by population demographics [13]. In addition to analyses by calendar month, trends in seroprevalence may be analyzed following waves of COVID-19 cases or among age groups targeted for vaccination at different times. For pediatric age groups, ongoing cross-sectional serosurveys may help to identify associations between timing of school and community mitigation measures and incidence of SARS-CoV-2 infections in school-aged children and adolescents [26].

Findings from this analysis are subject to several limitations. First, convenience samples of residual clinical specimens are not representative of the general population and weighted estimates accounted only for age, sex, and rural vs urban residence of children in the sample compared to the state population. Important differences have been reported in seroprevalence and infection-to-case ratios by race/ethnicity, socioeconomic status, and health insurance [27, 28], but these data were not available. Second, we restricted analyses to only 8 states with >90% completeness of individual case patient age in COVID-19 surveillance data. The 8 states included in this analysis included different geographic regions and variable timing and intensity of pandemic waves. Third, sample sizes for younger children

were small, limiting comparisons between pediatric age groups. Fourth, sensitivity of immunoassays for identifying past SARS-CoV-2 infections may be influenced by illness severity, kinetics of antibody responses in children, types of antibody measured (pan-immunoglobulin vs IgG-specific assays), and antigen targets of immunoassays [23, 29–35]. While the presence of cross-reactive antibodies to other human coronaviruses may affect SARS-CoV-2 antibody seroprevalence estimates at low levels of infection [36, 37], antibody cross-reactivity would have little impact on trends in seroprevalence over time. SARS-CoV-2 antibody waning below qualitative immunoassay cutoff values for seropositivity may have underestimated SARS-CoV-2 seroprevalence and numbers of children previously infected. However, the Roche Elecsys immunoassay, which detects total anti–SARS-CoV-2 nucleocapsid immunoglobulin, has been shown to be highly sensitive at least 6 months following infection in nonhospitalized patients [33]. Fifth, although commercial laboratories removed duplicate serum specimens from each convenience sample, residual sera from few individuals may have been included in >1 round. Finally, this analysis included data through the end of May 2021, before increased COVID-19 cases due to SARS-CoV-2 Delta variant viruses.

## CONCLUSIONS

Overall, these findings provide evidence of higher rates of COVID-19 among children than detected by case-based surveillance. Through May 2021, the majority of children had no serologic evidence of past SARS-CoV-2 infection, leaving them at risk for future infection. This finding reinforces the need for multiple layers of mitigation strategies to reduce the risk of viral transmission in schools, childcare centers, and other congregate settings. Use of masks, physical distancing, increased ventilation, and combined measures have demonstrated effectiveness [33, 38–46]. Among age groups where vaccines are FDA approved, vaccination is a critical component of strategies to protect children and reduce potential for transmission in households, schools, and communities. With increased COVID-19 incidence in some jurisdictions due to the highly transmissible SARS-CoV-2 Omicron variant, estimation of SARS-CoV-2 infection rates through population-level serosurveys can contribute to understanding the impact of the COVID-19 pandemic on children and adolescents [4].

### Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

### Notes

***Author contributions.*** A. Couture., B. C. L., C. R., K. E. N. C., B. F., and M. D. C. conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript. J. S., M. L. M., L. S., N. E., F. S. A., C. M. B., S. Y., I. A. A., B. J. K., A. Cope, K. D., L. B. T., J. D., and L. B. D. coordinated data collection and reviewed data for accuracy and critically reviewed and revised the manuscript for important public health content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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***Patient consent.*** This activity was reviewed by the CDC and determined to be consistent with non–human participant research activity. Informed consent was waived, as data were de-identified.

***Data sharing.*** De-identified individual participant data will not be made available.

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