

Predictors of Severe Acute Respiratory Syndrome Coronavirus 2 Seropositivity Before Coronavirus Disease 2019 Vaccination Among Children 0–4 Years and Their Household Members in the SEARCH Study

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Background. Estimates of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) seroprevalence in young children and risk factors for seropositivity are scarce. Using data from a prospective cohort study of households during the pre-coronavirus disease 2019 (COVID-19) vaccine period, we estimated SARS-CoV-2 seroprevalence by age and evaluated risk factors for SARS-CoV-2 seropositivity.

Methods. The SARS-CoV-2 Epidemiology and Response in Children (SEARCH) study enrolled 175 Maryland households (690 participants) with ≥ 1 child aged 0–4 years during November 2020–March 2021; individuals vaccinated against COVID-19 were ineligible. At enrollment, participants completed questionnaires about sociodemographic and health status and work, school, and daycare attendance. Participants were tested for SARS-CoV-2 antibodies in sera. Logistic regression models with generalized estimating equations (GEE) to account for correlation within households assessed predictors of individual- and household-level SARS-CoV-2 seropositivity.

Results. Of 681 (98.7%) participants with enrollment serology results, 55 (8.1%; 95% confidence interval [CI], 6.3%–10.4%) participants from 21 (12.0%) households were seropositive for SARS-CoV-2. Among seropositive participants, fewer children than adults reported being tested for SARS-CoV-2 infection before enrollment (odds ratio [OR] = 0.23; 95% CI, .06–.73). Seropositivity was similar by age (GEE OR vs 0–4 years: 1.19 for 5–17 years, 1.36 for adults; $P = .16$) and was significantly higher among adults working outside the home (GEE adjusted OR = 2.2; 95% CI, 1.1–4.4) but not among children attending daycare or school.

Conclusions. Before study enrollment, children and adults in this cohort had similar rates of SARS-CoV-2 infection as measured by serology. An adult household member working outside the home increased a household's odds of SARS-CoV-2 infection, whereas a child attending daycare or school in person did not.

Keywords. children; COVID-19; household transmission; risk factors; seroprevalence.

As of September 3, 2022, more than 94 million cases and 1 million deaths attributable to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection have been reported in the United States [1]. Children aged <18 years account for approximately 17% of reported coronavirus disease 2019

(COVID-19) cases but <1% of all COVID-19 deaths [1]. In the United States, COVID-19 vaccines have been available for children ages ≥ 5 years since October 2021, but they only recently became available to children aged 0–4 years in June 2022. Thus, during the current phase of the COVID-19 pandemic, this youngest age group may be at greater risk of SARS-CoV-2 infection and transmission than vaccinated individuals.

Although children are susceptible to SARS-CoV-2 infection and can transmit the virus to others [2], relatively few studies have focused on disease characteristics and patterns of transmission among children aged 0–4 years. Children are more frequently asymptomatic or mildly symptomatic compared with adults [3], and some household studies have found asymptomatic transmission to be significantly lower than symptomatic transmission [4, 5]. Because children are more likely to be asymptomatic when infected with SARS-CoV-2, they are

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also less likely to be tested, and their infections are less likely to be detected. As a result, young children's susceptibility to infection and their role in household transmission is not well understood.

The SARS-CoV-2 Epidemiology And Response in Children (SEARCh) study is a prospective, longitudinal cohort study that conducted SARS-CoV-2 surveillance in households with children ages 0–4 years. Participating households were followed with baseline and periodic serum collection for SARS-CoV-2 antibody testing and weekly molecular surveillance for SARS-CoV-2 infections using qualitative reverse-transcriptase polymerase chain reaction. In this study, we describe the characteristics of the SEARCh cohort, rates of SARS-CoV-2 seropositivity at enrollment by age group (0–4 years, 5–17 years, and ≥ 18 years), and an evaluation of risk factors associated with SARS-CoV-2 seropositivity at enrollment at the individual and household levels.

METHODS

Household Identification, Recruitment, and Enrollment

A convenience sample of Maryland households in Baltimore City and 8 neighboring counties (Anne Arundel, Baltimore, Calvert, Frederick, Harford, Howard, Montgomery, and Prince George's) was enrolled between November 20, 2020 and March 1, 2021 ([Supplementary Table 1](#)). In September 2020, Maryland's school superintendent approved plans for in-person reopening, but less than 20% of students were attending school in-person as of January 2021, prompting a request to all Maryland school systems to provide some in-person learning by March 2021 [6, 7]. Households in these locations were recruited sequentially, such that enrollment in Anne Arundel County and Baltimore City mostly occurred in December and January, and enrollment in the other locations mostly occurred in January and February. Households with ≥ 1 children aged 0–4 years were recruited from pediatric practices in Maryland via social media postings, email, and by word of mouth from study participants. Eligible households had ≥ 1 child aged 0–4 years and at least 75% of household members who were eligible and willing to enroll. Household members were eligible if they spent ≥ 4 nights a week in the dwelling, were not enrolled in a COVID-19 vaccine trial, and had not received a COVID-19 vaccine before enrollment. Efforts were made to ensure that children in each yearly age stratum among children aged 0–4 years were included.

Recruitment and enrollment were conducted remotely. At enrollment, participants completed individual questionnaires assessing demographic and sociodemographic characteristics, social history, health, prior diagnosis of COVID-19 by a healthcare provider, and in-person attendance at daycare, school, or work ([Supplementary Material S2](#)). Adults

completed questionnaires on behalf of children in the household. Adults were also asked about frequency of teleworking and close contact (within 6 feet) with others at work. Data were collected and stored using Research Electronic Data Capture (REDCap) hosted at Johns Hopkins University and Mosio text messaging software [8, 9].

Patient Consent Statement

This study was approved by the Johns Hopkins University (JHU) Bloomberg School of Public Health Institutional Review Board (IRB). The Centers for Disease Control and Prevention (CDC) IRB relied upon the JHU IRB review. After study team members reviewed the study protocol and procedures with study participants and answered questions during a televisit, electronic informed consent was obtained. Adults from eligible households provided consent for themselves and for children <18 years of age. Assent was also obtained from children ages 7–17 years.

Serologic Assays

Sera were obtained within 3 weeks after enrollment and tested for SARS-CoV-2 antibody to the nucleocapsid (N) and spike (S) protein receptor binding domain (RBD) using the high-throughput automated electrochemiluminescence double-antigen sandwich immunoassays Elecsys-N and Elecsys-S (Roche Diagnostics, Mannheim, Germany) [10]. Due to only 1 discrepant result between Elecsys-N and Elecsys-S assays, we report testing results as either positive or negative for S RBD throughout.

Analytic Definitions and Methods

Analyses describing cohort participant characteristics included all enrolled participants. Analyses related to SARS-CoV-2 serology were restricted to participants with an enrollment blood draw (681 of 690 enrolled participants). Attending scheduled routine activities outside the home was defined for children 0–4 years as going to childcare, for children 5–17 years as attending school in-person, and for adults as working outside the home. These exposure categories did not account for other activities outside the home involving face-to-face contact such as grocery shopping or social events. Conditions that confer an increased risk for severe COVID-19 were defined according to CDC criteria [11]. Body mass index for individuals ≥ 2 years was calculated from self-reported height and weight, and thresholds for overweight and obesity were defined using CDC standards [12, 13]. Household crowding was defined as mean number of people per bedroom. Healthcare workers (HCWs) were adults who self-identified as working in healthcare, mental health, or dentistry and who had close contact (within 6 feet) with others at work. Seropositive households were households with at least 1 seropositive member.

We estimated seroprevalence with 95% confidence intervals (CIs) overall and by age group (0–4 years, 5–17 years, ≥ 18 years). To assess predictors of individual SARS-CoV-2 seropositivity and account for within-household clustering, odds ratios (ORs) and 95% CIs were calculated using a generalized estimating equations (GEE) logistic regression model (“geepack” R package) [14]. The model was defined with an exchangeable correlation matrix, which evaluates the data as if all household members are equally correlated with each other, and generated robust standard errors. Predictors assessed included age group, race, ethnicity, number of household members, household crowding, and attending daycare, school, or work. To assess the possibility of a differential effect of attending daycare, school, or work by age group, we included an interaction term between these 2 variables in the model. The multivariable GEE model included variables that were statistically significant in univariate analyses and was adjusted for the enrollment time period (early, middle, late) to account for potential confounding due to (1) different counties being enrolled at different times and (2) increasing cumulative exposure to infection over time. Overall *P* values for categorical variables were estimated using a Wald test with a robust covariance matrix estimate. To assess child- and adult-specific exposures, stratified analyses were conducted by age group.

To assess predictors of household level SARS-CoV-2 seropositivity, a standard logistic regression model was used. Predictors assessed included number of household members, household crowding, having a HCW in the home, number of household members attending regular activities outside the home, household income, county, and enrollment time period. Seventeen households were missing income data and were excluded from the multivariate logistic regression model. All other household- and individual-level survey data included in the main tables shown were complete. Data analyses were conducted using R version 4.1.0 (R Foundation for Statistical Computing) in RStudio version 1.4.1717 (RStudio, Inc.).

RESULTS

Cohort Characteristics

A total of 690 participants from 175 households enrolled during the SEARCh enrollment period are included in analyses (Figure 1), including 256 children aged 0–4 years and 38 infants aged < 1 year (Supplementary Figures 1 and 2). Among these 690 participants, most were White (87.4%) and non-Hispanic (95.2%; Table 1, Supplementary Table 1). Among the 334 adult participants, few ($n = 4$) were 60 years or older (interquartile range [IQR], 34–39 years), 76.6% had health conditions that may confer an increased risk for severe COVID-19, and 33.2% had overweight or obesity as the sole health condition. A large proportion of children also had high-risk health

conditions (0–4 years: 73 of 256, 28.5%, 5–17 years: 38 of 100, 38.0%), with overweight or obesity as the sole high-risk condition for many. Among the 334 adults, 41.6% worked outside the home at enrollment, 81.3% (113 of 139) of whom had close contact (within 6 feet) with other people as part of their job; approximately one quarter of those (29 of 113, 25.7%) worked in the healthcare industry. Approximately half (48.8%) of children 0–4 years attended daycare outside the home at enrollment, and 23.0% of children 5–17 years attended school in-person.

Approximately half (44.0%) of the 175 households had ≥ 2 children 0–4 years, 36.6% had at least 1 child 5–17 years, and 22.3% had a HCW in the home (Supplementary Table 2). Most (74.9%) households had 2–4 members (median = 4, IQR = 3.0–4.5), > 1 person per bedroom (77.1%), and household income over \$150 000 (58.2%). Most (82.9%) households also had at least 1 member who regularly attended either daycare, school, or work outside the home, 14.5% (21 of 145) of which were exclusively children aged 0–4 years attending daycare.

Characteristics Associated With Severe Acute Respiratory Syndrome Coronavirus 2 Seropositivity

Of 681 (98.7%) participants with enrollment serology results available (Figure 1), 55 (8.1%; 95% CI, 6.3%–10.4%) individuals from 21 (12.0%) households were seropositive for SARS-CoV-2; all members were seropositive in 5 households, which ranged in size from 3 to 5 members. Although children 5–17 years had the highest proportion seropositive (13 of 96, 13.5%) compared to children 0–4 years (15 of 254, 5.9%) and adults (27 of 331, 8.2%), after accounting for clustering within the households there was no difference by age (GEE OR compared to children 0–4 years: 1.19 for 5–17 years and 1.36 for adults; $P = .16$) (Table 2). Among children aged 0–4 years, seropositivity rates were similar within each 1-year age stratum (5.3% in infants < 1 year and range 4.3%–6.7% in 1–4 years).

At enrollment, children who were SARS-CoV-2 seropositive were less likely to have been previously suspected or confirmed positive compared to adults (Figure 2, Supplementary Table 3). Parents reported prior SARS-CoV-2 testing less often for their children (35.7%) than themselves (56.1%; OR = 0.44; 95% CI, .32–.60) (Supplementary Table 3), including among those found to be seropositive (children 0–4 years = 46.7% with reported prior testing, children 5–17 years = 53.8%, adults = 81.5%; all children vs adults: OR = 0.23; 95% CI, .06–.73). A previous diagnosis of suspected COVID-19 infection was also less common in children than adults (among all participants: 4.3% vs 9.2%, OR = 0.45; 95% CI, .23–.83; among seropositive individuals: 46.4% vs 70.4%; OR = 0.34; 95% CI, .09–1.18).

After accounting for seropositive clustering within households and adjusting for other factors, only the subgroup of adults who worked outside the home was more likely to be seropositive ($P = .01$) (Table 2). Adults who worked outside the

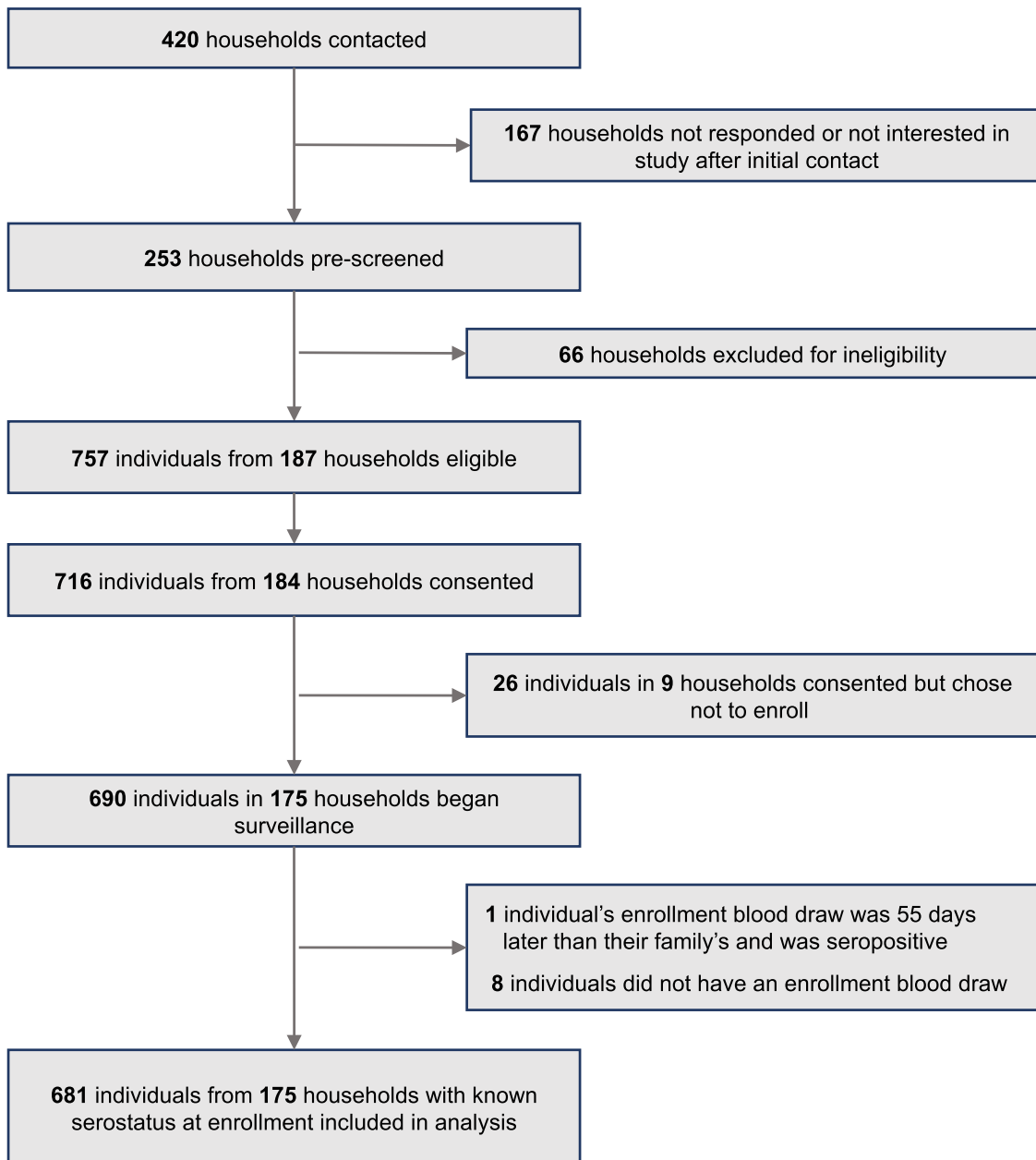


Figure 1. Study CONSORT diagram.

home were approximately twice as likely to be seropositive as those who did not (GEE adjusted OR [aOR] = 2.2; 95% CI, 1.1–4.4); for children who attended daycare or school outside the home, aORs were 1.1 (95% CI, .54–2.1) among 0–4 years and 0.93 (95% CI, .14–6.2) among 5–17 years (Table 2). All members were seronegative in the 30 households where no one attended daycare, school, or work outside the home. The proportion of households with ≥ 1 seropositive member increased with the number of members attending daycare, school, or work outside the home ($P = .003$) (Supplementary Table 2).

Participants living in crowded households (a mean of >1 person per bedroom) were more likely to be seropositive (9.6% vs 2.2%, $P = .009$), but this was not statistically significant after accounting for both clustering of positivity within households and adjusting for other characteristics (GEE aOR = 2.2; 95% CI, .50–9.7) (Table 2). There was a trend towards households with ≥ 5 people (OR = 2.0; 95% CI, .75–5.2) or >1 person per bedroom (OR = 1.9; 95% CI, .60–8.4) being more likely to have at least 1 seropositive member, but results did not reach statistical significance (Supplementary Table 2).

Table 1. Characteristics of SEARCH Participants

Characteristic	Overall, N=690	0–4 Years, N=256	5–17 Years, N=100	≥18 Years, N=334
Age (median, IQR)	12 (3–37)	3 (1–3)	7 (6–10)	37 (34–39)
Gender	<i>n</i> (column %) ^a	<i>n</i> (column %) ^a	<i>n</i> (column %) ^a	<i>n</i> (column %) ^a
Female	355 (51.4)	126 (49.2)	51 (51.0)	178 (53.3)
Male	335 (48.6)	130 (50.8)	49 (49.0)	156 (46.7)
Self-Reported Race	...	...	...	...
White	603 (87.4)	224 (87.5)	82 (82.0)	297 (88.9)
Black	24 (3.5)	7 (2.7)	4 (4.0)	13 (3.9)
Asian	15 (2.2)	3 (1.2)	2 (2.0)	10 (3.0)
Multiracial	43 (6.2)	22 (8.6)	12 (12.0)	9 (2.7)
Other	5 (0.7)	0 (0.0)	0 (0.0)	5 (1.5)
Ethnicity	...	...	...	...
Hispanic	33 (4.8)	16 (6.2)	3 (3.0)	14 (4.2)
Non-Hispanic	657 (95.2)	240 (93.8)	97 (97.0)	320 (95.8)
Asthma or Recurrent Wheezing	...	...	...	...
Yes	94 (13.9)	22 (8.8)	11 (11.2)	61 (18.6)
No	583 (86.1)	229 (91.2)	87 (88.8)	267 (81.4)
BMI Category	...	...	...	...
Underweight	29 (5.0)	19 (12.3) ^b	7 (7.3)	3 (0.9)
Normal	257 (44.7)	84 (54.2) ^b	61 (63.5)	112 (34.6)
Overweight	164 (28.5)	28 (18.1) ^b	17 (17.7)	119 (36.7)
Obese	125 (21.7)	24 (15.5) ^b	11 (11.5)	90 (27.8)
High risk for Severe COVID-19 ^c	...	...	...	...
Yes, ≥ 1 condition other than overweight/obesity	187 (27.1)	29 (11.3)	13 (13.0)	145 (43.4)
Yes, overweight/obesity alone	180 (26.1)	44 (17.2)	25 (25.0)	111 (33.2)
No	323 (46.8)	183 (71.5)	62 (62.0)	78 (23.4)
Prior Suspected COVID-19	...	...	...	...
Yes	45 (6.7)	10 (4.0)	5 (5.1)	30 (9.2)
No	631 (93.3)	241 (96.0)	93 (94.9)	297 (90.8)
Self-Reported Prior SARS-CoV-2 Lab Test	...	...	...	...
Positive	28 (4.2)	5 (2.0)	2 (2.0)	21 (6.4)
Negative	279 (41.5)	83 (33.3)	34 (34.7)	162 (49.7)
No prior test	366 (54.4)	161 (64.7)	62 (63.3)	143 (43.9)
Attends Regular Activities Outside the Home	287 (41.6)	...	...	...
Attends childcare	—	125 (48.8)	—	...
Attends school in-person	—	—	23 (23.0)	...
Works outside the home	—	—	—	139 (41.6)
Employed	—	—	—	282 (84.9)
Has close contact (<6 feet) with others at work	—	—	—	113 (40.5)
Industry Among Those With Close Contact With Others at Work	...	...	...	...
Healthcare workers ^d	—	—	—	29 (25.7)
Other office work	—	—	—	18 (15.9)
Service or factory work	—	—	—	15 (13.3)
Government	—	—	—	12 (10.6)
Construction/Engineering	—	...	...	10 (8.8)
Education	—	—	—	9 (8.0)
Other/Unknown	—	—	—	20 (17.7)
Pregnant	—	—	0 (0.0) ^e	6 (3.5) ^e
Cigarette Smoking Status	...	...	...	...
Current cigarette smoker	—	—	—	8 (2.5)
Former cigarette smoker	—	—	—	45 (13.8)
Never smoked cigarettes	—	—	—	273 (83.7)
Ever smoked an e-cigarette	—	—	—	29 (8.8)

Abbreviation: BMI, body mass index; COVID-19, coronavirus disease 2019; IQR, interquartile range; Lab, laboratory; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SEARCH, SARS-CoV-2 Epidemiology and Response in Children.

^aNumber of participants (column %).

^bAmong children 2–4 years of age.

^cParticipants who reported 1 or more of the following: overweight or obesity, cancer, chronic kidney disease, chronic lung disease, neurological conditions, diabetes, heart condition, stroke or cerebrovascular disease, human immunodeficiency virus infection, immunocompromised state, liver disease, pregnancy, sickle cell anemia or thalassemia, or being a current or former smoker (Centers for Disease Control and Prevention: <https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html>, accessed November 11, 2021).

^dHealthcare workers, dentists, mental health workers.

^eAmong women 18–50 years of age; all (8) girls 13–17 years of age responded not pregnant.

Table 2. Associations Between SARS-CoV-2 Serostatus and Participant Characteristics at Enrollment, Without and After Accounting for Clustering of Positivity in Households

Characteristic	Overall, N=681 n (col %)	Seropositive, N=55 n (row %)	Seronegative, N=626 n (row %)	Logistic Regression, Ignoring Clustering Within Household, Unadjusted			GEE, Accounting for Clustering Within Household, Adjusted ^a		
				OR	95% CI	P Value	aOR	95% CI	P Value
Age Group	...	...	...	...	...	.06 ^b	...	...	...
0–4 years	254 (37.3)	15 (5.9)	239 (94.1)	—	—	...	—	—	.16 ^c
5–17 years	96 (14.1)	13 (13.5)	83 (86.5)	2.50	1.13–5.47	.02	1.19	.58–2.43	.63 ^d
≥18 years	331 (48.6)	27 (8.2)	304 (91.8)	1.42	.75–2.78	.30	1.36	.92–2.00	.12
Daycare/School/Work Attendance Outside the Home	...	...	...	...	...	...	...	...	...
No	396 (58.1)	24 (6.1)	372 (93.9)	—	—	...	See age group stratified by attending daycare/school/work outside the home		
Yes	285 (41.9)	31 (10.9)	254 (89.1)	1.89	1.09–3.33	.02	...	...	...
Age Group Stratified by Daycare/School/Work Attendance Outside the Home ^f	...	...	...	...	...	...	...	...	.01^c
Children 0–4 Years Attending Daycare	...	...	...	...	...	...	...	...	...
No	130 (19.1)	6 (4.6)	124 (95.4)	Ref ^f	—	...	Ref ^f	—	...
Yes	124 (18.2)	9 (7.3)	115 (92.7)	1.62	.57–4.96	.38	1.06	.54–2.08	.87
Children 5–17 Years Attending In-Person School	...	...	...	...	...	...	...	...	...
No	74 (10.9)	10 (13.5)	64 (86.5)	Ref ^f	—	...	Ref ^f	—	...
Yes	22 (3.2)	3 (13.6)	19 (86.4)	1.01	.21–3.71	.99	0.93	.14–6.20	.94
Adults Working Outside the Home	...	...	...	...	...	...	...	...	...
No	192 (28.2)	8 (4.2)	184 (95.8)	Ref ^f	—	...	Ref ^f	—	...
Yes	139 (20.4)	19 (13.7)	120 (86.3)	3.64	1.60–9.07	.003	2.20	1.11–4.38	.02
Race	...	...	...	...	...	.82 ^b	...	...	.07 ^c
White, Non-Hispanic	569 (83.6)	48 (8.4)	521 (91.6)	—	—	...	—	—	...
White, Hispanic	26 (3.8)	1 (3.8)	25 (96.2)	0.43	.02–2.12	.42	0.38 ^g	.05–2.77	.34
Non-White, Hispanic/ Non-Hispanic ^e	86 (12.6)	6 (7.0)	80 (93.0)	0.81	.30–1.83	.65	1.74	.89–3.43	.11
Level of Crowding in the Household	...	...	...	...	...	...	...	...	...
≤1 person or bedroom	138 (20.3)	3 (2.2)	135 (97.8)	—	—	...	—	—	...
>1 person or bedroom	543 (79.7)	52 (9.6)	491 (90.4)	4.77	1.72–19.8	.009	2.21	.50–9.68	.29
Enrollment Time Period ^h	...	...	...	...	...	.04^b	...	...	.93 ^c
Early	209 (30.7)	11 (5.3)	198 (94.7)	—	—	...	—	—	...
Middle	234 (34.4)	17 (7.3)	217 (92.7)	1.41	.65–3.17	.39	0.94	.32–2.81	.91
Late	238 (34.9)	27 (11.3)	211 (88.7)	2.30	1.14–4.96	.02	1.11	.35–3.48	.86

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; col, column; GEE, generalized estimating equation; OR, odds ratio; Ref, reference group; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2. P-values less than 0.05 are bolded.

^aGEE logistic regression for age group is shown unadjusted; all others are adjusted for the following covariates: interaction between age and attending regular activities outside the home, race (because non-White vs White non-Hispanic was significant [$P=.03$] in GEE unadjusted model), household crowding defined as number of people per bedroom, and enrollment time period.

^bPearson's χ^2 test; Fisher's exact test.

^cOverall P values for categorical variables generated using Wald test with robust covariance matrix estimate.

^dAccounting for clustering within households using GEE meaningfully changes the results from the logistic regression OR because 5 of 13 seropositive 5- to 17-year-old children were from the same household.

^eThe model was run with a 6-level variable representing all combinations of age group and attending activities outside the home to explore the interaction between age group and attending daycare/school/work outside the home. The same model was run 3 times, changing the reference group each time to a different age group stratum that did not attend activities outside the home to produce the within-age ORs comparing those who attended daycare/school/work outside the home to those who did not.

^fSeropositivity among non-White participants: 0 of 24 (0%) Black, 3 of 15 (20%) Asian, 2 of 42 (4.8%) multiracial, 1 of 5 (20%) other race.

^gThe final model was adjusted for race because non-White versus White non-Hispanic was significant in GEE univariable analyses.

^hEarly: start of enrollment through December 21, 2020; Middle: January 1, 2021 through January 31, 2021; Late: February 1, 2021 through the end of enrollment.

An additional analysis restricted to adults only was conducted to assess HCW risk; those who were HCWs working outside the home were more frequently seropositive (6 of 29, 20.7%) than those who were non-HCWs working outside the home (13 of 110, 11.8%; GEE aOR = 3.62; 95% CI, 1.19–11.0) (data not shown). After accounting for household clustering and adjusting for crowding, enrollment time period, and living with a child going to daycare or school, HCWs had the highest odds of

seropositivity (aOR = 8.41; 95% CI, 2.74–25.9) relative to adults who did not work outside the home. Healthcare workers also had higher odds of seropositivity than non-HCWs who worked outside the home (aOR = 2.32; 95% CI, 1.02–5.29).

DISCUSSION

During November 2020 through March 1, 2021, 8.1% of individuals enrolled in the SEARCH household study in Maryland

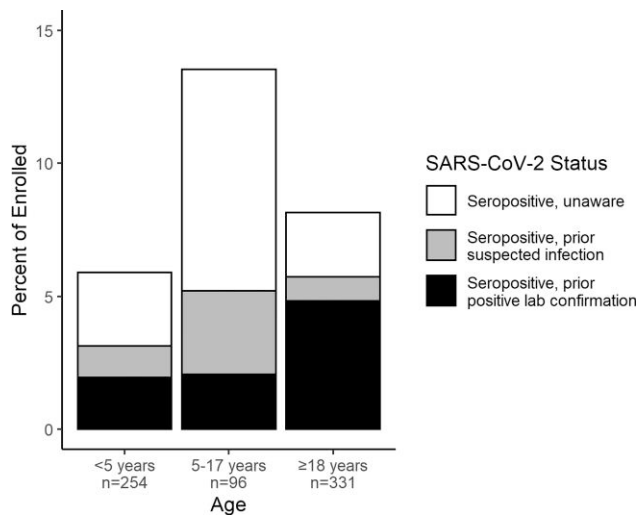


Figure 2. Proportion of participants seropositive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) at enrollment, by age and awareness of prior infection status, $N=681$ participants. Prior suspected infection refers to a self-report of being told by a health professional that they have suspected or confirmed coronavirus disease 2019. Prior laboratory (lab) test refers to a self-report of a SARS-CoV-2 lab test before the start of the SEARCH study. Positive prior lab test refers to a self-report of a positive SARS-CoV-2 lab test before the start of the SEARCH study.

had serologic evidence of prior SARS-CoV-2 infection, and the proportion seropositive was similar among children and adults. However, seropositive children were less likely than seropositive adults to have been tested for SARS-CoV-2 (50% vs 82%) or diagnosed with suspected COVID-19 by a healthcare provider (47% vs 70%) before enrollment, supporting the hypothesis that many pediatric infections were undetected during the early COVID-19 pandemic before the study period [2]. At the individual level, adults who worked outside the home were twice as likely to be seropositive than those who did not, whereas attending daycare or school was not a significant risk factor for children. At the household level, the risk of having any seropositive member significantly increased with the number of people attending work, school, or daycare.

The finding of comparable rates of SARS-CoV-2 seropositivity in children and adults is consistent with age-specific incidence rates reported in a similar household study conducted in Utah and New York City [2]. However, results from other studies have been mixed. Some found higher seroprevalence among children than adults [15], whereas others found that children, particularly younger children, may be less susceptible to infection than adults [16–20], although many of those studies did not systematically test all participants and most primarily tested only symptomatic participants. Given that children are more likely to be asymptomatic, and therefore less likely to be tested, these studies likely missed more cases among children than adults. The US seroprevalence studies based on data

from commercial laboratories have documented higher SARS-CoV-2 antibody seroprevalence rates among children aged 0–17 years compared to adults since December 2020 [1]. Children in the SEARCH study were almost half as likely as adults to have been tested for SARS-CoV-2 before enrollment, including children with suspected SARS-CoV-2 infection.

Most (82.9%) households (and all households with a seropositive member) had at least 1 member who regularly attended work, school, or daycare in-person (ie, outside the home); the 30 households that had no members with reported outside activities also had no seropositive members. Adults who worked outside the home as a HCW had more than 3-fold higher odds of being seropositive compared to adults who worked outside the home as a non-HCW. Household transmission studies have found high transmission rates between adults, from adults to their children, and from children to other household members [5, 19–24], which may be greater when the primary case is symptomatic [4].

We did not find in-person daycare attendance to be associated with seropositivity in children or their household members. School attendance by older children also did not confer higher risk, but the number of school-aged children in our study was relatively small, and other studies have observed differences between younger and older children [17, 18]. Children at daycare and preschools have previously been found to have almost 50% lower risk of infection compared to the adult staff, whereas elementary and high school children may have a similar risk to the staff [17]. Spread of SARS-CoV-2 in elementary schools was also more limited than in high schools in one study [18]. However, a household transmission study conducted in Catalonia, Spain found that children were unlikely to be drivers of household COVID-19 clusters, even if attending school [23].

Findings from this study build upon those from large nationwide serosurveys from the same time period by including young children ages 0–4 years and by documenting similar rates of seropositivity by age group among children and adults from the same households with otherwise similar demographic and community exposure characteristics [25]. However, several limitations should be considered when interpreting findings. Because this was a cross-sectional analysis, we could not differentiate between index and secondary cases within households and could not make inferences regarding within household transmission. Although we did not observe a higher risk for seropositivity among children who attended school or daycare, who may also be more likely to attend extracurricular in-person activities, we did not assess the amount of school and daycare attendance or the amount of social mixing behaviors. Because the majority of participants in the SEARCH cohort were White, non-Hispanic, and from households with income >\$150 000, we were unable to examine whether SARS-CoV-2 seropositivity was disproportionately observed among communities of color or lower income households as previously

observed in other studies [26, 27]. Finally, results may not be representative of the current pandemic conditions, because the study was conducted when COVID-19 vaccines were not yet widely available in the United States, public schools were closed in Maryland during a large portion of the pandemic leading up to this study, and recent SARS-CoV-2 Delta and Omicron variants were not yet circulating. Longitudinal data from follow up of the SEARCH cohort will allow opportunities to further understand susceptibility and transmissibility by age group, characterize COVID-19 vaccine uptake and its impact on SARS-CoV-2 infection incidence rates, evaluate age effects on dynamics of viral load and immune responses to infection over time, and the epidemiology of emerging SARS-CoV-2 variants.

CONCLUSIONS

Our results suggest that children and adults were equally likely to be infected with SARS-CoV-2 during the early COVID-19 pandemic when COVID-19 vaccines were not yet widely available to adults and older children aged 5–17 years. We also found that having an adult household member working outside the home increased a household's odds of SARS-CoV-2 infection introduction, whereas having a child attending daycare or school in-person did not. Given that children ages 0–4 years only recently became eligible for COVID-19 vaccination and will require a 2- or 3-dose series to be fully protected against infection, this is an important finding since vaccination of adults and older children may reduce exposure to SARS-CoV-2 for young children in the household. Future analyses of weekly nasal swabs and antibody data over time will provide more evidence on the susceptibility and transmissibility of SARS-CoV-2 for children and adults, the relationship between infection risk, and attending daycare, school, and work outside the home.

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.

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to data management. M. G. Q., S. Z., and M. D. K. contributed to data analysis. M. G. Q. and M. D. K. contributed to the original draft. All authors contributed to critical review and editing. The corresponding author had full access to all data used in the analysis and had final responsibility for the decision to submit for publication.

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