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Social Determinants of Health and Pediatric Long COVID in the US

Kyung E. Rhee, MD, MSc, MA; Tanayott Thaweethai, PhD; Deepti B. Pant, MPH; Cheryl R. Stein, PhD; Amy L. Salisbury, PhD; Patricia A. Kinser, PhD; Lawrence C. Kleinman, MD, MPH; Richard Gallagher, PhD; David Warburton, DSc, MD; Sindhu Mohandas, MD; Jessica N. Snowden, MD; Melissa S. Stockwell, MD, MPH; Kelan G. Tantisira, MD, MPH; Valerie J. Flaherman, MD, MPH; Ronald J. Teufel, MD, MSCR; Leah Castro, MA; Alicia Chung, EdD, MPH; Jocelyn Espinoza Esparza, MPH; Christine W. Hockett, PhD; Maria Isidoro-Chino, BA; Anita Krishnan, MD; Lacey A. McCormack, PhD, MPH; Aleisha M. Nabower, MD; Erica R. Nahin, PhD; Johana M. Rosas, PhD; Sarwat Siddiqui, BS; Jacqueline R. Szmuszkovicz, MD; Nita Vangeepuram, MD, MPH; Emily Zimmerman, PhD; Heather-Elizabeth Brown, MA; Megan Carmilani, MEd; K. Coombs, MTCM, Ac; Liza Fisher, MBA; Margot Gage Witvliet, PhD; John C. Wood, MD, PhD; Joshua D. Milner, MD; Erika B. Rosenzweig, MD; Katherine Irby, MD; Elizabeth W. Karlson, MD, MS; Zihan Qian, MS; Michelle F. Lamendola-Essel, DHSc, MS; Denise C. Hasson, MD; Stuart D. Katz, MD; H. Shonna Yin, MD, MSc; Andrea S. Foulkes, ScD; Rachel S. Gross, MD, MS; and the RECOVER-Pediatrics Group; and the ABCD-RECOVER Group; for the RECOVER-Pediatrics Consortium

IMPORTANCE Millions of children worldwide are experiencing prolonged symptoms after SARS-CoV-2 infection, yet social risk factors for developing long COVID are largely unknown. As child health is influenced by the environment in which they live and interact, adverse social determinants of health (SDOH) may contribute to the development of pediatric long COVID.

OBJECTIVE To identify whether adverse SDOH are associated with increased odds of long COVID in school-aged children and adolescents in the US.

DESIGN, SETTING, AND PARTICIPANTS This cross-sectional analysis of a multicenter, longitudinal, meta-cohort study encompassed 52 sites (health care and community settings) across the US. School-aged children (6-11 years; n = 903) and adolescents (12-17 years; n = 3681) with SARS-CoV-2 infection history were included. Those with an unknown date of first infection, history of multisystem inflammatory syndrome in children, or symptom surveys with less than 50% of questions completed were excluded. Participants were recruited via health care systems, long COVID clinics, fliers, websites, social media campaigns, radio, health fairs, community-based organizations, community health workers, and existing research cohorts from March 2022 to August 2024, and surveys were completed by caregivers between March 2022 and August 2024.

EXPOSURE Twenty-four individual social determinant of health factors were grouped into 5 Healthy People 2030 domains: economic stability, social and community context, caregiver education access and quality, neighborhood and built environment, and health care access and quality. Latent classes were created within each domain and used in regression models.

MAIN OUTCOMES AND MEASURES Presence of long COVID using caregiver-reported, symptom-based, age-specific research indices.

RESULTS The mean (SD) age among 4584 individuals included in this study was 14 (3) years, and 2330 (51%) of participants were male. The number of latent classes varied by domain; the reference group was the class with the least adversity. In unadjusted analyses, most classes in each domain were associated with higher odds of long COVID. After adjusting for many factors, including age group, sex, timing of infection, referral source, and other social determinant of health domains, economic instability characterized by difficulty covering expenses, poverty, receipt of government assistance, and food insecurity were associated with an increased risk of having long COVID (class 2 adjusted odds ratio [aOR], 1.57; 95% CI, 1.18-2.09; class 4 aOR, 2.39; 95% CI, 1.73-3.30); economic instability without food insecurity (class 3) was not (aOR, 0.93; 95% CI, 0.70-1.23). Poorer social and community context (eg, high levels of discrimination and low social support) was also associated with long COVID (aOR, 2.17; 95% CI, 1.77-2.66). Sensitivity analyses stratified by age group and adjusted for race and ethnicity did not alter or attenuate these results.

CONCLUSIONS AND RELEVANCE In this study, economic instability that included food insecurity and poor social and community context were associated with greater odds of pediatric long COVID. Those with food security, despite experiencing other economic challenges, did not have greater odds of long COVID. Further study is needed to determine if addressing SDOH factors can decrease the rate of pediatric long COVID.

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Supplemental content

Author Affiliations: Author affiliations are listed at the end of this article.

Group Information: The RECOVER-Pediatrics Group and the ABCD-RECOVER Group appear at the end of the article. The RECOVER-Pediatrics Consortium members are listed in Supplement 2.

Corresponding Author: Kyung E. Rhee, MD, MSc, MA, Department of Pediatrics, Division of Child and Community Health, University of California, San Diego School of Medicine, Rady Children's Hospital San Diego, 9500 Gilman Dr, MC 0874, La Jolla, CA 92093 (k1rhee@health.ucsd.edu).

SARS-CoV-2 contributes to the development of long COVID, a postacute chronic condition lasting at least 3 months that can affect almost every organ system. Adolescents may experience loss of smell or taste, muscle or joint pain, fatigue, postexertional malaise, cognitive issues, and mood changes.[1,2] In younger children, abdominal pain and itchy skin are also reported. It is difficult to estimate the true prevalence of long COVID due to varying symptom clusters, potential relapsing or remitting course, and reliance on self-report data in children. Nevertheless, prospective studies have estimated that 10% of children have experienced long COVID,[3-5] translating to millions of youth worldwide.

The World Health Organization (WHO) defines social determinants of health (SDOH) as nonmedical factors that influence health outcomes and are related to the conditions in which one is born, grows, works, lives, and ages.[6] In the US, Healthy People 2030 characterized SDOH into 5 domains: (1) economic stability, (2) social and community context, (3) education access and quality, (4) neighborhood and built environment, and (5) health care access and quality.[7] Children who experience adverse SDOH have an increased risk of poor health outcomes, including the development of chronic diseases (eg, cardiovascular disease, type 2 diabetes, and cancer).[8] Adverse SDOH act as chronic stressors that activate the hypothalamic-pituitary-adrenal axis, triggering glucocorticoid production that modulates cardiovascular responses, metabolic activity, cognitive or emotional responses, and immune function.[8-10] Prolonged exposure can desensitize the hypothalamus, resulting in damage to multiple organs and influence the pathogenesis and progression of disease.[10,11] Chronic stressors, like poverty, food insecurity, and recurring discrimination, may increase inflammation and alter immune responses to toxic exposures, including infections.[12] Since long COVID is a postviral syndrome,[13] stress-related immune dysfunction may make it difficult for the body to combat persistent viral components, immune dysregulation, or tissue damage that result in long COVID symptoms.[14]

To date, most research examining the association between SDOH and COVID-related health outcomes has focused on the risk of contracting the SARS-CoV-2 virus. This evidence comes from ecological studies conducted during the first year of the pandemic and focuses on a few SDOH factors at a time. Generally, COVID-19 case rates were higher in locations with lower SDOH ratings (eg, unfavorable working, transportation, and living conditions,[15-17] fewer grocery stores,[18] air pollution,[16,18] lack of health insurance,[17,18] poor access to primary care,[16,19] lower COVID-19 vaccination rates,[19] and worse Social Vulnerability Index,[20-22] Area Deprivation Index,[23] and COVID-19 Community Vulnerability Index[22] scores). However, the association of adverse SDOH with the development of long COVID remains understudied.[24]

Few studies have examined the association between SDOH and prolonged COVID symptoms. These adult-focused studies show that lower economic and education status, housing insecurity or overcrowding, lack of social support, and discrimination may be associated with prolonged symptoms.[25-30] Similar research in children has been difficult due to variability in long COVID definitions and age-specific differences in symptoms.[1] Nevertheless, long COVID is especially concerning in pediatric populations because of the potential for long-term physical and mental health effects that could persist into adulthood.[31] Therefore, examining the association between adverse SDOH and pediatric long COVID is an important step toward understanding disease prevention.

The objective of this analysis was to examine the cross-sectional association between SDOH and long COVID in school-aged children and adolescents given that chronic stressors may alter immune functioning and increase one's susceptibility to postviral syndromes. Furthermore, since social factors rarely exist in isolation, there was a need to evaluate the combined effect of all SDOH domains to determine if certain domains were more salient than others. Therefore, using data from the pediatric National Institutes of Health–funded Researching COVID to Enhance Recovery (RECOVER) initiative, we examined the association between Healthy People 2030 SDOH domains and long COVID.

Key Points

Question What is the association between adverse social determinants of health and long COVID in school-aged children and adolescents?

Findings In this cross-sectional analysis of a meta-cohort study including 4584 US children and adolescents, households with greater economic instability and poorer social or community context (eg, low social support and high levels of discrimination) experienced significantly higher odds of pediatric long COVID. However, those experiencing food security, despite other economic challenges, did not have higher odds of long COVID; results were similar across age groups.

Meaning The findings of an association between adverse social determinants of health and greater likelihood of pediatric long COVID suggest that addressing adverse social drivers may mitigate future disease risk.

Methods

Study Design

The RECOVER Pediatric Observational Cohort Study (RECOVER-Pediatrics)[1,32] is one of the largest, nationally representative, combined retrospective and prospective, longitudinal, observational meta-cohort study of children and young adults (newborn to age 25 years old) and their caregivers focused on long COVID. Participants were recruited across the US from health care and community-based settings or from the extant National Institutes of Health–funded Adolescent Brain Cognitive Development (ABCD) Cohort study.[33-35] Cohort and recruitment strategies have been previously described.[32] RECOVER-Pediatrics is under the oversight of the New York University Grossman School of Medicine single institutional review board (de novo cohort) or the University of California San Diego Human Research Protections Program (ABCD cohort). Caregiver-child pairs completed written informed consent and an age-appropriate assent (aged 7 years and older). The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Table 1. Demographic Characteristics of the Researching COVID to Enhance Recovery (RECOVER) Pediatric Observational Cohort, US, 2022 to 2024

Characteristic	No./total No. (%)		
	School-aged children, 6-11 y (n = 903)	Adolescents, 12-17 y (n = 3681)	Overall (n = 4584)
Sex assigned at birth			
Female	427/903 (47)	1827/3681 (50)	2254/4584 (49)
Male	476/903 (53)	1854/3681 (50)	2330/4584 (51)
Age at enrollment, mean (SD), y	9 (2)	15 (1)	14 (3)
Race and ethnicity[a]			
American Indian or Alaska Native	24/895 (3)	117/3667 (3)	141/4562 (3)
Asian	69/895 (8)	236/3667 (6)	305/4562 (7)
Black or African American, non-Hispanic	80/895 (9)	388/3667 (11)	468/4562 (10)
Hispanic, Latino, or Spanish	332/895 (37)	811/3667 (22)	1143/4562 (25)
Native Hawaiian or Other Pacific Islander	1/895 (0)	8/3667 (0)	9/4562 (0)
White, non-Hispanic	381/895 (43)	2073/3667 (57)	2454/4562 (54)
None of these fully describe me	8/895 (1)	34/3667 (1)	42/4562 (1)
Missing	8	14	22
Recruitment or referral source			
Existing, prospectively followed COVID cohort	32/903 (4)	10/3681 (0)	42/4584 (1)
Self-referral from RECOVER website or other unsolicited self-referral	169/903 (19)	221/3681 (6)	390/4584 (9)
Participant tested/treated in the health system	214/903 (24)	281/3681 (8)	495/4584 (11)
Community outreach	267/903 (30)	275/3681 (7)	542/4584 (12)
Existing non-COVID research or clinical cohort	65/903 (7)	2655/3681 (72)	2720/4584 (59)
Long COVID clinic	20/903 (2)	52/3681 (1)	72/4584 (2)
Community health center	75/903 (8)	66/3681 (2)	141/4584 (3)
Public health department list	25/903 (3)	68/3681 (2)	93/4584 (2)
Other	36/903 (4)	53/3681 (1)	89/4584 (2)
Prevalent SARS-CoV-2 strain at first infection			
Pre-Omicron (before Dec 1, 2021)	479/903 (53)	1949/3681 (53)	2428/4584 (53)
Omicron (Dec 1, 2021, or later)	424/903 (47)	1732/3681 (47)	2156/4584 (47)
Vaccination status at first infection[b]			
Fully vaccinated	220/903 (24)	1547/3681 (42)	1767/4584 (39)
Partially vaccinated	106/903 (12)	266/3681 (7)	372/4584 (8)
Not eligible for vaccination	425/903 (47)	1262/3681 (34)	1687/4584 (37)
Not vaccinated	125/903 (14)	484/3681 (13)	609/4584 (13)
Vaccinated but missing information	27/903 (3)	122/3681 (3)	149/4584 (3)
Caregiver relationship to child			
Mother	807/871 (93)	3289/3643 (90)	4096/4514 (91)
Someone else	64/871 (7)	354/3643 (10)	418/4514 (9)
Missing	32	38	70
Long COVID research index score			
Mean (SD)	3.1 (5.9)	2.3 (4.8)	2.4 (5.1)
Median (IQR)	0.0 (0.0-4.5)	0.0 (0.0-2.0)	0.0 (0.0-3.0)
Long COVID status[c]			
Long COVID-probable	196/903 (22)	580/3681 (16)	776/4584 (17)
Long COVID-unspecified	707/903 (78)	3101/3681 (84)	3808/4584 (83)

[a] Race and ethnicity were gathered via caregiver report and included in this analysis to enhance our understanding of how race and ethnicity may be associated with long COVID and social determinants of health. See the eMethods in Supplement 1 for additional details on how race and ethnicity were collected and categorized; note that participants could select more than 1 race and ethnicity group.

[b] See the eMethods in Supplement 2 for additional details on how vaccination categories were defined. Participants were ineligible for vaccination if their first infection date preceded when vaccines were available for children their age.

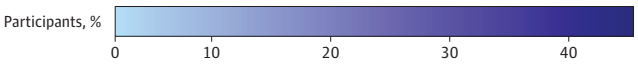
[c] Long COVID status is defined according to the long COVID research index as long COVID-probable if the long COVID research index score is 5.5 or greater for school-aged children or 5.0 or greater for adolescents. Otherwise, long COVID status is defined as long COVID-unspecified.

RECOVER-Pediatrics Participants

The analytic sample included children aged 6 to 17 years with a known SARS-CoV-2 infection and a baseline long COVID symptom survey[32] completed by caregivers between March 21, 2022, and August 27, 2024. Baseline long COVID symptom surveys were completed at variable time points after the child's first SARS-CoV-2 infection. Surveys for prolonged symptoms must have been completed at least 90 days after the child's first infection but not within 30 days of a reinfection. Evidence of SARS-CoV-2 antibodies was not required. Surveys were avail-

Figure 1. Proportion of Participants With Individual Social Determinants of Health Factors and Odds Ratios for Each Factor and Long COVID

Domain	Participants with factor, %	Among those with factor, % with long COVID	Among those without factor, % with long COVID	Total participants, No.	Missing, %	OR (95% CI)	*P* value from χ^2 test
Economic stability							
Food insecurity	13.0	31.5	13.3	3872	15.5	3.00 (2.42-3.71)	<.001
Housing instability or homelessness	2.8	22.4	16.1	4088	10.8	1.50 (0.96-2.35)	.09
Transportation difficulties	6.4	30.2	15.4	4113	10.3	2.38 (1.80-3.14)	<.001
Childcare difficulties	8.8	26.4	15.3	4107	10.4	1.99 (1.55-2.55)	<.001
Income <120% FPL	22.0	23.9	14.1	3794	17.2	1.91 (1.58-2.30)	<.001
Difficulty covering expenses	37.8	24.2	11.7	3952	13.8	2.40 (2.03-2.85)	<.001
Receipt of government financial assistance	18.4	27.6	13.8	4018	12.3	2.38 (1.97-2.88)	<.001
Receipt of government nutrition support	23.5	25.5	13.6	4059	11.5	2.19 (1.83-2.61)	<.001
Social and community context							
Caregiver not living with partner or unmarried	21.9	22.2	14.3	4125	10.0	1.70 (1.42-2.05)	<.001
Severe household overcrowding	6.5	25.1	15.7	4107	10.4	1.80 (1.35-2.40)	<.001
Childhood stressors	5.9	32.0	14.4	3837	16.3	2.79 (2.08-3.75)	<.001
Discrimination	29.9	24.8	12.9	4227	7.8	2.23 (1.88-2.63)	<.001
Low social support	41.2	22.8	12.9	4505	1.7	2.00 (1.71-2.34)	<.001
Medical discrimination	3.4	45.2	15.7	4496	1.9	4.41 (3.18-6.12)	<.001
Caregiver education access and quality							
Less than college education	36.9	20.4	14.0	4121	10.1	1.57 (1.33-1.86)	<.001
Low health literacy	2.1	26.1	16.0	4095	10.7	1.85 (1.14-3.00)	.02
Neighborhood and built environment							
Lower neighborhood social cohesion	21.6	22.5	14.5	4087	10.8	1.70 (1.41-2.05)	<.001
Disordered neighborhood	21.3	21.3	14.9	4058	11.5	1.54 (1.28-1.87)	<.001
Resides in a rural area	4.3	25.6	16.5	4584	0.0	1.74 (1.25-2.42)	.001
Health care access and quality							
Child is uninsured or receives government health insurance	33.2	21.6	14.6	4517	1.5	1.62 (1.38-1.90)	<.001
Caregiver is uninsured or receives government health insurance	38.2	21.9	14.0	4497	1.9	1.72 (1.47-2.01)	<.001
No health care visit in last 12 mo	9.2	8.2	17.7	4521	1.4	0.41 (0.29-0.59)	<.001
Unmet medical needs	14.1	35.6	13.8	4470	2.5	3.45 (2.86-4.16)	<.001
Resides in a medically underserved area	29.8	18.8	16.1	4584	0.0	1.20 (1.02-1.42)	.03



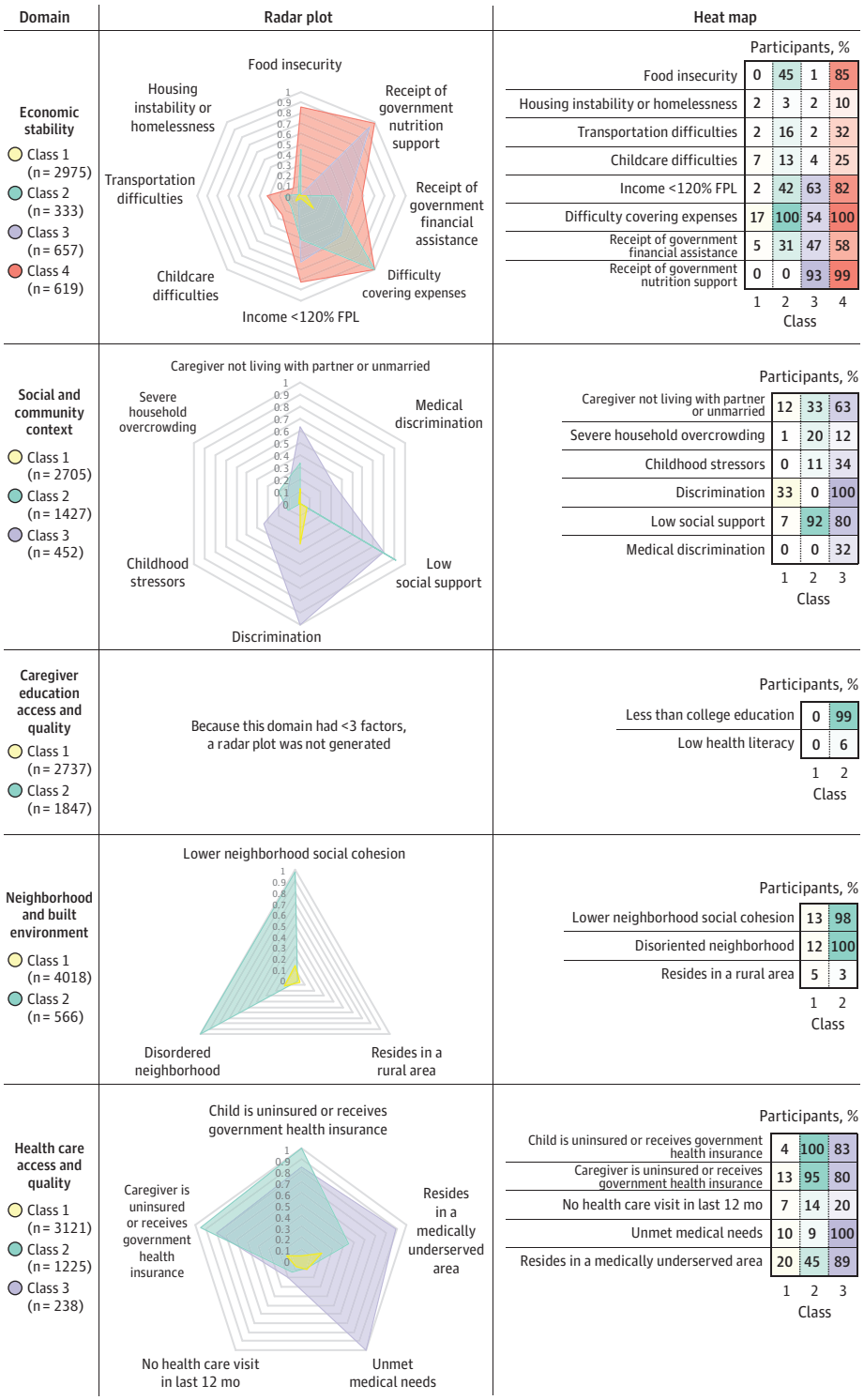
Total participants refers to the number of participants who do not have missing data for that factor (of the total sample size of 4584). Participants with missing data are excluded from analyses presented in this figure. The odds ratios (ORs) and 95% CIs are shown for a logistic regression where long COVID is the outcome and the factor is the sole predictor. The *P* value from a χ^2 test for the association between each factor and long COVID is shown as well. FPL indicates federal poverty level.

able in English and Spanish. Participants with an unknown date of first infection, history of multisystem inflammatory syndrome in children, or symptom surveys with less than 50% of questions completed were excluded.

Long COVID Outcome

The outcome was presence of long COVID at baseline based on RECOVER-Pediatrics age-specific long COVID research indices.[1] For this analysis, symptoms were considered prolonged if they

Figure 2. Healthy People 2030 Social Determinants of Health Domain Latent Classes in the Researching COVID to Enhance Recovery (RECOVER) Pediatric Cohort, US, 2022-2024 (N = 4584)



The radar plots and heatmaps show the proportion of individuals with each social determinant of health factor in each class. Class 1 reflects the class with the lowest average proportion of each social determinants of health factor in the study population. The displayed radar plots and heatmaps exclude participants with missing data (though missing data were accounted for when defining the latent classes via multiple imputation). FPL indicates federal poverty level.

were present at baseline, had persisted for at least 4 weeks, and were still present at the time of the survey (ie, at least 90 days after infection). For school-aged children (aged 6 to 11 years), long COVID-probable was defined as long COVID research index 5.5 or greater (range, 0.5-34.5) based on 10 symptoms (cognitive difficulties, back or neck pain, stomach pain, headache, fears about specific things, refusal to go to school, itchy skin or rashes, trouble sleeping, nausea or vomiting, and lightheaded-

Table 2. Estimated Odds Ratios for the Association Between Healthy People 2030 Social Determinants of Health (SDOH) Domain Latent Class and Long COVID

SDOH domain	Domain latent class[a]	No. (%)		OR (95% CI)		
		Participants[b]	Participants with long COVID[c]	Unadjusted[d]	Adjusted for other SDOH domains, sex, age group, timing of infection, referral source[e]	Adjusted for other SDOH domains, sex, age group, timing of infection, referral source, race and ethnicity[f]
Economic stability	1	2975 (65)	381 (12.8)	NA	NA	NA
	2	333 (7)	77 (23.1)	1.75 (1.31-2.35)	1.57 (1.18-2.09)	1.64 (1.23-2.18)
	3	657 (14)	95 (14.5)	0.96 (0.67-1.38)	0.93 (0.70-1.23)	0.98 (0.74-1.3)
	4	619 (14)	223 (36.0)	2.96 (2.23-3.92)	2.39 (1.73-3.30)	2.52 (1.82-3.49)
Social and community context	1	2705 (59)	351 (13.0)	NA	NA	NA
	2	1427 (31)	246 (17.2)	1.01 (0.79-1.30)	0.82 (0.64-1.05)	0.84 (0.66-1.08)
	3	452 (10)	179 (39.6)	3.13 (2.60-3.77)	2.17 (1.77-2.66)	2.18 (1.79-2.67)
Caregiver education access and quality	1	2737 (60)	388 (14.2)	NA	NA	NA
	2	1847 (40)	388 (21.0)	1.44 (1.19-1.74)	1.12 (0.96-1.3)	1.18 (1.01-1.38)
Neighborhood and built environment	1	4018 (88)	639 (15.9)	NA	NA	NA
	2	566 (12)	137 (24.2)	1.23 (0.96-1.57)	0.90 (0.73-1.12)	0.94 (0.75-1.16)
Health care access and quality	1	3121 (68)	441 (14.1)	NA	NA	NA
	2	1225 (27)	262 (21.4)	1.37 (1.05-1.80)	0.97 (0.76-1.23)	1.00 (0.80-1.26)
	3	238 (5)	73 (30.7)	2.09 (1.55-2.82)	1.14 (0.82-1.59)	1.20 (0.86-1.66)

Abbreviations: NA, not applicable; OR, odds ratio.

[a] Participants are grouped into latent classes within each SDOH domain, meaning each participant belongs to 5 latent classes (1 for each domain). For example, a participant may belong to latent class 1 for economic stability, 2 for social and community context, 1 for caregiver education access and quality, 2 for neighborhood and built environment, and 3 for health care access and quality.

[b] The number of participants that belong to each latent class within each domain. These numbers sum to the total sample size within each domain. The denominator for each percentage is the total sample size (n = 4584).

[c] The number of participants within a given latent class with long COVID. The denominator for each percentage is the number of participants within the given latent class.

[d] The estimated OR obtained from a logistic regression model with long COVID as the outcome and a single categorical predictor for the latent class within that domain. For example, this would be a 4-category variable for the economic stability domain. A separate model is fit for each domain.

[e] The estimated OR obtained from a logistic regression model with 5 categorical predictors, with 1 categorical variable representing the latent classes for each domain. The model is additionally adjusted for sex, age group, timing of infection, and recruitment or referral source. A single model is fit for all domains combined.

[f] The estimated OR from the same model as in the prior column, but with additional adjustment for race and ethnicity.

ness). For adolescents (aged 12 to 17 years), long COVID-probable was defined as long COVID research index 5 or greater (range, 0.5-25) based on 8 symptoms (altered smell or taste, body or joint pain, fatigue, postexertional malaise, back or neck pain, cognitive difficulties, headache, and lightheadedness). All other participants were defined as long COVID-unspecified.

Social Determinants of Health

RECOVER-Pediatrics collected data via 24 measures that align with the Healthy People 2030 SDOH domains.[6] SDOH were conceptualized through a multistep process. First, survey questions were mapped to individual SDOH factors. Second, individual SDOH factors were dichotomized to facilitate use in latent class analysis and enhance interpretability of results. Third, dichotomized factors were grouped into 5 SDOH domains. Detailed description of mapping and factor dichotomization is available in eTable 1 in Supplement 1.

Economic Stability

Economic stability contained 8 factors: (1) food insecurity, assessed using the 10-item US Department of Agriculture Household Food Security module, defined as low or very low food security[36]; (2) housing instability, identified by living in transitional housing, staying in a shelter, or experiencing homelessness,[37] (3) transportation difficulties, identified as difficulty getting to where they needed to go[38]; (4) childcare difficulties, identified as difficulty finding or keeping childcare[37]; (5) income less than 120% of the federal poverty level, based on state and household size-specific thresholds[39]; (6) difficulty covering expenses, including household expenses and bills; (7) receipt of government financial assistance, based on use of programs such as Temporary Assistance for Needy Families, Social Security, or Supplemental Social Security; and (8) receipt of government nutrition support, based on use of Supplemental Nutrition Assistance Program or Special Supplemental Nutrition Program for Women, Infants, and Children.

Social and Community Context

Social and community context contained 6 factors: (1) caregiver marital status, identified as being married or living with a partner vs not; (2) severe household overcrowding, defined according to WHO Housing and Health Guidelines (the number of people divided by the number of rooms in the household exceeds 1.5)[40]; (3) childhood stressors, assessed using a modified version of the 10-item Other Childhood Stressors scale, which assesses household relationship quality, bullying, incarceration, substance use, divorce, and neighborhood violence[41]; (4) discrimination experienced by the child, assessed using 9 items from the Everyday Discrimination Scale[42]; (5) medical discrimination experienced by the

child, assessed by 1 item from the Everyday Discrimination Scale (whether the caregiver believes their child is discriminated against while getting medical care); and (6) low social support, assessed using a shortened version of the Medical Outcomes Study Social Support Survey.[43]

Caregiver Education Access and Quality

Caregiver education access and quality contained 2 factors: (1) lower caregiver education, based on highest level of education completed (dichotomized as more or less than a bachelor's degree), and (2) low caregiver health literacy, measured using a validated 3-item screening tool which assessed needing help reading hospital materials, having problems learning about medical conditions, and low confidence in completing medical forms.[44,45]

Neighborhood and Built Environment

Neighborhood and built environment contained 3 factors: (1) lower neighborhood social cohesion (eg, helpfulness and trust in neighbors) using the 4-item Neighborhood Social Cohesion scale[46]; (2) disordered neighborhood, assessing elements such as neighborhood noise, vandalism, appearance, and abandoned buildings, using the 8-item Neighborhood Disorder scale[47,48]; and (3) living in a rural area as defined by the Health Resources and Services Administration.

Health Care Access and Quality

Health care access and quality contained 5 factors: (1) child does not have health insurance or receives health insurance from the government (eg, Medicaid and TRICARE); (2) caregiver does not have health insurance or receives health insurance from the government; (3) child did not have a health care visit in the past 12 months; (4) child has unmet health care needs (trouble getting needed health care visits or obtaining medical equipment or supplies); and (5) living in a medically underserved area as defined by the Health Resources and Services Administration.

Covariates

Demographic covariates included child sex, age, race, and ethnicity (eMethods in Supplement 1). Race and ethnicity data were collected via caregiver report and included in the study to enhance our understanding of how race and ethnicity may be associated with long COVID and SDOH. Survey covariates included recruitment or referral source and caregiver relationship to child. Clinical covariates included prevalent SARS-CoV-2 strain at time of first infection and vaccination status at first infection (eMethods in Supplement 1).

Statistical Analysis

First, we described the associations between each of the 24 dichotomized SDOH factors and long COVID using χ^2 tests and estimated unadjusted odds ratios using logistic regression. Second, we completed a latent class analysis using the dichotomized factors within each SDOH domain to address high levels of correlation across SDOH factors within domains.[49,50] As a result, each participant belonged to 1 latent class for each domain. This approach allowed for equal weighting of each domain, rather than allowing the domain with the most factors (ie, economic stability) to be the primary driver of the identified latent classes. Missingness in SDOH was addressed using multiple imputation by chained equations with 25 imputations.[51] The procedure for identifying latent classes across imputations is described in the eMethods in Supplement 1. Across all domains, classes were ordered from lowest to highest average proportion across all factors. Therefore, the reference class (class 1) represented those with the fewest adverse SDOH factors, and the class with the highest number represented those with the most adverse SDOH factors. The caregiver education access and quality domain was not amenable to latent class analysis because it contained only 2 factors, so this domain was grouped a priori into 2 classes. Radar plots and heat maps were used to illustrate the prevalence of dichotomized SDOH factors within classes for each SDOH domain.

Third, we estimated whether the odds of long COVID differed across latent class domains in 3 sets of models. First, unadjusted models were fit for each latent class domain by fitting a logistic regression with a single categorical variable for latent class membership. Second, given the intersectionality of SDOH domains, we ran a combined model containing all 5 categorical variables (1 for each domain), adjusting for child age group, sex, time of infection (pre- vs post-Omicron, defined as first SARS-CoV-2 infection before vs on or after December 1, 2021), and recruitment or referral source (self-referral or community outreach vs other). Third, based on the National Academies of Sciences, Engineering, and Medicine's recommendation on using race and ethnicity identity in an analysis,[22] we repeated model 2 with an adjustment for child race and ethnicity. Comparing results with and without race and ethnicity could help determine how well our measures of SDOH captured the association of cultural identity with long COVID risk in children. To fit these models, generalized estimating equations were used with exchangeable correlation structure to account for clustering by recruitment site. Interpretation of results focused on estimated odds ratios where the lower bound of the 95% CI exceeds 1. Two-tailed P values less than .05 were considered statistically significant.

In sensitivity analysis, we repeated the latent class analysis and all regression analyses stratified by age group (school-aged children and adolescents). All statistical analyses were performed using the *poLCA*, *irr*, and *geepack* packages in R version 4.4.0.

Results

After applying inclusion and exclusion criteria (eFigure 1 in Supplement 1), the study sample included 4584 participants (903 school-aged children and 3681 adolescents) recruited from 52 sites: 2330 (51%) of participants were male and 2254 (49%) were female, and the mean (SD) age was 14 (3) years (**Table 1**). As reported by the caregivers, 141 participants were American Indian or Alaska Native; 305 were Asian; 468 were Black or African American; 1143 were Hispanic, Latino, or Spanish; 9 were Native Hawaiian or Other Pacific Islander; 2454 were White; 22 were missing race and ethnicity data; and 42 reported that none of the

provided categories fully described them. More than half of participants (2428) were infected with SARS-CoV-2 before December 1, 2021 (pre-Omicron), and (776) 17% had long COVID based on the long COVID Research Index. The distribution of the long COVID research index is shown in eFigure 2 in Supplement 1.

Participants or their households who experienced adverse SDOH are presented in **Figure 1**. Most adverse SDOH factors across domains were associated with greater unadjusted odds of long COVID (Figure 1; eFigure 3 in Supplement 1). In the latent class analysis (**Figure 2**), 1658 participants (36%) did not experience any adverse SDOH in any domain, thus belonging in class 1 for all domains. Additionally, 1006 (22%) experienced adverse SDOH in only 1 domain, and 1920 (42%) experienced adverse SDOH in 2 or more domains. Of those experiencing adverse SDOH in 2 or more domains, 256 (13%) experienced adverse SDOH in all 5 domains. In each SDOH domain, individual classes were characterized by different SDOH factors. For example, in the economic stability domain, class 2 was predominantly characterized by difficulty covering expenses, class 3 by receipt of government nutrition support, and class 4 by food insecurity, income less than 120% of the federal poverty level, difficulty covering expenses, and receipt of government assistance. Model diagnostics for how the optimal numbers of latent classes were chosen are provided in eTable 2 in Supplement 1.

In each SDOH domain, the prevalence of long COVID was lowest in class 1 (the reference group) (**Table 2**). Across unadjusted models, the odds of long COVID were higher in economic stability class 2 and 4, social and community context class 3 (characterized by experiencing discrimination, low social support, and caregiver living alone), caregiver education access and quality class 2 (less than college and/or low health literacy), and health care access and quality class 2 (child and caregiver are uninsured or receive government health insurance) and class 3 (similar to class 2, plus living in a medically underserved area and having unmet medical needs).

Adjusting for sex, age group, time of infection, recruitment or referral source, and other SDOH domains attenuated all effect estimates, and the lower bound of the 95% CI for latent classes in the education and health care domains no longer exceeded 1. However, youth in economic stability class 2 still had higher odds of long COVID compared to youth in economic stability class 1 (adjusted odds ratio [aOR], 1.57; 95% CI, 1.18-2.09). Economic stability class 4 also had higher odds of long COVID (aOR, 2.39; 95% CI, 1.73-3.30). Class 3, characterized by economic instability without food insecurity, did not have higher odds of long COVID (aOR, 0.93; 95% CI, 0.70-1.23). Youth in social and community context class 3, predominantly characterized by experiencing discrimination and low social support, had 2.17 (95% CI, 1.77-2.66) times higher odds of long COVID compared to those in class 1. Additional adjustment for race and ethnicity did not substantively alter the pattern of results.

In sensitivity analyses, performing latent class analysis within age groups resulted in similar latent classes as identified in the primary analysis (not shown). Using the latent classes identified in the primary analysis, stratification by age group only impacted the precision of the results due to smaller sample sizes (eTable 3 in Supplement 1).

Discussion

In this cross-sectional analysis of a meta-cohort study, we found that US children living in households experiencing greater adversity in 2 SDOH domains, economic instability and adverse social and community context, were more likely to have pediatric long COVID compared to households experiencing the fewest social hardships. These associations were consistent between school-aged children and adolescents despite the different symptoms included in the age-specific long COVID research indices.[1] Multiple sensitivity analyses, including adjustment for race and ethnicity, did not meaningfully alter results. This is one of few studies that demonstrated an association between adverse SDOH and long COVID in children.[24] The breadth of data available in RECOVER-Pediatrics allowed for rich characterization of all 5 Healthy People 2030 SDOH domains and delineated the independent association of several SDOH with long COVID while accounting for the larger social context in which children were living.

In the US, it can be challenging to disentangle low socioeconomic status, discrimination, and other adverse SDOH factors from race and ethnicity because persons from racial and ethnic marginalized groups are more likely to be impacted by racism and stress related to their socioeconomic position.[52] There is some evidence that long COVID is more prevalent in Black and Hispanic adults[53] and that life stressors related to lower socioeconomic status may increase risk for long COVID.[54] In our analysis, we were able to demonstrate an association between long COVID and the social and community context domain, which incorporates measures of discrimination. This association did not change after adjustment for race and ethnicity, implying that discrimination and other social community factors were independently associated with long COVID.

The American Academy of Pediatrics recognized the association between adverse SDOH and child health in 2016 and reaffirmed it in 2021.[55] For children with long COVID, the combined effect of a serious viral infection and adverse social conditions may have increased their risk,[56] as chronic stress can lead to abnormal cortisol responses and immunologic derangements.[57-59] Thus, mitigating the potential impact of poverty and other adverse SDOH on child health is critical.[55,60-63] The COVID-19 pandemic bolstered some nutrition[64] and economic support programs,[65-67] and the expanded use of telehealth altered access to comprehensive health care. The impact of nutrition support programs may have been observed in our analysis as those experiencing economic instability without food insecurity were not at higher risk of long COVID, even after controlling for access to health care. It has been shown that some health behaviors, like exercise, sufficient sleep, and healthy diets, can decrease inflammation.[68] Efforts to support healthy lifestyle behaviors and strengthen an array of protective social factors particularly relevant to child health should be a policy priority.

Limitations

This study has limitations. First, selection bias may have limited generalizability of these results. Families most affected by

adverse SDOH could have been less likely to enroll, and study procedures were conducted in English and Spanish only. Second, SDOH data were reported by caregivers, and objective neighborhood-level data were unavailable. Third, since we used a research index of long COVID, we may have unintentionally miscategorized children with only 1 or 2 symptoms into the long COVID-unspecified group, resulting in conservative estimates of the associations between SDOH and long COVID. Furthermore, creation of latent classes in this analysis may not be similar to latent classes in other cohorts. Additionally, the factors in the study were dichotomized to facilitate latent class analysis and enhance interpretability. It is possible some conclusions may have been different if the variables were dichotomized in a different way, treated as continuous variables, or grouped into more categories. This was a cross-sectional investigation, which precludes causal inference and our understanding of the directionality of associations. Nevertheless, RECOVER-Pediatrics is poised to examine trajectories and identify long-term health impacts as the cohort continues to be followed.

Conclusions

The results of this study demonstrate that long COVID is more prevalent among children living with economic instability and adverse social and community contexts. Given their young age and unclear trajectory of symptoms over the life course, the long-term economic effects and the health care needs of this population may be immense. Public health efforts to address modifiable adverse SDOH associated with long COVID are essential to potentially mitigate long COVID risk and promote child health more broadly as children continue to acquire COVID-19.

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Author Affiliations: Department of Pediatrics, Division of Child and Community Health, University of California San Diego School of Medicine, Rady Children's Hospital, San Diego (Rhee); Massachusetts General Hospital Biostatistics, Boston (Thaweethai, Pant, Qian, Foulkes); Department of Medicine, Harvard Medical School, Boston, Massachusetts (Thaweethai, Foulkes); Department of Child and Adolescent Psychiatry, New York University Grossman School of Medicine, New York (Stein, Isidoro-Chino); School of Nursing, Virginia Commonwealth University, Richmond (Salisbury, Kinser, Espinoza Esparza); Department of Pediatrics, Division of Population Health, Quality, and Implementation Sciences, Rutgers Robert Wood Johnson Medical School, New Brunswick, New Jersey (Kleinman); Bristol Myers Squibb Children's Hospital, New Brunswick, New Jersey (Kleinman); Department of Child and Adolescent Psychiatry, Child Study Center, New York University Grossman School of Medicine, New York (Gallagher); Department of Pediatrics, Division of Neonatal-Perinatal Medicine, Children's Hospital Los Angeles, Keck School of Medicine, University of Southern California, Los Angeles (Warburton); Department of Pediatrics, Division of Infectious Diseases, Children's Hospital Los Angeles, Keck School of Medicine, University of Southern California, Los Angeles (Mohandas); Department of Pediatrics, Division of Infectious Diseases, University of Arkansas for Medical Sciences, Little Rock (Snowden); Department of Pediatrics, Division of Child and Adolescent Health, Columbia University Vagelos College of Physicians and Surgeons, New York, New York (Stockwell); Department of Population and Family Health, Mailman School of Public Health; New York-Presbyterian Hospital, New York (Stockwell); Department of Pediatrics, Division of Respiratory Medicine, University of California San Diego School of Medicine, Rady Children's Hospital, San Diego (Tantisira); Department of Pediatrics, Division of General Pediatrics, University of California, San Francisco (Flaherman); Department of Pediatrics, Division of Pediatric Hospital Medicine, University of California San Diego School of Medicine, Rady Children's Hospital, San Diego (Teufel); Researching COVID to Enhance Recovery (RECOVER) Study, New York, New York (Castro, Brown, Carmilani, Coombs, Fisher, Witvliet); Department of Population Health, New York University Grossman School of Medicine, New York (Chung, Nahin, Rosas, Yin, Gross); Avera Research Institute, Sioux Falls, South Dakota (Hockett, McCormack); Department of Pediatrics, University of South Dakota School of Medicine, Sioux Falls (Hockett, McCormack); New York Medical College, Westchester Medical Center, Valhalla (Krishnan); Department of Pediatrics, University of Nebraska Medical Center and Children's Nebraska, Omaha (Nabower); David Geffen School of Medicine, University of California, Los Angeles (Siddiqui); Children's Hospital Los Angeles, Los Angeles, California (Szmuszkovicz); Icahn School of Medicine at Mount Sinai, New York, New York (Vangeepuram); Department of Communication Sciences & Disorders, Northeastern University, Boston, Massachusetts (Zimmerman); Long Covid Families, Charlotte, North Carolina (Carmilani); Vermont Center for Independent Living, Montpelier (Coombs); Department of Pediatrics, Division of Cardiology, Children's Hospital Los Angeles, Keck School of Medicine, University of Southern California, Los Angeles (Wood); Department of Pediatrics, Division of Pediatric Allergy, Immunology and Rheumatology, Columbia University Vagelos College of Physicians and Surgeons, New York, New York (Milner); Department of Pediatrics, Division of Cardiology, Columbia University Vagelos College of Physicians and Surgeons, New York, New York (Rosenzweig); Department of Pediatrics, Division of Critical Care, University of Arkansas for Medical Sciences, Little Rock (Irby); Department of Medicine, Division of Rheumatology, Inflammation, and Immunity, Massachusetts General Hospital, Boston (Karlson); Massachusetts General Brigham, Boston (Karlson); Department of Medicine, New York University Grossman School of Medicine, New York (Lamendola-Essel); Department of Pediatrics, Division of Pediatric Critical Care Medicine, New York University Grossman School of Medicine, New York (Hasson); Department of Medicine, Division of Cardiology, New York University Grossman School of Medicine, New York (Katz); Department of Pediatrics, Division of General Pediatrics, New York University Grossman School of Medicine, New York (Yin, Gross); Department of Biostatistics, Harvard T. H. Chan School of Public Health, Boston, Massachusetts (Foulkes).

The RECOVER-Pediatrics Group and the ABCD-RECOVER Group: Judy L. Aschner, MD; Andrew M. Atz, MD; Dithi Banerjee, PhD; Amanda Bogie, MD; Hulya Bukulmez, MD; Katharine Clouser, MD; Lesley A. Cottrell, PhD; Kelly Cowan, MD; Viren A. D'Sa, MD; Allen J. Dozor, MD; Amy J. Elliott, PhD; E. Vince S. Faustino, MD, MHS; Alexander G. Fiks, MD, MSCE; Sunanda Gaur, MD; Maria L. Gennaro, MD; Stewart T. Gordon, MD; Uzma N. Hasan, MD; Christina M. Hester, PhD, MPH; Alexander H. Hogan, MD, MS; Daniel S. Hsia, MD; David C. Kaelber, MD, PhD, MPH; Jessica S. Kosut, MD; Sankaran Krishnan, MD, MPH; Russell J. McCulloh, MD; Ian C. Michelow, MD; Sheila M. Nolan, MD, MSCE; Carlos R. Oliveira, MD, PhD; Wilson D. Pace, MD, PhD; Paul Palumbo, MD; Hengameh Raissy, PharmD; Andy Reyes, MD; Judith L. Ross, MD; Juan C. Salazar, MD, MPH; Rangaraj Selvarangan, PhD; Michelle D. Stevenson, MD, MS; Alan Werzberger, MD; John M. Westfall, MD, MPH; Kathleen Zani, MD; William T. Zempsky, MD, MPH; James Chan, MA; Torri D. Metz, MD, MS; Jane W. Newburger, MD; Dongngan T. Truong, MD, MS; Candace H. Feldman, MD, MPH, ScD; Robin Aupperle, PhD; Fiona C. Baker, PhD; Marie T. Banich, PhD; Deanna M. Barch, PhD; Arielle Baskin-Sommers, PhD; James M. Bjork, PhD; Mirella Dapretto, PhD; Sandra A. Brown, PhD; B. J. Casey, PhD; Linda Chang, MD; Duncan B. Clark, MD, PhD; Anders M. Dale, PhD; Thomas M. Ernst, PhD; Damien A. Fair, PA-C, PhD; Sarah W. Feldstein Ewing, PhD; John J. Foxe, PhD; Edward G. Freedman, PhD; Naomi P. Friedman, PhD; Hugh Garavan, PhD; Dylan G. Gee, PhD; Raul Gonzalez, PhD; Kevin M. Gray, MD; Mary M. Heitzeg, PhD; Megan M. Herting, PhD; Joanna Jacobus, PhD; Angela R. Laird, PhD; Christine L. Larson, PhD; Krista M. Lisdahl, PhD; Monica Luciana, PhD; Beatriz Luna, PhD; Pamela A.F. Madden, PhD; Erin C. McGlade, PhD; Eva M. Müller-Oehring, PhD; Bonnie J. Nagel, PhD; Michael C. Neale, PhD; Martin P. Paulus, PhD; Alexandra S. Potter, PhD; Perry F. Renshaw, MD, PhD; Elizabeth R. Sowell, PhD; Lindsay M. Squeglia, PhD; Lucina Q. Uddin, PhD; Sylia Wilson, PhD; Deborah A. Yurgelun-Todd, PhD.

Affiliations of The RECOVER-Pediatrics Group and the ABCD-RECOVER Group: Department of Pediatrics, Division of Infectious Diseases, Children's Hospital Los Angeles, Keck School of Medicine, University of Southern California, Los Angeles (Ernst); Department of Pediatrics, Center for Discovery and Innovation, Hackensack Meridian School of Medicine, Nutley, New Jersey (Aschner); Medical University of South Carolina, Charleston, South Carolina (Atz); Children's Mercy Hospital and Clinics, Kansas City, Missouri (Banerjee); Department of Pediatrics, Oklahoma University Health Science Center, Oklahoma City (Bogie); MetroHealth System, Cleveland, Ohio (Bukulmez); Department of Pediatrics, Division of Pediatric Hospital Medicine, Hackensack Meridian School of Medicine, Nutley, New Jersey (Clouser, Reyes); Department of Pediatrics, West Virginia University, Morgantown (Cottrell); Department of Pediatrics, Division of Pediatric Pulmonology, University of Vermont, Burlington (Cowan); Department of Pediatrics, Rhode Island Hospital, Providence (D'Sa); Department of Pediatrics, Division of Pediatric Pulmonology, Allergy and Sleep Medicine, Boston Children's Health Physicians, New York Medical College, Valhalla (Dozor, Krishnan); Avera Research Institute, Sioux Falls, South Dakota (Elliott); Department of Pediatrics, Division of Critical Care, Yale University School of Medicine, New Haven, Connecticut (Faustino); Department of Pediatrics, Division of General Pediatrics, Children's Hospital of Philadelphia, Perelman School of Medicine at the University of Pennsylvania, Philadelphia (Fiks); Department of Pediatrics, Division of Allergy, Immunology, and Infectious Diseases, Rutgers Robert Wood Johnson Medical School, New Brunswick, New Jersey (Gaur); Department of Public Health, Medicine, Immunology, Microbiology, Infectious Diseases, Rutgers New Jersey Medical School, Newark (Gennaro); Pennington Biomedical Research Center, Clinical Trials Unit, Baton Rouge, Louisiana (Gordon, Hsia); Department of Pediatrics, Division of Infectious Diseases, Cooperman Barnabas Medical Center, Livingston, New Jersey (Hasan); DARTNet Institute, Aurora, Colorado (Hester, Pace, Westfall); Department of Pediatrics, Connecticut Children's, University of Connecticut School of Medicine, Hartford (Hogan, Zempsky); Departments of Pediatrics, Internal Medicine, and Population and Quantitative Health Sciences, MetroHealth System, Cleveland, Ohio (Kaelber); Department of Pediatrics, Division of Pediatric Hospitalist, University of Hawaii, John A Burns School of Medicine, Honolulu (Kosut); Department of Pediatrics, Division of Pediatric Hospital Medicine, University of Nebraska Medical Center, Omaha (McCulloh); Department of Pediatrics, Division of Infectious Diseases, Connecticut Children's, University of Connecticut School of Medicine, Hartford (Michelow, Salazar); Department of Pediatrics, Division of Infectious Diseases, Boston Children's Health Physicians, New York Medical College, Valhalla (Nolan); Department of Pediatrics, Division of Infectious Diseases, Yale University School of Medicine, New Haven, Connecticut (Oliveira); Department of Pediatrics and Medicine, Division of Infectious Disease and International Health, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire (Palumbo); Department of Pediatrics, Division of Pulmonary, University of New Mexico School of Medicine, Albuquerque (Raissy); Department of Pediatrics, Nemours Children's Health, Wilmington, Delaware (Ross); Department of Pediatrics, Children's Mercy Hospital and Clinics, Kansas City, Missouri (Selvarangan); Department of Pediatrics, Division of Norton Children's Emergency Medicine, University of Louisville School of Medicine, Louisville, Kentucky (Stevenson); Department of Pediatrics, Division of Child and Adolescent Health, Columbia University Vagelos College of Physicians and Surgeons, Best Healthcare, Monroe, New York (Werzberger); Department of Pediatrics, Division of Critical Care, University of Arkansas for Medical Sciences, Little Rock (Zani); Massachusetts General Hospital Biostatistics, Boston (Chan); Department of Obstetrics and Gynecology, Division of Maternal-Fetal Medicine, University of Utah Health, Salt Lake City (Metz); Department of Cardiology, Boston Children's Hospital; Department of Pediatrics, Harvard Medical School, Boston, Massachusetts (Newburger); Children's Healthcare of Atlanta Cardiology, Emory University School of Medicine, Atlanta, Georgia (Truong); Department of Medicine, Division of Rheumatology, Inflammation, and Immunity, Brigham and Women's Hospital, Boston, Massachusetts (Feldman); Department of Medicine, Harvard Medical School, Boston, Massachusetts (Feldman); Laureate Institute for Brain Research, Tulsa, Oklahoma (Aupperle, Paulus); Center for Health Sciences, Stanford Research Institute International, Menlo Park, California (Baker, Müller-Oehring); Institute of Cognitive Science and Department of Psychology and Neuroscience, University of Colorado Boulder, Boulder (Banich); Departments of Psychological & Brain Sciences, Psychiatry, and Radiology, Washington University in St Louis, St Louis, Missouri (Barch); Department of Psychology, Yale University, New Haven, Connecticut (Baskin-Sommers, Gee); Institute for Drug and Alcohol Studies, Virginia Commonwealth University, Richmond (Bjork); Department of Psychiatry and Biobehavioral Sciences, University of Southern California, Children's Hospital Los Angeles, Los Angeles (Dapretto, Uddin); Department of Psychology and Psychiatry, University of California San Diego School of Medicine, Rady Children's Hospital, San Diego (Brown); Department of Psychology, Barnard College, Columbia University, New York, New York (Casey); Department of Diagnostic Radiology and Nuclear Medicine, University of Maryland Baltimore, Baltimore (Chang); Department of Psychiatry, University of Pittsburgh, Pittsburgh, Pennsylvania (Clark, Luna); Departments of Neurosciences, Radiology, and Psychiatry, University of California San Diego School of Medicine, Rady Children's Hospital, San Diego (Dale); Institute of Child Development, Department of Pediatrics, Masonic Institute for the Developing Brain, University of Minnesota, Minneapolis (Fair); Oregon Health & Science University, Portland (Fair); Department of Psychology, University of Rhode Island, Kingston (Feldstein Ewing); Del Monte Institute for Neuroscience, Department of Neuroscience, University of Rochester School of Medicine, Rochester, New York (Foxe, Freedman); Institute for Behavioral Genetics and Department of Psychology and Neuroscience, University of Colorado, Boulder (Friedman); Department of Psychiatry, University of Vermont, Burlington (Garavan); Department of Psychology, Florida International University, Miami (Gonzalez); Department of Psychiatry and Behavioral Sciences, Division of Addiction Sciences, Medical University of South Carolina, Charleston (Gray, Squeglia); Department of Psychiatry, University of Michigan, Ann Arbor (Heitzeg); Department of Population and Public Health Sciences, University of Southern California, Children's Hospital Los Angeles, Los Angeles (Herting); Department of Psychiatry, University of California San Diego School of Medicine, Rady Children's Hospital, San Diego (Jacobus); Department of Physics, Florida International University, Miami (Laird); Department of Psychology, University of Wisconsin, Milwaukee (Larson, Lisdahl); Department of Psychology, University of Minnesota, Minneapolis (Luciana); Department of Psychiatry, Washington University in St Louis, St Louis, Missouri (Madden); Department of Psychiatry , University of Utah School of Medicine, Salt Lake City (McGlade, Renshaw, Yurgelun-Todd); Rocky Mountain Mental Illness Research Education and Clinical Center, Department of Veterans Affairs, Salt Lake City Veterans Affair Medical Center, Salt Lake City, Utah (McGlade, Renshaw, Yurgelun-Todd); Department of Psychiatry, Oregon Health & Science University, Portland (Nagel); Virginia Institute for Psychiatric & Behavioral Genetics, Virginia Commonwealth University, Richmond (Neale); Department of Psychiatry, Division of Clinical Neuroscience Research Unit, University of Vermont, Burlington (Potter); Department of Pediatrics, University of Southern California, Children's Hospital Los Angeles, Los Angeles (Sowell); Institute of Child Development, University of Minnesota, Minnesota (Wilson).

Author Contributions: Drs Thaweethai and Foulkes had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Drs Rhee and Thaweethai are co–first authors. Drs Foulkes and Gross are co–senior authors.
Concept and design: Rhee, Thaweethai, Pant, Stein, Kinser, Kleinman, Gallagher, Warburton, Mohandas, Snowden, Teufel, Hockett, Nahin, Rosas, Szmuszkovicz, Vangeepuram, H. Brown, Carmilani, Fisher, Milner, Rosenzweig, Hasson, Katz, Foulkes, Gross, Bukulmez, Clouser, Cottrell, Kaelber, Kosut, Raissy, Salazar, Stevenson, Newburger, Feldman, S. Brown, Casey, Clark, Jacobus, Lisdahl, Luna, McGlade, Paulus, Squeglia.
Acquisition, analysis, or interpretation of data: Rhee, Thaweethai, Pant, Stein, Salisbury, Kleinman, Gallagher, Mohandas, Snowden, Stockwell, Tantisira, Flaherman, Castro, Chung, Espinoza Esparza, Hockett, Isidoro-Chino, A. Krishnan, McCormack, Nabower, Siddiqui, Szmuszkovicz, Vangeepuram, Zimmerman, Carmilani, Coombs, Fisher, Gage Witvliet, Wood, Rosenzweig, Irby, Karlson, Qian, Lamendola-Essel, Katz, Yin, Foulkes, Gross, Aschner, Atz, Banerjee, Bogie, Bukulmez, Cowan, D'Sa, Dozor, Elliott, Faustino, Fiks, Gaur, Gennaro, Gordon, Hasan, Hester, Hogan, Hsia, Kaelber, S. Krishnan, McCulloh, Michelow, Nolan, Oliveira, Pace, Palumbo, Reyes Santos, Ross, Selvarangan, Stevenson, Werzberger, Westfall, Zani, Zempsky, Chan, Metz, Truong, Feldman, Aupperle, Baker, Banich, Barch, Baskin-Sommers, Bjork, Casey, Chang, Clark, Dale, Dapretto, Ernst, Fair, Feldstein Ewing, Foxe, Freedman, Friedman, Garavan, Gee, Gonzalez, Gray, Heitzeg, Herting, Jacobus, Laird, Larson, Lisdahl, Luciana, Luna, Madden, McGlade, Müller-Oehring, NAGEL, Neale, Potter, Renshaw, Sowell, Uddin, Wilson, Yurgelun-Todd.
Drafting of the manuscript: Rhee, Thaweethai, Pant,

Stein, Kinser, Gallagher, Teufel, Espinoza Esparza, Hockett, McCormack, Nahin, Vangeepuram, Gross, Bjork, Luna, Paulus.
Critical review of the manuscript for important intellectual content: Rhee, Thaweethai, Pant, Stein, Salisbury, Kleinman, Warburton, Mohandas, Snowden, Stockwell, Tantisira, Flaherman, Castro, Chung, Hockett, Isidoro-Chino, A. Krishnan, McCormack, Nabower, Rosas, Siddiqui, Szmuszkovicz, Vangeepuram, Zimmerman, H. Brown, Carmilani, Coombs, Fisher, Gage Witvliet, Wood, Milner, Rosenzweig, Irby, Karlson, Qian, Lamendola-Essel, Hasson, Katz, Yin, Foulkes, Gross, Aschner, Atz, Banerjee, Bogie, Bukulmez, Clouser, Cottrell, Cowan, D'Sa, Dozor, Elliott, Faustino, Fiks, Gaur, Gennaro, Gordon, Hasan, Hester, Hogan, Hsia, Kaelber, Kosut, S. Krishnan, McCulloh, Michelow, Nolan, Oliveira, Pace, Palumbo, Raissy, Reyes Santos, Ross, Salazar, Selvarangan, Stevenson, Werzberger, Westfall, Zani, Zempsky, Chan, Metz, Newburger, Truong, Feldman, Aupperle, Baker, Banich, Barch, Baskin-Sommers, Bjork, S. Brown, Casey, Chang, Clark, Dale, Dapretto, Ernst, Fair, Feldstein Ewing, Foxe, Freedman, Friedman, Garavan, Gee, Gonzalez, Gray, Heitzeg, Herting, Jacobus, Laird, Larson, Lisdahl, Luciana, Madden, McGlade, Müller-Oehring, NAGEL, Neale, Potter, Renshaw, Sowell, Squeglia, Uddin, Wilson, Yurgelun-Todd.
Statistical analysis: Thaweethai, Pant, Teufel, Vangeepuram, Qian, Foulkes, Chan, Neale.
Obtained funding: Rhee, Thaweethai, Salisbury, Kinser, Kleinman, Warburton, Snowden, Stockwell, Tantisira, Wood, Milner, Katz, Foulkes, Gross, Aschner, Cottrell, D'Sa, Elliott, Faustino, Raissy, Salazar, Selvarangan, Aupperle, Baker, Banich, Barch, Baskin-Sommers, Bjork, Casey, Chang, Clark, Dale, Ernst, Fair, Feldstein Ewing, Foxe, Friedman, Garavan, Gee, Gonzalez, Gray, Herting, Jacobus, Lisdahl, Luciana, Müller-Oehring, NAGEL, Renshaw, Sowell, Squeglia, Wilson.
Administrative, technical, or material support: Rhee, Stein, Snowden, Stockwell, Flaherman, Chung, Hockett, Isidoro-Chino, Nabower, Nahin, Rosas, Siddiqui, Zimmerman, Carmilani, Wood, Irby, Karlson, Qian, Lamendola-Essel, Hasson, Katz, Gross, Atz, Bukulmez, Cottrell, D'Sa, Dozor, Fiks, Gennaro, Gordon, Hogan, Hsia, Kaelber, S. Krishnan, McCulloh, Raissy, Ross, Stevenson, Westfall, Chan, Aupperle, Barch, Baskin-Sommers, Chang, Clark, Ernst, Feldstein Ewing, Foxe, Herting, Jacobus, Lisdahl, Luciana, Madden, McGlade, Paulus, Squeglia, Uddin.
Supervision: Rhee, Thaweethai, Kleinman, Mohandas, Snowden, Stockwell, Hockett, Nabower, Szmuszkovicz, H. Brown, Wood, Irby, Katz, Foulkes, Gross, Bukulmez, Dozor, Fiks, Hester, Hogan, Hsia, Kaelber, Kosut, S. Krishnan, Nolan, Oliveira, Raissy, Selvarangan, Feldman, Bjork, S. Brown, Chang, Dapretto, Ernst, Foxe, Garavan, Gee, Gonzalez, Heitzeg, Jacobus, Lisdahl, Madden, McGlade, Renshaw, Squeglia.

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