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Measuring Equity From The Start: Disparities In The Health Development Of US Kindergartners

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ABSTRACT **Racialized disparities in health and well-being begin early in life and influence lifelong health outcomes. Using the Early Development Instrument—a population-level early childhood health measure—this article examines potential health inequities with regard to neighborhood income and race/ethnicity in a convenience sample of 183,717 kindergartners in ninety-eight US school districts from 2010 to 2017. Our findings demonstrate a distinct income-related outcome gradient. Thirty percent of children in the lowest-income neighborhoods were vulnerable in one or more domains of health development, compared with 17 percent of children in higher-income settings. Significantly higher rates of income-related Early Development Instrument vulnerability—defined as children falling below the tenth-percentile cutoff on any Early Development Instrument domain—were demonstrated for Black/African American and Hispanic/Latinx children. These findings underscore the utility of the Early Development Instrument as a way for communities to measure child health equity gaps and inform the design, implementation, and performance of multisector place-based child health initiatives. More broadly, results indicate that for the US to make significant headway in decreasing lifelong health inequities, it is important to achieve health equity by early childhood.**

The US suffers from significant, persistent, and highly racialized health inequities rooted in complex historical, social, and structural factors—particularly at the nexus of race and income.[1] Eliminating these inequities would drastically reduce health care costs, increase productivity, diminish preventable human suffering, and begin to remedy the consequences of centuries of unremitting and unresolved racial injustice.[2] The need to reduce inequity has been on display during the current coronavirus disease 2019 (COVID-19) pandemic, during which preexisting racialized health vulnerabilities have resulted in devastating outcomes for people of color throughout the US.[3]

A robust body of research has demonstrated that racialized inequities in health originate early in life and condition lifelong patterns of health and well-being.[4,5] Numerous studies further demonstrate how early adversity can result in toxic levels of stress that can alter neurobiological reactivity and function, cause pro-inflammatory shifts in immune signaling, and condition metabolic dysregulation.[6] These early exposures can profoundly influence health development—that is, the dynamic processes over the life course steeped in biological, behavioral, and social science research—resulting in higher rates of chronic conditions including diabetes, heart disease, drug use, mental health disorders, and dementia.[5,6] As a result of long-established patterns

of racial segregation, on average, 76 percent of Black/African American children and 69 percent of Hispanic/Latinx children live in neighborhoods with poverty rates higher than those found in the neighborhoods with the highest concentrations of White poverty.[1,7] By recognizing the racialized and spatial origins of health inequities, prevention policies can target emerging patterns of risk before they take hold and widen over the lifespan.[4,5,8,9]

Addressing inequities in early health development requires a strategic approach to population health measurement and surveillance.[4,5] Yet routine surveillance of children has, to date, primarily focused on traditional public health indicators of mortality and morbidity at the expense of more multidimensional measures of health development and well-being. Confronting this shortcoming, several nations have adopted the Early Development Instrument (EDI) to measure population-level health development and school readiness.[4,10] The EDI is a teacher-reported assessment of early child development in five domains: physical health and well-being, social competence, emotional maturity, language and cognitive development, and general knowledge and communication skills.[11,12] The EDI is completed for individual children, and the scores are then aggregated to reflect the area-level health development of children. Thus, its purpose differs markedly from other early child development tools that focus on diagnostic individual assessments.[13] To reflect a multidimensional concept of child development that requires children's optimal functioning in all areas, *vulnerability* is defined as children falling below the tenth-percentile cutoff on any EDI domain.

In the US, with support of the W. K. Kellogg Foundation, the University of California Los Angeles Center for Healthier Children, Families, and Communities launched the Transforming Early Childhood Community Systems initiative in 2010 to support a new era of place-based early childhood system building. In the past decade more than seventy communities in nineteen states have adopted the EDI.

In this article we examine the contribution of race/ethnicity to vulnerability in child health development over and above that of neighborhood income. We quantify the relationship between race/ethnicity and child health development at kindergarten entry (ages 4–6) in the context of socioeconomic inequities, as measured by neighborhood income.[14]

Study Data And Methods

PROCEDURE Ninety-eight participating school districts from eight different states trained kindergarten teachers to administer the Early Development Instrument in all elementary schools districtwide. Students' data were linked to their home addresses for place-based analyses. All data were collected between 2010 and 2017.

STUDY POPULATION AND SAMPLE The current study sample was derived from the US EDI database that included 301,792 children in sixteen states and Washington, D.C., and seventy-one sites, collected from 2010 to 2017. To minimize bias from selective inclusion of schools or children, we excluded school districts with either fewer than 90 percent of schools or fewer than 90 percent of students represented, jurisdictions with fewer than 500 students (because of lower data quality and significant missing data for small sites), and children's EDI records that did not have valid data (at least 75 percent responses) on at least four of five domains. The resulting analytic sample included 183,717 children in eight states plus Washington, D.C., and twenty-five sites, ninety-eight school districts, and 2,799 census tracts from 2010 to 2017. The sample was also clustered at the school level into 1,252 schools. See online appendix A for a flowchart of how the sample was selected.[15]

The final sample included the following breakdown by teacher-reported children's race/ethnicity: Black ($n = 15,237$; 8.3 percent); Asian/Native Hawaiian/other Pacific Islander ($n = 12,283$; 6.7 percent); Latinx ($n = 110,958$, 60.4 percent); White ($n = 36,275$, 19.8 percent); and other ($n = 8,964$, 4.9 percent). Appendix B provides the sample characteristics by race/ethnicity and income.[15] We compared our demographic breakdown with that of national figures from the 2019 ChildStats, a publication of the Federal Interagency Forum on Child and Family Statistics.[16] Our sample consisted of a smaller proportion of Black children (8.3 percent versus 13.8 percent, respectively) and a higher proportion of Latinx children (60.4 percent versus 25.4 percent, respectively), relative to national estimates. The final sample included a nearly equal proportion of boys ($n = 94,268$, 51.3 percent) and girls ($n = 89,440$, 48.7 percent) (Nine children were missing gender designation data but were included in the analysis). The mean age was 5.99 years (standard deviation: 0.41).

MEASURES Vulnerability in the five domains of health development was measured via the EDI. A description of the tool, domains, and sample items is in appendix C.[15] The EDI has been widely used in Canada, Australia, and more than a dozen other countries.[13] It has undergone extensive psychometric investigation and validation, including multilevel validity, differential item functioning, internal consistencies, factor structure, and prediction of concurrent and future

measures of development.[17–19] The EDI includes items that are based on children's developmental progression, are easily observable in a classroom context, and require no additional assessments. It is easy to administer and requires little respondent (teacher) training, making it cost-effective and scalable. Because it is administered as a census of the full population of children in a school district, it is not readily dismissed by local policy makers as not representing children in their district. The EDI is geocoded using students' home addresses or postal or ZIP codes, and results are mapped at the neighborhood, school district, and city levels. Geographic mapping links EDI outcomes to the combination of local factors that support or undermine early childhood development. Appendix D provides an example of a citywide map for Washington, D.C.[15]

To reflect a multidimensional concept of child development that requires children's optimal functioning in all areas,[20,21] *overall vulnerability* is defined as a child's vulnerability on one or more domains. As has become the international standard, in this study children were considered vulnerable below the tenth-percentile cutoff on any EDI domain, based on normative US database distribution from the 2008–09 school year convenience sample ($N = 10,244$).

CHILD DEMOGRAPHICS Addresses included on the EDI were used to geocode children's records to their home census tracts at the time of data collection. Income was represented by the census tract–level median household income, which was then divided into quintiles using all census tracts in which children in the EDI population resided. The quintiles are $6,688–$30,025 (quintile 1), $30,026–$39,697 (quintile 2), $39,718–$53,777 (quintile 3), $53,778–$74,828 (quintile 4), and $74,833–$250,001 (quintile 5).

NEIGHBORHOOD-LEVEL DATA Median household income, aggregated to census tracts, comes from American Community Survey 2012 five-year estimates from the Census Bureau.

DATA ANALYSIS First, we examined vulnerability by neighborhood median income quintile. In these analyses we calculated grand means for percentage vulnerability by median income quintiles. We conducted chi-square tests using pairwise comparisons and Bonferroni adjustments for multiple comparisons. Next, we conducted equivalent analyses to investigate vulnerability by race/ethnicity. Finally, we examined vulnerability by both race/ethnicity and neighborhood median income quintiles, again using equivalent analyses. To further investigate the extent that race/ethnicity and income predict developmental vulnerability, we used a generalized estimating equation with the exchangeable correlation structure, clustering at the school level, and a log link function to account for the dichotomous outcome variables. We incorporated state-level fixed effects, using median neighborhood income as the independent variable rather than the broader income quintiles to allow for more accurate prediction. All coefficients are represented as odds ratios. We used generalized estimating equation–exchangeable because it is more efficient when calculating within-cluster covariates compared with generalized estimating equation–independent. As a note, because of our large sample size ($N = 183,717$) and number of clusters ($n = 1,252$), there are minimal differences in coefficients and interpretation between generalized estimating equation–exchangeable and generalized estimating equation–independent. In addition to testing for main effects, we tested for interaction effects, using the margins command in Stata to interpret differences in vulnerability. We can also present race/ethnicity vulnerability data as a more easily visualized equity gap relevant for local policy makers, calculated by subtracting the quintile-specific mean from the mean of each racial/ethnic group (that is, racial/ethnic distances from the quintile mean) (appendix F).[15]

LIMITATIONS There were several limitations in this analysis. First, our sample was a convenience sample based on individual sites that elected to collect EDI data and not representative of the US as a whole. Nevertheless, it contains more than 183,000 children, and the school district samples include approximately 100 percent of the kindergarten population. Second, we used median household income from the census tract because individual family income data were not available. However, these are population-level estimates, routinely mapped at the neighborhood level, so the median household income is arguably a better measure of the local resource context. Third, we acknowledge that there are more specific measures of race/ethnicity than the five categories used in this article. Nevertheless, because of their similarity to widely used categories, they facilitate the comparability and interpretability of our results. Fourth, although we were able to assess EDI-measured vulnerability in relation to a child's race/ethnicity and neighborhood income, we were not able to measure potential confounders such as individual-level income, parental mental health, or the wide range of other potential positive and negative influences because of data limitations.

Study Results

NEIGHBORHOOD MEDIAN HOUSEHOLD INCOME AND VULNERABILITY Exhibit 1 demonstrates the relationship between neighborhood (census

tract) median household income and the percentage of children vulnerable in one or more domains. This relationship shows a linear income-related gradient, with children in the lowest-income neighborhoods (quintile 1) reporting 30 percent vulnerability, while vulnerability drops to 17 percent in those living in higher-income settings (quintile 5). Vulnerability differs significantly by quintile ($p < 0.001$). Pairwise comparisons revealed significant differences between all income levels even after multiple comparisons were accounted for.

RACE/ETHNICITY AND VULNERABILITY Exhibit 2 demonstrates large racial/ethnic differences in children's vulnerability. Black children demonstrate the highest level of vulnerability (32 percent), followed by Latinx (26 percent), other (24 percent), White (19 percent), and Asian (18 percent) children. Chi-square analyses revealed that vulnerability varies significantly by race/ethnicity ($p < 0.001$). Pairwise comparisons revealed significant differences in vulnerability among all racial/ethnic groups except between White and Asian children.

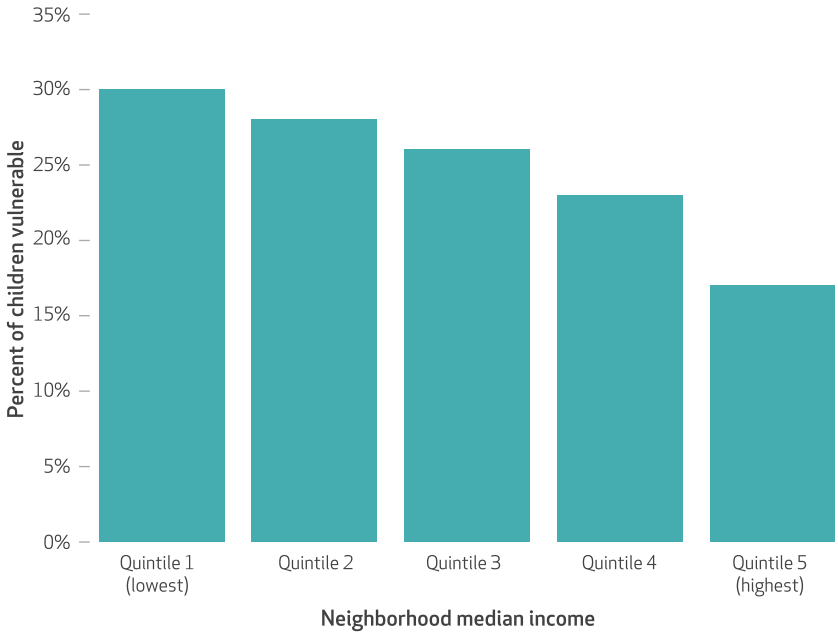
INCOME, RACE/ETHNICITY, AND VULNERABILITY Exhibit 3 demonstrates disparities in children's vulnerability based on race/ethnicity and neighborhood median income. Appendix E provides comparable vulnerability gradient graphs for each of the EDI domains.[15] Although there is significant variation by race/ethnicity across neighborhood income levels ($p < 0.001$), Black children's vulnerability does not differ as substantially by income relative to other racial/ethnic groups. Specifically, the vulnerability of Black children in the highest-income neighborhoods (quintile 5), with vulnerability rates of 25 percent, is only 10 percentage points lower than that for their lowest-income counterparts, who have vulnerability rates of 35 percent. On further analysis of mean centered differences, for Black children in the highest income quintile, the equity gap is substantially larger than in the other income quintiles (appendix F).[15]

The vulnerability in White children demonstrates a steeper difference, going from 36 percent vulnerable in the lowest income quintile to 14 percent in the highest income quintile. In comparison, vulnerability rates for Asian children decreased from 26 percent in the lowest income quintile to 14 percent in the highest income quintile. The vulnerability rates for Asian children in the lowest-income neighborhoods are comparable to those of Black children in the highest-income neighborhoods. Latinx children show the least change across the different income quintiles, with 28 percent vulnerability rates for those from the lowest income quintile and 21 percent for those in the highest income quintile. Of note, there is less pronounced Black-White disparity at the lowest income levels (35 percent and 36 percent, respectively). All interaction effects between race and income were significant ($p < 0.000$).

Exhibit 4 depicts generalized estimating equation logistic regression models that test the relationships among race/ethnicity, median household income, and vulnerability on each EDI domain separately, as well as on one or more domains. The models show that racial/ethnic groups differ substantially in levels of vulnerability, even when income is controlled for. For instance, for all outcomes, compared with Black children, the odds of a White child being vulnerable on one or more domains are around 40 percent lower, accounting for area-level median income ($p < 0.001$). For physical health, emotional maturity, social competence, and overall vulnerability, Black children have the highest odds of being vulnerable. For language and cognition and for communication and general knowledge, Latinx children have the highest odds of being vulnerable. Compared with Black children, Asian children have around 40–65 percent lower odds of being vulnerable for all domains except commu-

EXHIBIT 1

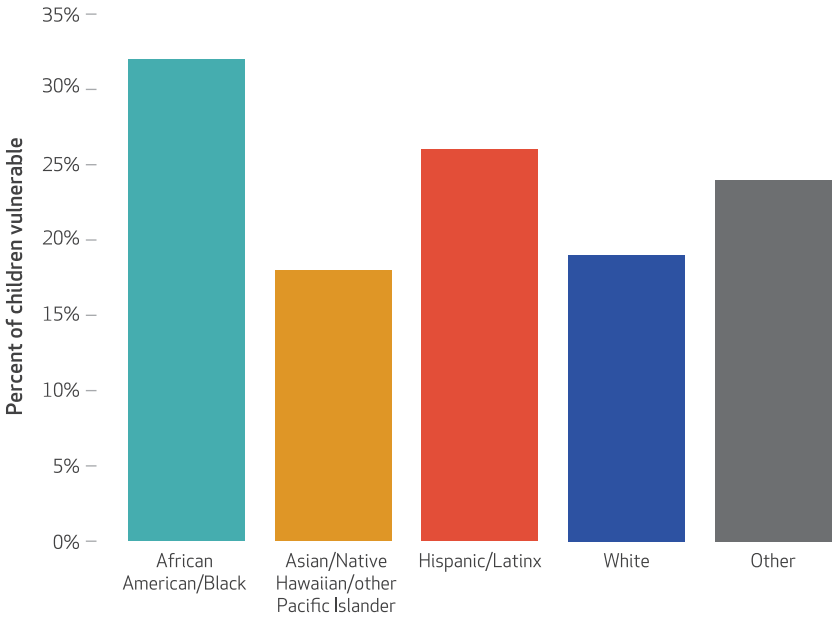
Vulnerability of children on one or more EDI domains, by neighborhood median income



SOURCES Authors' analysis of the Early Development Instrument (EDI); American Community Survey 2012 five-year estimates. **NOTES** Quintiles of median household income are established using 5,617 census tracts where children in the EDI population reside; specific income levels are in the text. $N = 183{,}717$. Children were considered vulnerable on a particular EDI domain if they fell below the tenth-percentile cutoff, based on normative US database distribution from the 2008–09 school year convenience sample ($N = 10{,}244$). The EDI domains are described in the text. Chi-square analyses revealed that vulnerability differs significantly across median income quintiles ($p < 0.001$).

EXHIBIT 2

Vulnerability of children on one or more EDI domains, by child race/ethnicity



SOURCE Authors' analysis of the Early Development Instrument (EDI). **NOTES** The definition of *vulnerability*, sample sizes, and statistical significance (for differences between racial/ethnic groups) are in the notes to exhibit 1. The EDI domains are described in the text.

nication and general knowledge, in which they have 19 percent higher odds of being vulnerable. See appendix G for full regression tables.[15]

Discussion

This study examined population-level inequities in early health development among children in relation to neighborhood income and race/ethnicity in a sample of more than 185,000 kindergartners in ninety-eight communities. It revealed distinct racialized area-level income gradients in child health development, with two predominant patterns emerging with respect to race/ethnicity. First, across income levels, Black children demonstrated the highest levels of vulnerability, followed by Latinx children, with Asian children demonstrating the lowest. This trend was also reflected in regression analyses, even when income was controlled for. Second, White children demonstrated the steepest neighborhood income gradient of vulnerability, with the highest levels of vulnerability for those in the lowest-income areas and the lowest levels of vulnerability for those in higher-income areas, suggesting that income-related social status is a stronger predictor of vulnerability for White children than for children from other racial/ethnic backgrounds. Although there are substantial Black-White differences that are greatest at the highest income levels, at the lowest income levels those differences are substantially reduced.

The magnitude of the neighborhood income–related difference in EDI vulnerability scores was comparable to that seen in results from other English-speaking countries (Australia, Canada, Ireland, and Scotland), which have also demonstrated steep income-related gradients in EDI scores.[10,11,22–24] None of the studies in the other countries, however, investigated the differential nature of these gradients for children from ethnically diverse backgrounds.

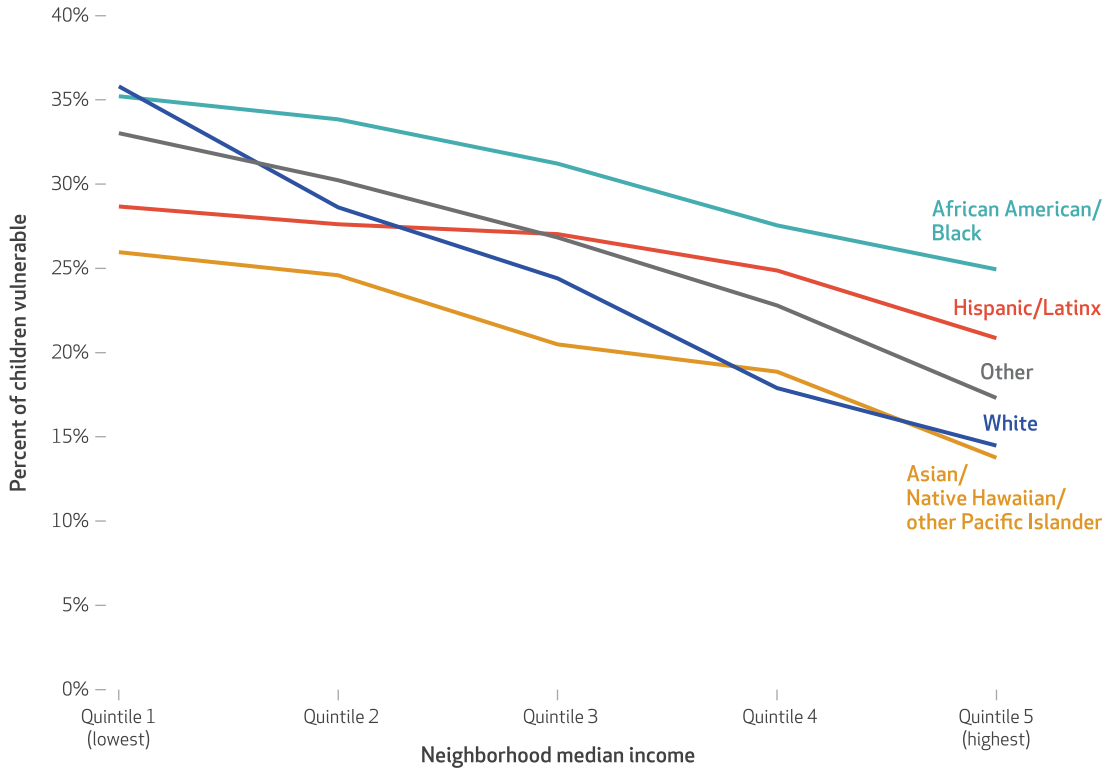
This study also showed the utility of a population-based measure of children's health development for assessing racialized equity gaps before school entry. We demonstrated that although Black children are more vulnerable than children of other racial/ethnic groups in each quintile, Black children from the highest income quintile, relative to other high-income children, are especially vulnerable, experiencing a greater equity gap. This pattern suggests that Black children in more affluent areas may experience additional barriers to healthy development compared with higher-income children from other racial/ethnic groups. This is consistent with "Minorities' Diminished Return" theory, which argues that higher income does not buffer Black children from the toxic effects of racism, which seem to overwhelm the protective effect of income.[25–27] This is also consistent with other life-course development research on the role of racism in perpetuating inequities in child development, including disparities in racial identity;[28] neighborhood social capital;[29] and access to programs, services, safety, and positive role models.[30]

Our study adds to the literature that demonstrates the key role that the association of race/ethnicity and income plays in the developmental origins of health disparities.[5,8,9,24] Although race is not a biologically accurate descriptor of human diversity, its ubiquity in the way people are identified, classified, and treated in the US makes race both an important social construct and a predictor of health outcomes.[31,32] Race becomes a risk factor in the face of racism—that is, when discrimination impedes opportunities for success.[33] From infant mortality and birthweight to hypertension and life expectancy and almost every health outcome in between, patterns of racial inequality inevitably emerge.[34]

Research documenting the racialized distribution and impact of adversity in the lives of children demonstrates how early experiences of adversity are embedded into children's biological and behavioral functioning and exert long-term impacts on health development trajectories.[35] Indeed, our data suggest that what will become racialized health disparities among adults are

EXHIBIT 3

Vulnerability of children on one or more EDI domains, by race/ethnicity and neighborhood median income



SOURCE Authors' analysis of the Early Development Instrument (EDI). **NOTES** The definition of *vulnerability*, sample sizes, and statistical significance are in the notes to exhibit 1. All interaction effects between race and income were significant ($p < 0.001$). The EDI domains are described in the text.

already evident by the time children enter school. Moreover, because our sample overrepresented less advantaged communities, the effects demonstrated may be even stronger in nationally representative samples.

Implications

A mounting body of research highlights how early experiences and exposures condition lifelong health. The present study highlights the potential missed opportunity of not achieving

EXHIBIT 4

Adjusted vulnerability among children, by race/ethnicity and income

	Odds ratios by EDI domain					
	One or more EDI domains	Physical health	Social competence	Emotional maturity	Language and cognition	Communication and general knowledge
Race[a]						
Asian/Native Hawaiian/other Pacific Islander	0.50	0.37	0.41	0.38	0.51	1.19
Hispanic/Latinx	0.78	0.67	0.58	0.51	1.23	1.31
White	0.60	0.67	0.56	0.60	0.64	0.65
Other	0.72	0.74	0.64	0.65	0.85	0.95
Median income	0.99	0.99	0.99	0.99	0.99	0.99

SOURCES Authors' analysis of the Early Development Instrument (EDI); American Community Survey five-year estimates. **NOTES** We used a generalized estimating equation with the exchangeable correlation structure, clustering at the school level, and a log link function to account for the dichotomous outcome variables. We incorporated state-level fixed effects. All coefficients are represented as odds ratios. The unit of analysis is the child ($N = 183{,}717$, from 1,252 school clusters). All outcomes are dichotomous (1 = vulnerable, 0 = not vulnerable). $p < 0.001$ for all coefficients except "other" for the communication and general knowledge category ($p = 0.283$). [a]African American/Black is the reference category.

equity from the start of life, especially for Black and Latinx children, but also for the increasing number of children growing up in underresourced communities. Although we did not measure racism directly, the patterns of racialized inequities revealed by this analysis suggest that any comprehensive, equity-focused early childhood policy strategy must directly target structural and cultural racism. Further, such strategies should address other forms of racial discrimination that pervade the lives of children and the systems that serve them. An effective policy response must consider the services, supports, and interventions that children and families need to promote optimal health development. In addition, polices must address racialized ecological exposures, where privilege and discrimination are historically structured and institutionally concentrated with developmental consequences that affect life-course outcomes.

Although the federal government can claim some significant accomplishments in advancing specific early childhood education, health, and special-needs initiatives, the US has not been able to advance an equity-focused, cross-cutting, well-funded, and sustainable early childhood policy response. For example, comprehensive approaches to children's health and well-being, including Early Head Start, home visiting and family support programs, and essential early care and education efforts, have all received partial funding that ranges from marginal to minimal. The Maternal and Child Health Bureau has supported state-level early childhood plans, cross-sector alignment, and program-specific improvement strategies through the state Early Childhood Comprehensive System initiative and the Maternal and Infant Early Childhood Home Visiting program. However, the US has yet to adopt and implement a comprehensive early childhood strategy similar to the World Health Organization's Nurturing Care Framework for early childhood development, which many nations are now using to upgrade their national early childhood health development systems.[36]

Given the potentially devastating impacts of a COVID-19 pandemic–induced economic collapse on children and families and the growing appreciation of the impact of racism on racial, class, gender, generational, and regional inequalities, Congress and the next administration should consider a "Marshall Plan" for children that would target racialized inequities and ensure that all children thrive. Early childhood vulnerabilities—clearly documented in this study—can stymie academic success, burden children with costly lifelong health conditions, and undermine their ability to lead their best lives. This, in turn, ultimately limits the future potential of the nation. Incremental new policies to patch holes and fill current gaps will undoubtedly continue to proliferate, but they will fall short of catalyzing the transformative systems-level changes needed to transition from an underperforming patchwork of siloed services into an integrative ecosystem of health development services and supports. What is needed is a scalable, cross-sector early childhood policy agenda that has the potential to transform the services and systems that address the needs of children. Such an agenda could include an early childhood data system, using multidimensional population measures such as the Early Development Instrument to enhance rapid-cycle learning, catalyze innovation, drive systems improvement, facilitate shared accountability, and enhance multisector collaboration, which enables and empowers community engagement and ownership.

Conclusion

Using US population-level measures of children's developmental health, we demonstrated strong income gradients in developmental outcomes, which differed markedly for children in five race/ethnicity categories. Our findings show that significant inequities and social gradients in vulnerability are measurable by the time children reach school. Given the potential role of structural racism in the observed Early Development Instrument racialized patterns, our findings underscore the importance of local and federal antiracist responses for children, families, and early childhood systems. Comprehensive antiracist approaches for achieving population health equity need to specifically address the developmental origins of health inequalities and recognize that equity in health outcomes is difficult to achieve without achieving equity from the start. ■

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