Annenberg Institute
BROWN UNIVERSITY

EdWorkingPaper No. 26-1410

Beyond the Shutdown: Tracking Language Growth in Early Head Start Children Before, During, and After COVID-19

Monica G. Lee
Stanford University

Kathleen Lynch
University of Connecticut

Susanna Loeb
Stanford University

Understanding early language outcomes for low-income children in the wake of the COVID-19 pandemic is an important concern for researchers, policymakers, and educators. We examined language environments and language development among infants and toddlers in Early Head Start from pre-COVID, through the pandemic peak and beyond to 2025. Study children were aged 2-43 months (N = 2,763; 47% girls; 42% Hispanic of any race; 46% Black/African American, Non-Hispanic; 6% White, Non-Hispanic; 4% Multi/biracial, Non-Hispanic; 3% Other race or unspecified, Non-Hispanic). On average, measures of children's classroom language environments improved post-pandemic, but children experienced declines in parent-reported language skills and growth lags in child vocalizations in the pandemic's wake. We examine potential moderators and discuss implications for future research and practice.

VERSION: February 2026

Suggested citation: Lee, Monica G., Kathleen Lynch, and Susanna Loeb. (2026). Beyond the Shutdown: Tracking Language Growth in Early Head Start Children Before, During, and After COVID-19. (EdWorkingPaper: 26-1410). Retrieved from Annenberg Institute at Brown University: https://doi.org/10.26300/yvzm-0b36

Beyond the Shutdown: Tracking Language Growth in Early Head Start Children Before, During, and After COVID-19

Monica G. Lee, Stanford University

Kathleen Lynch, University of Connecticut Neag School of Education

Susanna Loeb, Stanford University

Abstract

Understanding early language outcomes for low-income children in the wake of the COVID-19 pandemic is an important concern for researchers, policymakers, and educators. We examined language environments and language development among infants and toddlers in Early Head Start from pre-COVID, through the pandemic peak and beyond to 2025. Study children were aged 2-43 months (N = 2,763; 47% girls; 42% Hispanic of any race; 46% Black/African American, Non-Hispanic; 6% White, Non-Hispanic; 4% Multi/biracial, Non-Hispanic; 3% Other race or unspecified, Non-Hispanic). On average, measures of children's classroom language environments improved post-pandemic, but children experienced declines in parent-reported language skills and growth lags in child vocalizations in the pandemic's wake. We examine potential moderators and discuss implications for future research and practice.

Keywords: language environments, language development, child care, COVID-19, Early Head Start

Lay Summary

We examined language environments and language development among infants and toddlers in Early Head Start from pre-COVID, through the pandemic peak and beyond to 2025. We found that children's classroom language environments improved post-pandemic, but children experienced declines in parent-reported language skills and growth lags in child vocalizations in the wake of the pandemic. We suggest implications for accelerating young children's language learning opportunities post-COVID-19.

Beyond the Shutdown: Tracking Language Growth in Early Head Start Children Before, During, and After COVID-19

During the first three years of life, children accrue critical experiences and skills in their language development that strongly influence later outcomes. Language skills grow rapidly in the first three years, and early childhood interactions with caregivers and other aspects of children's language environment play a key role in shaping the development of these skills as well as other cognitive outcomes (e.g., Huttenlocher et al., 2010; National Research Council, 2000; Rowe, 2008). For instance, the quality of parental communication with their infants and toddlers, as measured by vocabulary and number of conversational turns, predicts neural activity while processing language (Romeo et al., 2021), better vocabulary skills as older toddlers (Rowe, 2012; Weisleder & Fernald, 2013), and stronger long-run cognitive and language skills (Gilkerson et al., 2018). The quality of conversation in preschools, where many children spend a significant amount of time, also predicts subsequent language skills and reading ability (e.g., Cabell et al., 2015; Dickinson & Porche, 2011).

However, in recent research and policy documents, scholars and civic leaders have raised concerns about the potential long-run effects of the COVID-19 pandemic on young children's development of critical language skills (e.g., National Academies of Science, Engineering, and Medicine, 2023). For infants and toddlers, their language development could conceivably have been harmed by pandemic-restricted social interactions and the stressors that the pandemic inflicted on parents and caregivers. On the other hand, a variety of supportive factors could plausibly have buffered infants and toddlers from pandemic-inflicted language delays. As we discuss below, limited research to date has examined how the language development of infants

and toddlers has fared during and since the COVD-19 pandemic, particularly for children in high-poverty settings in child care services.

We address this issue by examining the extent to which the language environment and language development trajectories of low-income children enrolled in Early Head Start, a federally subsidized free childcare program serving low-income children, varied pre-COVID versus post-COVID. Within this study, which we classify as exploratory in nature given the relatively novel domain and small size of the sample, we also investigate the extent to which associations between the pandemic and children's language environment and language development may have differed by demographic characteristics. To address these questions, we use a novel dataset capturing language environment and language development skills among infants and toddlers in a network of Early Head Start centers from 2017 to 2025.

In the following sections, we first briefly overview relevant prior literature pertaining to early language environment and skills, particularly for low-income children, as well as recent evidence on how young children's language skills and environments have fared during the pandemic.

Background: The Importance of Early Language Skills

Together, existing research points to the importance of enriching language environment and language skills in early childhood for children's school readiness and future achievement. Early language skills are linked to subsequent language development outcomes, reading ability, and overall academic success (e.g., Bleses et al., 2016; Joner, 2025), as early knowledge scaffolds the acquisition of more complex skills (Snow & Matthews, 2016). Meta-analytic studies have documented links between early language skills and later school outcomes, such as better reading achievement in first and second grade (Lonigan & Shanahan, 2009) and lower

instances of behavioral challenges (Chow et al., 2018). In a nationally representative U.S. cohort, children with larger vocabularies at 24 months of age entered kindergarten with higher early reading and math skills, better self-regulation, and fewer behavioral issues (Morgan et al., 2015).

Low Income Children's Child Care Environments and Early Language Development During the Pandemic

Since the onset of COVID-19, child psychologists and pediatricians have predicted substantial pandemic-induced hazards to young children's development, with particular concerns expressed over potential effects on low-income children (e.g., National Academies of Science, Engineering, and Medicine, 2023). The onset of the pandemic catalyzed major disruptions to children's everyday experiences, with various layers of their ecological contexts being affected (Bronfenbrenner, 1979). Many child care centers closed early in the pandemic; once they reopened, many operated at reduced capacity due to social distancing requirements, and/or faced the frequent need to send children, teachers, or whole classrooms home to quarantine due to virus exposures (e.g. Thomas et al., 2022; Jung & Barnett, 2021). Overall enrollment in child care declined during the pandemic, particularly in low-income settings (Weiland et al., 2021).

While recent studies suggest that the pandemic may have led to disruptions to young children's language environment and delays in language skills overall, little is known about how low-income children enrolled in childcare environments may have weathered these shocks. One scoping review found that preschool children (children from birth to age six) experienced declines in their language development during the pandemic across multiple domains, including vocabulary, literacy, and social communication (Zuniga-Montanez et al., 2024). However, the review was only able to locate one study of infants and toddlers in childcare environments, and it was conducted with a predominantly middle class sample. Other studies have found that infants

born since the onset of the pandemic have tended to score lower on motor and cognitive functioning (Deoni et al., 2022), and were at greater risk of delays in fine motor skills and other developmental delays by age one (Giesbrecht et al., 2023; Huang et al., 2021), but these studies center on birth and maternal differences and do not take early childhood education into account in exploring pandemic-related risks. One analysis of infants' experiences within their home environments found that infants aged 0-9 months born after the pandemic had fewer vocalizations and experienced fewer conversational turns with adults in their households relative to their counterparts born prior to the pandemic, with pandemic-related differences being the largest among the poorest families (LENA, 2022). This study, while quite informative, was focused on home interactions rather than child care centers and did not examine longitudinal data, indicating that more can be learned from research examining children in childcare environments over a span of years during the pandemic period.

To date, the extent to which infants and toddlers from low-income backgrounds receiving child care services experienced harms to their language development due to the pandemic is less clear. On the one hand, low-income individuals are often expected to bear an especially heavy burden of disasters (Baez et al., 2010), as initial inequities may be exacerbated (Ceci & Papierno, 2005). In line with this, a professional consensus study report by the National Academies of Science, Engineering, and Medicine (2023) concluded that "In almost every outcome related to social, emotional, behavioral, educational, mental, physical, and economic health and well-being, families identifying as Black, Latino, and Native American, and those with low incomes, have disproportionately borne the brunt of the negative effects of the pandemic" (p. 18). If this is the case, we may expect the developmental trajectories of children enrolled in EHS to experience deleterious effects from the pandemic.

On the other hand, a wide range of assets and strengths of families from low-income and minoritized backgrounds, ranging from positive family routines and extended family network supports to active home literacy practices (e.g., Bustamante & Hindman, 2020; Jarrett & Coba-Rodriguez, 2017), may have served as protective factors buffering the effects of stressors and disruptions to children's daily lives (e.g., Spencer et al., 1997). While the literature mentioned above suggests that young children experienced language losses or delays during the pandemic, some may have avoided delays or even exceeded outcomes.

Another possibility is that any negative effects of the pandemic on low-income children's language development may have been buffered or mitigated by exposure to high-quality early child care environments. Prior literature suggests that high-quality childcare has considerable potential for fostering the foundational language skills of infants and toddlers (Duncan et al., 2023), and can offset the negative relationship between stressors like flux in household routines and delays in child cognitive development (e.g., Berry et al., 2016). For low-income children, participation in early care and education (ECE) settings can stimulate meaningful language growth, especially if the settings contain features of high-quality childcare such as predictable routines, rich conversation and interactions with caregivers, small group sizes, and guided play (Finders et al., 2023; Hadley et al., 2025; Love et al., 2005; Turnbull et al., 2009).

As a major example, in the United States, the Early Head Start (EHS) program (described below) provides federally-funded free childcare to over 200,000 low-income infants and toddlers yearly, and EHS centers also worked to provide families with supports throughout the pandemic. Overall, participation in EHS-provided childcare can lead to better support for parents in their communication with their children (Harden et al., 2012), serve as a buffer for children from

parental stress (Vallotton et al., 2012), and improve language skills relative to low-income children who do not attend EHS (Administration for Children and Families, 2002; Love et al., 2005; Love & Brooks-Gunn, 2010). EHS centers also made concerted efforts to support enrolled children and families during COVID-19. During lockdowns and center closures, program directors and staff increased their services and outreach to families, often delivering meals, diapers and infant supplies, educational materials, and other necessities to enrollees' homes; conducting frequent check-ins with parents and caregivers; and helping connect parents and caregivers with needed resources such as housing, employment and financial assistance, transportation, and mental health support (e.g., Jeffrey et al., 2020; Shaw et al., 2023; Silver & Coba-Rodriguez, 2025). Qualitative interview research also suggests that when centers reopened in fall of 2020, EHS center directors perceived that the newly-reduced class sizes necessitated by social distancing helped foster children's social skills, reduced behavior challenges, and allowed teachers to supply children with more individualized attention than was possible pre-pandemic (Silver & Zinsser, 2022).

Specific to language development patterns among ECE enrollees during the pandemic period, in one study, young children attending early childhood centers in-person during the pandemic outperformed their peers who did not receive in-person services (Narea et al., 2025). Another study reported evidence that low-income children enrolled in Head Start preschool programs in early 2022 were making language skill gains that were similar to gains observed in a 2014-15 cohort, which the researchers suggested could indicate the possibility of resilience in language growth in the pandemic-exposed cohort (McCormick et al., 2023; see also Lynch et al., 2023). However, pandemic-related evidence has yet to emerge for younger children (i.e., younger toddlers and infants).

Additional Sociodemographic Factors

A constellation of other early environmental and contextual factors can contribute to young children's language acquisition trajectories, and could conceivably have interacted with the pandemic to influence outcomes.

Regarding age-specific factors, the kinds of interactions that facilitate language development may vary across infancy and toddlerhood. For infants, amount of child-directed speech and direct engagement with adults have been posited as particularly important for language-processing efficiency and early vocabulary acquisition (e.g., Jones & Rowland, 2017; Lawton et al., 2023; Weisleder & Fernald, 2013). Early skills such as babbling serve as foundational competencies that later lead to language processing and attention (Schwab & Lew-Williams, 2016). Infants in low-income households show stronger processing skills and larger vocabularies when exposed to more direct caregiver talk, despite typically receiving less input overall than higher-income peers (Weisleder & Fernald, 2013). By toddlerhood, children tend to have an established baseline of basic vocabulary skills and to exhibit a greater developmental need to explore their environments independently. Cognitively stimulating interactions that are more complex, such as adult-child conversational turns, tend to play a more pronounced role in vocabulary growth and emerging language skills at this age (e.g., Hirsh-Pasek et al., 2015; Romeo et al., 2018; Valloton et al., 2017). These developmental trajectories highlight the need for age-specific strategies in supporting children's language growth, especially among low-income populations where challenges often emerge earliest and remain persistent (Fernald et al., 2013).

The effects of early language environments on children's development may also vary by sociodemographic factors such as gender and race, although evidence exclusively from low-

income settings is limited. Several studies have documented that girls tend outperform boys in early vocabulary and syntax skills, including in low-income settings (e.g., Huttenlocher et al., 1991; Vallotton et al., 2012), although these studies do not explore longitudinal trajectories by gender. Girls may display greater responsiveness to caregiver speech, amplifying early gains (Morisset et al. 1995). Research on potential differential effects of early language exposure by child gender in low-income settings is generally limited as well. Some research suggests that girls may glean slightly larger language benefits from Early Head Start compared with boys, but the evidence is not conclusive (Vallotton et al., 2012).

Prior research also documents that in general, many observed disparities by racial/ethnic subgroups in language development are explained by factors such as poverty, maternal education, and access to resources (e.g., Aratani et al., 2011). When socioeconomic factors are accounted for, differences narrow substantially (e.g., Huttenlocher et al., 2010), suggesting that longstanding inequalities in access to educational and employment resources facing Black and Hispanic families are critical contributors to language development opportunity gaps. Understanding how the pandemic may have affected children from specific groups whom public childcare programs aim to serve is an important concern for policy.

Therefore, much remains to be understood about how the language trajectories of infants and toddlers from low-income and/or racially minoritized families have fared in the wake of the COVID-19 pandemic. Research on how COVID-19 may have influenced the youngest low-income children enrolled in subsidized childcare is quite limited. Given these different influences and hypotheses of development during a crisis, it is important to know how this group's language environment and language development have fared during the pandemic and in its wake. Accordingly, we address the following research questions in our study:

1. To what extent did the language environment and language development trajectories of low-income children enrolled in EHS vary pre-COVID versus post-COVID?
2. To what extent did the association between the pandemic and children's language environment and language development differ by demographic characteristics and child age at pandemic onset?

We address these questions by applying mixed modeling techniques to panel data from 2017-18 to 2024-25 on Early Head Start-enrolled infants' and toddlers' measures of language environment and language development skills derived from the Language Environment Analysis (LENA) assessment technology.

Methods

Sample

Researchers partnered with an Early Head Start provider operating 96 early child care centers across four states – two in the mid-Atlantic region, one in the Midwest, and one in the Southwestern region of the United States. As contextual background, the Early Head Start program is one of the largest childcare programs in the United States. It is part of the Head Start model which has provided federally-funded free childcare to over 37 million low-income children in the United States to date. The US spends over $10 billion annually on Head Start and Early Head Start, and in a typical year over 200,000 children attend Early Head Start (Office of Head Start, 2025). Several pathways exist for determining eligibility for EHS services. Generally, children of families receiving public benefits like the Temporary Assistance for Needy Families (TANF) or Women, Infants, and Children (WIC) program are categorically eligible for EHS. In addition, foster children, homeless children, and children living in households with an income at or below the federal poverty level may also be eligible. Many

children served by EHS are from sociodemographic backgrounds at heightened risk of experiencing delayed general language skills by age three relative to their counterparts from higher-income family backgrounds (Rowe, 2008). EHS maintains low teacher-child ratios, makes home visits and provides parenting education programming, and offers additional wraparound supports such as help with securing housing and acquiring services for children with disabilities (Office of Head Start, 2025).

The EHS provider collected demographic data and was responsible for administering LENA measures to participants a minimum of two times each program year. The research team combined annual administrative datasets containing demographic information with child-by-assessment level LENA outcome data, containing our outcome measures of interest (details below).

Table 1 shows the number of children assessed across LENA assessment periods and program years. For instance, 242 children were assessed during the Fall LENA assessments in the 2018-19 program year (Table 1, column 1). Observations included in the final study sample had non-missing demographic data from the administrative dataset along with at least one set of LENA outcome data in any given program year during which the child was enrolled; 671 LENA data points had missing demographic data and were dropped. The EHS programs used LENA assessments over the study time period as a part of their regular evaluation of their programming. They assessed a smaller number of participants in the first year of using the LENA system, then scaled up the assessments in future years. In line with the nature of Early Head Start where infants and toddlers age out to preschool at age 3 by construction and enroll and unenroll on a rolling basis, children tend to be enrolled in EHS over a relatively short span; our EHS dataset averages about 2.9 observations per child.

Overall, our final study sample consists of 7,849 child-assessment-year observations of 2,763 children enrolled across eight program years – 2017-2018 PY through 2024-25 PY. As discussed below, we refit the analytic models omitting the first PY from the analyses as a sensitivity check.

We present demographic characteristics in Table 2 for the entirety of the study sample, as well as separately for the sample by the pre-and post-pandemic periods. Across both pre- and post-pandemic periods, mean age of children was approximately 26 months, and girls comprised 46-47 percent of the sample. In the Early Head Start administrative data, parents identified their child's race as Black/African American, White, Biracial/Multiracial, or Other Race or unspecified and their ethnicity as Hispanic or not Hispanic. Pooling across periods, 46% of children had parent-identified child race/ethnicity as Black/African American, Non-Hispanic; 6% as Black/African American, Hispanic; 6% as White, Non-Hispanic; 20% as White, Hispanic; 4% as Multi/biracial, Non-Hispanic; 3% as Multi/biracial, Hispanic; 13% as Other race or unspecified, Hispanic; and 3% as Other race or unspecified, Non-Hispanic.

Three-quarters of all children primarily speak English at home, although a significant portion (about a quarter) are dual language learners. Although socioeconomic characteristics are largely consistent before and after the pandemic, children observed post-pandemic are slightly more likely to have at least one parent employed full-time (from 38 to 47 percent).

Outcome Measures

For our analysis of language environment and language development, we use data from the LENA assessment program. LENA users wear low-powered, child-sized vests containing wireless digital recorders. The LENA technology records and processes environmental sounds to produce a set of language measures (described below). The EHS provider conducted LENA

assessments twice or three times each program year (see Table 1). Teachers at each center fitted children with vests, and the assessments occurred for two consecutive days to reach the recommended 12 or more recording hours (Cristia et al., 2021). As described below, the LENA outcome measures also include a validated parent-report measure that captures facets of children's language development. For research syntheses on how the LENA system is used by researchers, see e.g., Ganek & Eriks-Brophy (2018) and Greenwood et al. (2018).

We define our outcomes of interest as either outcomes pertaining to the child's *language environment* or *language development skills*, and describe measures pertaining to each below.

Language Environment Measures

LENA captures measures of language environment in two different ways: *adult word count* and *conversational turns*. *Adult word count* indicates the average total number of adult words spoken near the child for each hour of recording (within the current study data: mean = 1,058.45; SD = 454.29). *Conversational turns* indicate the average total number of adult-child conversational exchanges per hour, where conversational exchanges consist of child vocalizations (e.g., babbling, coos, words) followed by an adult response, or an adult speaking followed by child vocalizations in response (within the current study data: mean = 25.01; SD = 13.79).

These language environment measures track the amount of language stimulation and engagement offered in the classroom, as opposed to the child's own language development skills. In a nationally representative sample of children in the LENA Natural Language study, a 24-month-old child scoring at the 50th percentile had an average hourly adult word count of 1,024.75 (12,297 across 12 hours) and an average conversational turn count of 39.5 per hour (474 across 12 hours; Gilkerson & Richards, 2009). Notably, there is a great deal of variation in

adult word count. For instance, average adult word count amongst children at the 99th percentile is nearly fivefold of that measured amongst children at the 10th percentile (Gilkerson & Richards, 2009). Adult word count can also vary by time of day, with a tendency to be higher in the mornings and to dip during the afternoon when children often have lunch and naps (Gilkerson & Richards, 2009).

Language Development Measures

In addition to environment, LENA also captures language development skills using three additional measures: *child vocalizations*, *Automatic Vocalization Assessment (AVA) scores*, and *Developmental Snapshot scores*.

Child vocalizations indicate the number of utterances that a child makes per hour (within the current study data: mean = 106.39; SD = 55.54). In a nationally representative sample of children in the LENA Natural Language study, a typical 24-month-old child scoring at the 50th percentile had an average child vocalization count of 162.92 per hour (1,955 across 12 hours; Gilkerson & Richards, 2009). *AVA scores* are age-adjusted percentile scores that capture the extent to which children are developing expressive language skills, taking into account the type of vocal output children make and how that mimics adult language skills (Richards et al., 2017) (within the current study data: mean = 47.9; SD = 24.71). *Developmental Snapshot scores* are age-adjusted scores based on a 52-item survey completed by parents capturing the extent to which they report observing their children meeting age-appropriate milestones in expressive and receptive language. Developmental Snapshot scores are scaled to a mean of 100 and a standard deviation of 15 (Gilkerson & Richards, 2009; Richards et al., 2017) (within the current study data: mean = 91.79; SD = 20.57).

Validity Evidence for LENA Measures

Numerous other studies have used LENA to study language environments and development skills for young children (e.g., Ganek & Eriks-Brophy, 2018; Romeo et al., 2018). Researchers have documented positive correlations between LENA-produced measures and children's outcomes on other standardized language assessments (Gilkerson & Richards, 2009; Richards et al., 2017; Xu et al., 2009). Regarding specific indicators, a recent review concluded that LENA adult word count outcomes tend to demonstrate small to medium associations with alternative measures of children's language skills, while conversational turns and child vocalization outcomes tend to display medium associations with other language skills measures (Wang et al., 2020). Prior LENA research has also found that lower AVA scores are associated with heightened risk of language developmental delays (Gilkerson & Richards, 2009; Gilkerson et al., 2017), and that LENA can be used to assess outcomes for subpopulations including deaf/hard-of-hearing children (Aragon & Yoshinaga-Itano, 2012) and children with ASD (e.g., Woynaroski et al., 2017).

Analytic Approach

Given the structure of the data, within and across calendar years, and pre and post-pandemic periods, we were able to preserve and model time (in months), while also allowing for random intercepts at the child level, by applying mixed models of the following form (Laird & Ware, 1982; in line with Martin et al., 2025):

$$y_{it} = \beta_0 + \beta_1 month_{it} + \beta_2 post_{it} + \beta_3 month_{it} \times post_{it} + X_i'\gamma + W_{it}'\delta + u_i + \varepsilon_{it}$$

where y_{it} is one of LENA's measures of language environment or language development for child *i* at assessment *t*, $month_{it}$ is a continuous variable indexing the month that LENA assessment *t* occurred, centered on January 2021 (when the first post-pandemic assessment occurred), and $post_{it}$ is a dichotomous indicator that equals one if the LENA assessment

occurred after pandemic onset (i.e., January 2021 or later) and zero otherwise. X_i' is a vector of time-invariant covariates for child *i,* including indicators for parent-reported child gender and race/ethnicity, including African American/Black, Hispanic, Other Race, Multiple Race/Biracial, and White. W_{it}' is a vector of time-varying child covariates including child age in months, centered at the sample mean; and indicators for whether the child's primary language is English, whether the child is a dual language learner, whether at least one parent attended college, whether at least one parent is employed full-time, whether the child is living in a single-parent household, and whether the family ever received public benefits from Supplemental Security Income [SSI], Temporary Assistance for Needy Families [TANF], the Special Supplemental Nutrition Program for Women, Infants, and Children [WIC], or Supplemental Nutrition Assistance Program [SNAP] in the program year. The term $u_i \sim \mathcal{N}(0, \sigma_u^2)$ represents child-level random intercepts, and $\varepsilon_{it} \sim \mathcal{N}(0, \sigma^2)$ is the residual.

In our model specification, β_0 is the average baseline value for a reference child at mean sample age; β_1 captures the pre-pandemic monthly growth trajectory in each language environment or development outcome of interest; β_2 captures the level change in the outcome at the time of the first post-pandemic assessment (i.e., January 2021), signaling whether there is a discontinuous jump relative to the pre-pandemic trend prediction; and β_3 indicates the change in post-pandemic monthly growth trajectory in the outcome of interest relative to what the trend pre-pandemic would have predicted. In effect, $\beta_1 + \beta_3$ is the average post-pandemic monthly slope value for the outcomes of interest. We allow for fixed slopes across children in our sample to maximize precision levels given the small number of repeated assessments per child. Random intercepts allow children to start at heterogeneous baseline levels of language environment and language development skills. As noted above, given the relatively small number of enrollees

assessed during the first year of the assessments, as a sensitivity check we also refit all models omitting observations from the 2017-18 program year.

As an alternative specification, we also apply fixed effects regression models to a subset of panel data consisting of children with LENA assessments both prior to and after the pandemic. This approach uses data from a subset of 192 children from two cohorts and includes the same variables and child covariates as above, but accounts for child fixed effects to examine average within-child growth trajectories. We also refit these models using random effects as a sensitivity check; as discussed below, results are similar.

To assess subgroup heterogeneity, we extend the mixed-effects model to include three-way interactions between time, pandemic period, and each subgroup of interest. Specifically, for each subgroup $Group$ (indicator for female; indicator for Black; indicator for Hispanic; and a continuous variable for child age in months), we estimate the following:

$$y_{it} = \beta_0 + \beta_1 month_{it} + \beta_2 post_{it} + \beta_3 month_{it} \times post_{it} + \beta_4 Group_i + \beta_5 month_{it} \times Group_i + \beta_6 post_{it} \times Group_i + \beta_7 month_{it} \times post_{it} \times Group_i + X_i'\gamma + W_{it}'\delta + u_i + \varepsilon_{it}$$

This specification allows us to estimate subgroup-specific pre-pandemic slopes, level shifts at the initial assessment after the onset of the pandemic, and post-pandemic changes in monthly growth trajectories.

Results

Pairwise Correlations

Before turning to the main findings, we examine pairwise correlations among our outcomes of interest in terms of language environment measures (adult word count, conversational turns) and language development measures (AVA percentile scores,

Developmental Snapshot, and child vocalizations). See Table 3. We examine correlations separately for infants and toddlers given that child language tends to develop differently by child age (e.g., Gilkerson & Richards, 2008).

We observe that measures of language environment are positively correlated with one another in both age groups, providing evidence of convergent validity. For infants, conversational turns correlate strongly with adult word count ($r = .590$, $p < .001$). Child vocalizations are also strongly associated with conversational turns ($r = .790$, $p < .001$) and modestly but significantly with AVA percentiles and adult word count. Generally, measures follow a similar pattern for toddlers. Conversational turns are strongly correlated with adult word count ($r = .494$, $p < .001$) and child vocalizations ($r = .794$, $p < .001$). While parent-reported Developmental Snapshot scores are not significantly correlated with other measures of language environment or development among infants, they are weakly or moderately correlated with conversational turns, child vocalizations, and AVA percentiles for toddlers, suggesting that the parent survey and/or the LENA-derived measures may better capture language milestones (have lesser measurement error) for toddlers relative to infants.

Turning to correlations with age, among infants, child age has a weak negative association with conversational turns ($r = -0.185$, $p < .001$), adult word count ($r = -0.213$, $p < .001$), and child vocalizations ($r = -0.139$, $p < .001$), and a weak positive association with AVA percentiles ($r = 0.160$, $p < .001$), which are age-adjusted. Due to the lack of data points among infants, these associations should be interpreted with caution. Among toddlers, however, conversational turns and child vocalizations are positively associated with age ($r = 0.223$, $p < .001$ and $r = 0.311$, $p < .001$, respectively). AVA percentiles and Developmental Snapshots are weakly negatively associated with age amongst toddlers. Associations between conversational

turn rates and child age are broadly consistent with trends seen in prior LENA research conducted in ECE classroom settings, which observed a drop-off in children's experience of conversational turns in ECE between infancy and toddlerhood, followed by a modest trend back upward in the later toddler years (LENA, n.d.).

Main Results

RQ 1: Average Effects

Table 4 displays estimates from our main mixed model specification (see also Figure 1). For each of our five outcomes of interest, we estimate models iteratively, first without and then with a full set of child covariates. Across outcomes, we observe that adjusted estimates are generally similar to unadjusted ones, indicating that the main patterns are robust to observed differences in children and families. Accordingly, we focus on adjusted estimates in our interpretation of the results below.

Language Environment Outcomes

First, we observe positive post-pandemic level shifts in our two measures of language environment. Prior to the pandemic, we do not observe significant monthly growth in language environmental measures capturing conversational turns per hour and adult word count per hour. In the first assessment captured after the onset of the pandemic (i.e., January 2021), conversational turns increase by approximately 2.72 turns/hour ($p < .01$) on average. We observe a similar pattern with adult word count, which increases by 98.66 words/hour ($p < .01$) at the time of this first-post-pandemic assessment. Post-pandemic monthly growth trajectories (*Months x Post-COVID)* for conversational turns and adult word count are both negative in sign, but the estimates are not statistically significant. Results from models omitting the first PY are similar (see Appendix Table A1).

Language Development Outcomes

We observe slightly divergent patterns across our three measures of language development skills prior to and after the pandemic. Prior to the pandemic, monthly growth is flat across the two age-adjusted language development measures – AVA scores and Developmental Snapshots – and positive for child vocalizations per hour ($B = 0.27$, $p < 0.10$). Flat growth patterns in AVA and Developmental Snapshots are consistent with age-typical monthly growth on these measures for our sample during the pre-pandemic period, given these measures are age-adjusted. We do not observe statistically significant jumps in AVA scores or in child vocalizations at the first post-pandemic-onset assessment. On the parent-reported Developmental Snapshot, we observe declines on the first post-pandemic-onset assessment in the main models (model including child covariates: $B = -11.60$, $p < .05$; in supplemental models omitting the first data collection year, the coefficient is negative in sign but not statistically significant [see Appendix Table A1]).

Post-pandemic changes in monthly growth trajectories for language development are mostly negative in sign. These changes are statistically significant for AVA ($B = -.20$, $p < .05$) and child vocalizations ($B = -.34$, $p < .05$) in the main models, and marginally significant for the same variables in supplemental models omitting the first PY (see Appendix Table A1). Relative to pre-pandemic trends, children in the post-pandemic months tend to experience monthly declines of .09 percentage points in their AVA scores (.1103-.1953) and 0.07 vocalizations/hour in child vocalization (.2669-.3407). The results jointly suggest that growth in early language skills may have slowed down after the onset of the pandemic relative to pre-pandemic trends.

In our alternative specification, we address the same research question using child fixed effects on a balanced panel of children observed at least once prior to and after the pandemic; see

Appendix Table A2 for full results (see also Appendix Table A3 for random effects model results, which are similar). Findings are broadly consistent with our mixed model estimates with regards to changes to infant and toddler language environments at immediate post-pandemic assessment: There are significant and positive level shifts in conversational turns and adult word counts at the first measurement after the pandemic. In the balanced panel, we also observe significant positive increases in child vocalizations at the first post-pandemic assessment. However, in the balanced panel, after these initial level shifts, we do not observe significant changes in post-pandemic monthly growth trajectories on any of our measures of language environment or language development relative to pre-pandemic trends. Observed differences from the results found in the mixed model approach are likely due to several factors. First, this alternative strategy restricts to a smaller subsample of children which reduces statistical power and precision. Secondly, this model alters the composition of the group relative to the full sample; specifically, the subsampled children were from cohorts beginning in the 2018-19 or 2019-20 PY, the only cohorts at the appropriate age range to be enrolled in EHS both immediately before and in the immediate aftermath of the pandemic. While estimates are noisy, it is also plausible that this subgroup's consistent affiliation with EHS during the height of the COVID crisis could conceivably have led them to be affected by the pandemic in a way that was systematically different from other children in the full sample. We return to this issue in the discussion.

RQ 2: Heterogeneity by Child Demographics

Figures 2, 3, and 4 show the predicted marginal estimates and 95% CIs from fitting mixed models examining whether immediate shocks of the pandemic and differences between

pre-pandemic and post-pandemic trends varied by child age, gender, and race/ethnicity (see Tables A4, A6, and A8 for corresponding mixed model estimates).

Regarding age, unsurprisingly, older children have more conversational turns per hour ($B = 0.44$, $p < .001$; see Table A4) and more child vocalizations per hour ($B = 2.67$, $p < .001$) compared to younger children prior to the pandemic. The magnitude and sign of the coefficients on the post-COVID by age interaction terms suggest that the level shifts in child outcomes on the first post-COVID assessment may have varied by age, such that shifts tended to be more negative (or less positive) for older children compared to younger children; however, the estimates based on the covariate-adjusted models are marginally significant for one only of the five measures. There is no significant moderation by age in differences in monthly growth in language environments or development skills post-pandemic versus pre-pandemic; all slope estimates interacted with age are close to zero and nonsignificant. Appendix Table A5 shows results omitting the first PY, which are similar.

Table A6 and Figure 3 show moderation results by gender, and Appendix Table A7 shows moderation results omitting the first PY. Girls generally did not perform differently from boys at baseline, and pre-pandemic trajectories were similar by gender. The one exception is with Developmental Snapshots, for which parents tended to rate girls higher for the reference assessment and report faster progress for girls pre-pandemic in the main models; however, in the models omitting the first PY, the score difference on the reference assessment was only marginally significant, and the pre-pandemic progress difference was not significant. On the first assessment after the onset of the pandemic, boys and girls experienced similar shifts in their language skills and environments, with the exception that girls experienced a decline in Developmental Snapshot scores that was 22.60 points larger than that which boys experienced (*p*

< 0.05); in models omitting the first PY, this difference was marginally significant. Differences between pre-pandemic versus post-pandemic monthly growth (slopes) in language outcomes did not differ significantly by gender.

Results of analyses examining potential heterogeneity in language environment and language development outcomes by race/ethnicity are shown in Table A8 and Figure 4. For most outcomes, we observe no significant differences in post-COVID outcomes nor post-COVID-onset slopes compared to pre-pandemic trends by race/ethnicity. The one exception is for the parent-reported Developmental Snapshot measure. On this measure, Black children tended to have more negative baseline (pre-pandemic) parent-reported averages and slower parent-reported pre-pandemic growth relative to their non-Black peers. These differences in score levels and monthly growth rates tended to shrink post-pandemic, mainly due to decreases in the scores and growth rates of non-Black children in Early Head Start. For full output of estimates of heterogeneity by age, gender, and race/ethnicity, see Appendix Tables A4, A6, and A8; for sensitivity checks refitting these models excluding the first PY, see Appendix Tables A5, A7, and A9.

Sensitivity Analysis Excluding Infants

Given developmental differences between infants and toddlers in both language environments and language growth, and the relatively small number of infant observations in our sample, we conduct a sensitivity analysis replicating our main results while restricting the sample to toddlers 13 aged months and older (see Appendix Table A10). While some coefficients and significance levels vary, generally, language environment trends align with the main results, in that while adult word count increases at the immediate post-pandemic assessment, slope changes stay largely flat. Language development patterns are also generally similar to the main findings

in Table 4. As in the primary models, a negative level shift in Developmental Snapshot outcomes is evident at the first assessment after the pandemic onset; this coefficient is negative in sign but not significant in the models omitting the first PY (see Table A11). The coefficient on the post-pandemic monthly growth rate for child vocalizations is significant and negative, mirroring the main finding with the full sample; the corresponding coefficient for AVA percentile is negative in sign but not significant in the models excluding infants. The pattern of findings is similar in models omitting the first PY (Table A11).

Discussion

Years after the COVID-19's onset, concerns persist about how young children's development may have been affected. Our main analysis, examining language environment and language development skills among low-income infants and toddlers enrolled in Early Head Start pre-, mid-, and beyond COVID, shows two primary findings. First, as captured in the first wave of assessments collected after the onset of COVID-19, we observe an 'initial shock' associated with the pandemic in the form of an improvement to study children's classroom language environments. We find that on average, children experienced a more enriched classroom language environment during the height of the pandemic compared to pre-pandemic norms: On average, adult word counts per hour and conversational turns per hour measured within the classroom were higher by 10-11% at the first post-pandemic LENA assessment relative to pre-pandemic. Subsequently, rates of monthly growth in children's language environments after the onset of the pandemic were not significantly different from those observed pre-pandemic, suggesting that after the onset of the pandemic, children continued to experience a different (more positive), but not increasingly enriched, environment than was present pre-pandemic.

While the current study is descriptive in nature and data are not available to make causal determinations, we hypothesize that a relevant factor in the observed improvement in children's classroom language environments after the pandemic onset may have been class size reductions. Based on conversations with the partner organization, similar to many other ECE and Head Start centers around the U.S. (for example, across the state of California, Kim et al., 2022), substantial efforts were made to reduce class sizes in the program after the onset of the pandemic, in order to accommodate social distancing and mitigate virus spread. Group sizes in EHS were likely also intermittently smaller than pre-COVID norms at the height of the pandemic due to higher-then-typical absences among children who were quarantined (e.g., Authors, 2023). These class size reductions could have had some unintended positive effects: Experimental research has found that Head Start class size reductions improve children's literacy skills, perhaps in part because they also increase the number of one-on-one interactions that children have with their teachers (Francis & Barnett, 2019). Smaller class sizes in Head Start are also associated with lower levels of teacher stress, which in turn may bolster teachers' capacity for leading a well-organized classroom and engaging in positive teacher-child interactions (Friedman-Krauss et al., 2014).

This hypothesis aligns with qualitative research; in an interview study that examined Head Start and Early Head Start center directors' experiences with reopening after COVID lockdowns, Silver and Zinser (2022) reported that "A theme that came up consistently throughout the reopening interviews, when discussing both child and staff well-being, were the smaller class sizes that were being required as a result of social distancing. Several directors noted that it has been 'great for kids and staff,' it 'improved the quality of learning,' and that teachers are able to provide more 'one-on-one attention'" (page 370). The study also suggested that the reduced class sizes may have been more optimal that the regular pre-COVID class sizes,

with one EHS director stating that “we're getting a taste almost of the ratios and feeling that it's kind of the way it should be” (Silver & Zinsser, 2022, pp. 370-371).

However, this enhanced classroom language support may not have been enough to fully buffer young children’s language development from post-COVID declines. Recall that by January 2021, infants and toddlers in many areas of the U.S. had experienced pandemic lockdowns, reduced exposure to novel environments, and social interactions with a narrower network of people than would have been common pre-pandemic, all potential risk factors for language delays (e.g., Rocha, 2021). While we do not observe immediate post-COVID declines on child language measures captured with LENA, the findings from our main models controlling for child covariates do suggest a decline in children’s parent-reported language development outcomes at the first assessment after pandemic onset. However, we note that this result was not significant in the uncontrolled model specification or in supplemental models omitting data from the first pre-COVID data collection year. As such, this finding should be considered not as definitive but as suggestive of noteworthy parent-identified concerns.

The second primary finding is that study children experienced two kinds of *‘post-COVID growth lags’* after the pandemic onset. While pre-pandemic, study children enrolled in Early Head Start centers were progressing in their expressive language skills (as captured by AVA scores) at a rate that generally maintained their consistent standing relative to age-adjusted peer norms, after the pandemic onset, growth in AVA scores pandemic was negative, falling by about -.09 percentiles monthly. In a similar vein, regarding child vocalizations, study children were making marginally significant monthly progress on these measures pre-COVID, at about 0.27 additional vocalizations per hour each month. However, children’s monthly growth rate on these outcomes after the onset of COVID was significantly lower than pre-pandemic. This pattern of

findings suggests that some post-pandemic language skills slowdowns did persist after initial onset of COVID-19 (Zuniga-Montanez et al., 2024). These findings are generally robust to inclusion of child covariates. In sum, overall, we observe richer classroom language environments after the onset of COVID-19, suggesting that low-income children enrolled in public childcare during the pandemic may have enjoyed an uptick in classroom language environment quality. Given the importance of early child care environments for language development (Love & Brooks-Gunn, 2010), this could have served as a protective factor against COVID-induced language development risks for EHS children. However, we also observe some potential warning signs of language development drops or slowdowns in the wake of the pandemic, suggesting that young children who were already at heightened risk for language delays due to the myriad challenges associated with low SES may need additional supports to accelerate their language development in the pandemic's aftermath.

Regarding moderators, we examined the extent to which associations between the pandemic and children's language development may have been moderated by gender, race/ethnicity, and child age. The pattern of findings from older toddlers in the sample, who vocalized and engaged more in conversations than their younger counterparts prior to the pandemic, showed some suggestive signs of a more negative decline in language skills compared to younger children. It is plausible that older toddlers, for whom complex conversations and cognitive stimulation from adults and peers are believed to be particularly salient for continual language development (e.g., Weisleder & Fernald, 2013), may have been especially affected by disruptions to these conversational opportunities that accompanied program closures, social distancing, adult/child masking, and reduced exposure to novel environments in the early days of

the pandemic, prior to widespread implementation of vaccinations in summer of 2021. However, coefficients differ somewhat across models; thus caution is urged in interpretation.

On most measures, we observe few differences by gender in the association between the pandemic and children's language environments and outcomes. The one difference is parent-reported Developmental Snapshot scores, for which parents reported larger negative score jumps for girls at the first assessment after the onset of the pandemic. One possibility is that girls may have had 'more to lose' from the pandemic-induced drop-off in social interactions (Martin et al., 2025), as they were gaining expressive language skills more rapidly in the pre-pandemic social environment as compared with boys.

We also find limited evidence of differences by race and ethnicity in terms of pandemic-related changes in language environment and language development skills. Most EHS participants are from low-income backgrounds, and as noted in the literature, many disparities associated with race and ethnicity in early language outcomes are linked to poverty and other socioeconomic factors (e.g., Aratani et al., 2011). As above, the one exception was with the Developmental Snapshot assessment. On this measure, parent-reported expressive language skills saw a larger initial drop-off for non-Black children in Early Head Start, perhaps because their parents perceived them to be gaining expressive language skills at a faster rate pre-COVID and hence tended to perceive more of a shift in momentum when the environment changed. However, we do not observe similar moderation effects to the parent reports on device-based outcomes such as AVA scores or child vocalizations.

Lastly, results from our alternative balanced panel modeling specification show both similarities to the main findings and some potentially interesting variations. For the balanced panel, comprised of a subsample of children who were enrolled in the EHS program consistently

before, amidst, and after the height of the pandemic, the finding of a typically enriched classroom language environment after the onset of the pandemic is similar to our primary models. However, different from the primary models, children in the balanced panel subsample experienced positive level shifts in child vocalizations and parent-reported Developmental Snapshots at the first assessment after the onset of the pandemic, and their language skill growth trajectories were not significantly different post-COVID onset compared to pre-COVID.

One possibility is that variations across models could be due to unobserved differences in the populations of families who enrolled children in child care consistently throughout the pandemic and those who did not, and/or due to other cohort-specific variations. Another possibility, while suggestive only, is that the pattern of findings is consistent with a possible 'buffer' effect of consistent EHS program affiliation through the height of the pandemic on language development. Beginning immediately after the onset of COVID-19 in March 2020, and continuing throughout the pandemic, the study EHS centers were quite proactive in offering families of enrolled children a range of supports, including frequent Zoom meetings and phone calls with teachers and program staff; distributions of material resources such as food, books, and diapers; and web-based educational resources for parents (e.g., National Head Start Association, n.d.). Other research has documented that Head Start and EHS centers typically increased their services during the pandemic in helping families locate financial assistance, employment and transportation, and medical and mental health support, in addition to increasing direct resource provision such as meal and supply deliveries (e.g., Padilla & Franchett, 2025; Silver & Coba-Rodriguez, 2022). In an analysis of national data from the 2019 Head Start Family and Child Experiences Survey (FACES) collected in spring of 2020, a few months after the pandemic began, Padilla and Franchett (2025) found that "Head Start went above and beyond their normal

services to meet the needs of families during the pandemic," and that Head Start parents/caregivers who were under the most financial pressure showed reduced symptoms of depression post-pandemic onset. While not causal, the authors suggested that being connected to the Head Start program's resources and community during the pandemic could have been a factor in bolstering families' well-being. As such, it seems plausible that for children who were provided a steady stream of EHS-based supports consistently throughout the pandemic, the effects of these supports could have accumulated to buttress their language development from pandemic-induced slowdowns. However, as noted above, the current data do permit us to analyze reasons for observed trends causally.

Implications for Interventions and Support

We found that infants and toddlers enrolled in subsidized childcare settings in the current study tended to experience post-COVID setbacks in important facets of their language skills. This observation leads to questions about policies and practices that may help to accelerate young children's language development progress moving forward from the pandemic. For early childhood centers and preschools, offering teachers additional professional development in effective practices for supporting early language acquisition and skills may help bolster children's language and literacy outcomes (e.g., Joseph et al., 2022). In a meta-analysis of the effects of teacher professional development programs for early childhood teachers, Egert et al. (2018) found that to improve overall instructional quality, professional development should be of an adequate duration (i.e., at least 45 hours), and should supply ECE teachers with ongoing opportunities for coaching. Prior research also suggests that parents can be taught to implement a variety of language interventions at home that support facets of children's language outcomes (e.g., Roberts & Kaiser, 2011; Zauche et al., 2016), including shared book reading interventions

(e.g., Buschmann et al., 2009; Huebner & Meltzoff, 2005). As such, programming and supports for parents and caregivers to help them reinforce language development at home may also be of value.

While not causal, it is also perhaps interesting to observe that the subsample of children in the current study that were consistently affiliated with EHS before, at, and after the onset of the pandemic tended to have somewhat more positive trajectories compared to their counterparts without such consistent affiliations. It could be of value to study the supports that high-quality EHS centers were offering to infants, toddlers, and their families throughout the COVID pandemic, to consider whether some of these policies might be worth replicating in the longer term (e.g., Silver & Coba-Rodriguez, 2022). The possibility that smaller ECE class sizes at the height of the pandemic could have contributed to enhanced language environments may also warrant follow-up.

Strengths, Limitations, and Directions for Future Research

Limitations of the current study point towards potentially generative future research directions. First, this study is observational in nature; as in most research on the COVID pandemic generally, the design does not support causal inference. Although we adjust for a rich array of child covariates and use alternative specification strategies, confounding is still possible. Thus, we view the current findings as suggestive of patterns in children's opportunities and outcomes over the pandemic era that warrant follow-up.

Additionally, the nature of the sample and assessment schedule for the current study made data missingness a reality. The EHS programs administered the assessments as part of their regular program evaluation work; a smaller subsample of children were assessed in the first year, and the assessment schedule increased from twice per program year through 2020-21 to three

times per program year thereafter. As well, Early Head Start serves children from ages 6 weeks to 36 months of age by regulation, after which enrollees start to age out of EHS services. Caregivers can enroll and unenroll children in Early Head Start at any time, and may enroll children for only a subset of the period when they are age-eligible for a variety of reasons.

Our analysis applied fixed slopes across children to improve precision due to the limited number of repeated assessments collected per child. In future studies, the collection of more repeated measures across a fully balanced panel could permit a broader range of modeling approaches (e.g., applying random slopes to probe child-level heterogeneous trajectories). Future research linking ECE language measures with growth into later years, such as kindergarten and early elementary school, could expand our understanding of whether effects of the pandemic may fade out or persist into the schooling years, and additionally whether facets of children's subsequent schooling environments may be associated with greater likelihood of language growth rebounds. Data were also not available on the experiences of families that kept their children home from childcare during the pandemic, but more research on this group would be of significant interest to the field.

Lastly, LENA measures are in widespread use by the research community due to their well-documented validity evidence, the clear advantage of being far more scalable relative to human-transcribed recordings for measuring early language acquisition, and the utility of the information they provide for research and practice (e.g., Ganek & Eriks-Brophy, 2018; Gilkerson & Richards, 2009; Richards et al., 2017; Xu et al., 2009); however, they do not measure everything. As well, as is generally the case with surveys, parent-reported Developmental Snapshot responses have the strength of contributing parental insights yet may also reflect social desirability bias. We do not have reasons to expect this to differ systematically in the pre- versus

post-pandemic periods or thus to bias estimates; however, more future studies examining additional language environment and language development constructs over the pandemic era would certainly be of interest to the field.

In particular, more qualitative and mixed methods studies examining language environment and language development skill growth could add valuable complementary evidence to enrich our understanding of mechanisms and promising future supports. For example, a study using audio transcripts could explore whether features of educational settings, such as specific kinds of child care activities, could be facilitative of more enriched environments and outcomes after the pandemic. Ethnographies, interviews of caregivers, or other fieldwork could shed further light on mechanisms that may have contributed to changes in language environments and language development, lending additional insights into policies and practices that can further support low-income children's long-run opportunities and outcomes in the wake of the pandemic.

References

Administration for Children and Families, Office of Planning, Research, and Evaluation. (2002). *Making a difference in the lives of infants and toddlers and their families: The impacts of Early Head Start. Volume I: Final technical report.* U.S. Department of Health and Human Services, Office of Planning, Research, and Evaluation, and Head Start Bureau. https://acf.gov/sites/default/files/documents/opre/impacts_vol1.pdf

Aragon, M., & Yoshinaga-Itano, C. (2012). Using Language ENvironment Analysis to improve outcomes for children who are deaf or hard of hearing. *Seminars in Speech and Language, 33,* 340–353. doi:10.1055/s-0032-1326918

Aratani, Y., Wright, V., & Cooper, J. (2011). *Racial gaps in early childhood: Socio-emotional Health, Developmental, and Educational Outcomes Among African-American Boys.* National Center for Children in Poverty, Columbia University.

Baez, J., De la Fuente, A., & Santos, I. (2010). *Do natural disasters affect human capital? An assessment based on existing empirical evidence* (No. 5164). IZA Discussion Papers. https://www.econstor.eu/bitstream/10419/46154/1/657569674.pdf

Berry, D., Blair, C., Willoughby, M., Garrett-Peters, P., Vernon-Feagans, L., Mills-Koonce, W. R., & Family Life Project Key Investigators (2016). Household chaos and children's cognitive and socio-emotional development in early childhood: Does childcare play a buffering role? *Early Childhood Research Quarterly*, *34*, 115–127.

Bleses, D., Makransky, G., Dale, P. S., Højen, A., & Ari, B. A. (2016). Early productive vocabulary predicts academic achievement 10 years later. *Applied Psycholinguistics*, *37*(6), 1461-1476.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and*

design. Cambridge, MA: Harvard University Press.

Buschmann, A., Jooss, B., Rupp, A., Feldhusen, F., Pietz, J., & Philippi, H. (2009). Parent based language intervention for 2-year-old children with specific expressive language delay: a randomised controlled trial. *Archives of Disease in Childhood*, *94*(2), 110-116.

Bustamante, A. S., & Hindman, A. H. (2020). Construyendo en la Fuerza: Approaches to learning and school readiness gains in Latino children served by head start. *Early Childhood Research Quarterly*, *52*, 124-137.

Cabell, S. Q., Justice, L. M., McGinty, A. S., DeCoster, J., & Forston, L. D. (2015). Teacher–child conversations in preschool classrooms: Contributions to children's vocabulary development. *Early Childhood Research Quarterly*, *30*, 80-92.

Ceci, S. J., & Papierno, P. B. (2005). The rhetoric and reality of gap closing: When the "have-nots" Gain but the "haves" gain even more. *American Psychologist, 60*(2), 149-160.

Chow, J. C., Ekholm, E., & Coleman, H. (2018). Does oral language underpin the development of later behavior problems? A longitudinal meta-analysis. *School Psychology Quarterly, 33*(3), 337–349. https://doi.org/10.1037/spq0000255

Cristia, A., Lavechin, M., Scaff, C., Soderstrom, M., Rowland, C., Räsänen, O., Bunce, J., & Bergelson, E. (2021). A thorough evaluation of the Language Environment Analysis (LENA) system. *Behavior Research Methods, 53*(2), 467–486.

Deoni, S. C., Beauchemin, J., Volpe, A., Dâ Sa, V., & RESONANCE Consortium (2022). The COVID-19 pandemic and early child cognitive development: A comparison of development in children born during the pandemic and historical references. *medRxiv*.

Dickinson, D. K., & Porche, M. V. (2011). Relation between language experiences in preschool classrooms and children's kindergarten and fourth-grade language and reading

abilities. *Child Development, 82*(3), 870–886. https://doi.org/10.1111/j.1467-8624.2011.01576.x

Duncan, R. J., Anderson, K. L., King, Y. A., Finders, J. K., Schmitt, S. A., & Purpura, D. J. (2023). Predictors of preschool language environments and their relations to children's vocabulary. *Infant and Child Development*, 32(1),2381. https://doi.org/10.1002/icd.2381

Egert, F., Fukkink, R. G., & Eckhardt, A. G. (2018). Impact of in-service professional development programs for early childhood teachers on quality ratings and child outcomes: A meta-analysis. *Review of Educational Research*, *88*(3), 401-433.

Fernald, A., Marchman, V.A., & Weisleder, A. (2013). SES differences in language processing skill and vocabulary are evident at 18 months. *Developmental Science, 16*: 234-248. https://doi.org/10.1111/desc.12019

Finders, J., Wilson, E., & Duncan, R. (2023). Early childhood education language environments: considerations for research and practice. *Frontiers in Psychology*, *14*, 1202819.

Francis, J., & Barnett, W. S. (2019). Relating preschool class size to classroom quality and student achievement. *Early Childhood Research Quarterly*, *49*, 49-58.

Friedman-Krauss, A. H., Raver, C. C., Neuspiel, J. M., & Kinsel, J. (2014). Child behavior problems, teacher executive functions, and teacher stress in Head Start classrooms. *Early Education and Development*, *25*(5), 681-702.

Ganek, H., & Eriks-Brophy, A. (2018). Language ENvironment Analysis (LENA) system investigation of day long recordings in children: A literature review. *Journal of Communication Disorders, 72*, 77–85. https://doi.org/10.1016/j.jcomdis.2017.12.005

Giesbrecht, G. F., Lebel, C., Dennis, C. L., Silang, K., Xie, E. B., Tough, S., McDonald, S., & Tomfohr-Madsen, L. (2023). Risk for developmental delay among infants born during the

COVID-19 pandemic. *Journal of Developmental and Behavioral Pediatrics*, *44*(6), e412–e420. https://doi.org/10.1097/DBP.0000000000001197

Gilkerson, J., & Richards, J. A. (2008). The LENA natural language study. LENA Foundation. https://www.lena.org/wp-content/uploads/2016/07/LTR-02-2_Natural_Language_Study.pdf

Gilkerson, J., & Richards, J. A. (2009). *The power of talk: Impact of adult talk, conversational turns, and TV during the critical 0–4 years of child development* (2nd ed.; LENA Foundation Technical Report ITR-01-2). LENA Foundation. https://www.lena.org/wp-content/uploads/2016/07/LTR-01-2_PowerOfTalk.pdf

Gilkerson, J., Richards, J. A., Greenwood, C. R., & Montgomery, J. K. (2017). Language assessment in a snap: Monitoring progress up to 36 months. *Child Language Teaching and Therapy, 33*(2), 99–115. https://doi.org/10.1177/0265659016660599

Gilkerson, J., Richards, J. A., Warren, S. F., Oller, D. K., Russo, R., & Vohr, B. (2018). Language experience in the second year of life and language outcomes in late childhood. *Pediatrics, 142*(4), e20174276. https://doi.org/10.1542/peds.2017-4276

Greenwood, C. R., Schnitz, A. G., Irvin, D., Tsai, S. F., & Carta, J. J. (2018). Automated Language Environment Analysis: A research synthesis. *American Journal of Speech-Language Pathology*, *27*(2), 853–867. https://doi.org/10.1044/2017_AJSLP-17-0033

Hadley, E. B., Liu, S., Kim, E., McKenna, M., & Hull, K. (2025). Tracing the impact of COVID-19 on early language and literacy development from pre-K through first grade. *AERA Open*, *11*, 23328584251338816.

Harden, B. J., Sandstrom, H., & Chazan-Cohen, R. (2012). Early Head Start and African American families: Impacts and mechanisms of child outcomes. *Early Childhood*

Research Quarterly, 27(4), 572–581. https://doi.org/10.1016/j.ecresq.2012.07.006

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., ... & Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science*, *26*(7), 1071-1083.

Huang, P., Zhou, F., Guo, Y., Yuan, S., Lin, S., Lu, J., Tu, S., Lu, M., Shen, S., Guedeney, A., Xia, H., & Qiu, X. (2021). Association between the COVID-19 pandemic and infant neurodevelopment: A comparison before and during COVID-19. *Frontiers in Pediatrics*, *9*, 662165. https://doi.org/10.3389/fped.2021.662165

Huebner, C. E., & Meltzoff, A. N. (2005). Intervention to change parent–child reading style: A comparison of instructional methods. *Journal of Applied Developmental Psychology, 26*(3), 296–313. http://dx.doi.org/10.1016/j.appdev.2005.02.006

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology, 27*(2), 236–248. https://doi.org/10.1037/0012-1649.27.2.236

Huttenlocher, J., Waterfall, H., Vasilyeva, M., Vevea, J., & Hedges, L. V. (2010). Sources of variability in children's language growth. *Cognitive Psychology*, *61*(4), 343–365.

Jarrett, R. L., & Coba-Rodriguez, S. (2017). "We keep the education goin' at home all the time": Family literacy in low-income African American families of preschoolers. *Journal of Education for Students Placed at Risk, 22*(2), 57-76.

Jeffrey, J., Szeftel, Z., & Herman, A. (2020). Supporting Head Start employee well-being during the COVID-19 pandemic. *JAACAP Connect*, 17-21.

Joner, M. D. (2025). Cause for concern? The relationship between language skills in toddlers and later reading skills in school. *Early Childhood Education Journal*, *53*(3), 679-688.

Jones, G., & Rowland, C. F. (2017). Diversity not quantity in caregiver speech: Using computational modeling to isolate the effects of the quantity and the diversity of the input on vocabulary growth. *Cognitive Psychology*, *98*, 1-21.

Joseph, G. E., Soderberg, J., Abbott, R., Garzon, R., & Scott, C. (2022). Improving language support for infants and toddlers: Results of FIND coaching in childcare. *Infants & Young Children*, *35*(2), 91-105.

Jung, K., & Barnett, W. S. (2021). *Impacts of the pandemic on young children and their parents: Initial findings from NIEER's May–June 2021 Preschool Learning Activities Survey*. National Institute for Early Education Research. https://nieer.org/research-library/impacts-pandemic-young-children-their-parents

Kim, Y., Montoya, E., Doocy, S., Austin, L. J., & Whitebook, M. (2022). Impacts of COVID-19 on the early care and education sector in California: Variations across program types. *Early Childhood Research Quarterly*, *60*, 348-362.

Laird, M., & Ware, J. H. (1982). Random-effects models for longitudinal data. *Biometrics*, *38*(4), 963–974.

Lawton, W., Araujo, O., & Kufaishi, Y. (2023). Language environment and infants' brain structure. *Journal of Neuroscience*, *43*(28), 5129-5131.

LENA. (n.d.). *Every interaction counts*. https://www.lena.org/every-interaction-counts/

LENA. (2022, March 7). *Covid-era infants vocalize less and experience fewer conversational turns, says LENA Research Team*. LENA. https://www.lena.org/resources/blog-posts/covid-infant-vocalizations-conversational-turns/

Lonigan, C. J., & Shanahan, T. (2009). *Developing early literacy: Report of the National Early Literacy Panel. Executive summary*. National Institute for Literacy.

https://files.eric.ed.gov/fulltext/ED508381.pdf

Love, J. M., & Brooks-Gunn, J. (2010). Getting the most out of Early Head Start: What has been accomplished and what needs to be done. *Investing in young children: New directions in federal preschool and early childhood policy*, 29-37.

Love, J. M., Kisker, E. E., Ross, C., Raikes, H., Constantine, J., Boller, K., Brooks-Gunn, J., Chazan-Cohen, R., Tarullo, L. B., Brady-Smith, C., Fuligni, A. S., Schochet, P. Z., Paulsell, D., & Vogel, C. (2005). The effectiveness of Early Head Start for 3-year-old children and their parents: Lessons for policy and programs. *Developmental Psychology*, *41*(6), 885–901. https://doi.org/10.1037/0012-1649.41.6.88

Lynch, K., Lee, M., & Loeb, S. (2023). An investigation of Head Start preschool children's executive function, early literacy, and numeracy learning in the midst of the COVID-19 pandemic. *Early childhood research quarterly*, *64*, 255–265. https://doi.org/10.1016/j.ecresq.2023.04.002

Martin, A., Pollak, S. D., Phillips, D. A., Livas-Stein, G., Wright, A. M., & Johnson, A. D. (2025, May). Are the kids mostly alright? The surprisingly minimal effects of COVID school closures on children's social-emotional outcomes. Paper presented at the Society for Research on Child Development (SRCD) Biennial 2025 Meeting.

McCormick, M., Goldberg, M., Swinth, E., Smith Todd, C., Carlis, L., & Chavez, V. (2023, May). *Young children's resilience in the wake of the COVID-19 pandemic: Evidence from Acelero Learning Head Start programs*. MDRC. https://www.mdrc.org/sites/default/files/Acelero_Covid_Brief_2023.pdf

Morgan, P. L., Farkas, G., Hillemeier, M. M., Hammer, C. S., & Maczuga, S. (2015). 24-month-old children with larger oral vocabularies display greater academic and behavioral

functioning at kindergarten entry. *Child Development, 86*(5), 1351–1370. https://doi.org/10.1111/cdev.12398

Morisset, C. E., Barnard, K. E. & Booth, C. L. (1995). Toddlers' language development: Sex differences within social risk. *Developmental Psychology, 31*, 851–865.

Narea, M., Soto-Ramírez, P. & Abufhele, A. (2025). Childcare center attendance during the Covid-19 pandemic: Boosting cognitive and language development. *Child Development*., 96: 1395-1408. https://doi.org/10.1111/cdev.14238

National Academies of Sciences, Engineering, and Medicine. (2023). *Addressing the Long-Term Effects of the COVID-19 Pandemic on Children and Families.* Washington, DC: The National Academies Press. https://doi.org/10.17226/26809.

National Head Start Association. (n.d.). Drive-through distributions, community partnerships help mitigate food insecurity. https://nhsa.org/community-partnerships-mitigate-food-insecurity/

National Research Council. (2000). *From neurons to neighborhoods: The science of early childhood development.* National Academies Press.

Office of Head Start. (2025). *Head Start program facts: Fiscal year 2023*. https://www.headstart.gov/program-data/article/head-start-program-facts-fiscal-year-2023

Padilla, C. M., & Franchett, A. (2025). Head Start centers supported families' well-being during the pandemic. https://cms.childtrends.org/wp-content/uploads/1980/03/FamilyWellbeing_ChildTrends_March2025.pdf

Richards, J. A., Xu, D., Gilkerson, J., Yapanel, U., Gray, S., & Paul, T. (2017). Automated assessment of child vocalization development using LENA. *Journal of Speech,*

Language, and Hearing Research, *60*(7), 2047-2063. https://doi.org/10.1044/2017_JSLHR-L-16-0157

Roberts, M. Y., & Kaiser, A. P. (2011). The effectiveness of parent-implemented language interventions: A meta-analysis. *American Journal of Speech-Language Pathology, (20),* 180–199.

Rocha, P. M. B. (2021). The Covid-19 pandemic and its possible consequences to language/speech development and delay in children: An urgent issue. *Audiology-Communication Research*, *26*, e2566.

Romeo, R. R., Leonard, J. A., Robinson, S. T., West, M. R., Mackey, A. P., Rowe, M. L., & Gabrieli, J. D. E. (2018). Beyond the 30-million-word gap: Children's conversational exposure is associated with language-related brain function. *Psychological Science*, *29*(5), 700–710. https://doi.org/10.1177/0956797617742725

Romeo, R. R., Leonard, J. A., Grotzinger, H. M., Robinson, S. T., Takada, M. E., Mackey, A. P., Scherer, E., Rowe, M. L., West, M. R., & Gabrieli, J. D. E. (2021). Neuroplasticity associated with changes in conversational turn-taking following a family-based intervention. *Developmental Cognitive Neuroscience, 49*, 100967.

Rowe, M. L. (2008). Child-directed speech: Relation to socioeconomic status, knowledge of child development and child vocabulary skill. *Journal of Child Language*, *35*(1), 185-205.

Rowe, M. L. (2012). A longitudinal investigation of the role of quantity and quality of child-directed speech in vocabulary development. *Child Development, 83*(5), 1762–1774.

Schwab, J. F., & Lew-Williams, C. (2016). Language learning, socioeconomic status, and child-directed speech. *Wiley interdisciplinary reviews: Cognitive science*, *7*(4), 264–275.

Shaw, S., Franchett, A., LaForett, D., Maxwell, K., & Bultinck, E. (2023). *Head Start's response to the COVID-19 pandemic* OPRE Report #2023-025. Washington, DC: Office of Planning, Research, and Evaluation, Administration for Children and Families, U.S. Department of Health and Human Services.

Silver, H. C., & Coba-Rodriguez, S. (2022). "There's no off-switch for us:" Head Start family engagement amidst COVID-19. *Children and Youth Services Review*, *137*, 106475.

Silver, H. C., & Coba-Rodriguez, S. (2025). "Hey, what do you need?": How Head Start directors responded to COVID-19 challenges. *Early Childhood Education Journal*, *53*(5), 1645-1656.

Silver, H. C., & Zinsser, K. M. (2022). Lessons for the future: Supporting the social-emotional needs of children, families, and educators in Head Start during the COVID-19 pandemic. *Translational Issues in Psychological Science*, *8*(3), 362.

Snow, C. E., & Matthews, T. J. (2016). Reading and language in the early grades. *The Future of Children*, 57-74.

Spencer, M. B., Dupree, D., & Hartmann, T. (1997). A phenomenological variant of ecological systems theory (PVEST): A self-organization perspective in context. *Development and Psychopathology*, *9*(4), 817-833.

Thomas, L. J. G., Lee, M. G., Todd, C. S., Lynch, K., Loeb, S., McConnell, S., & Carlis, L. (2022). Navigating Virtual Delivery of Assessments for Head Start Children During the COVID-19 Pandemic. *Journal of Early Intervention*, *44*(2), 151-167. https://doi.org/10.1177/10538151221085942

Turnbull, K. P., Anthony, A. B., Justice, L., & Bowles, R. (2009). Preschoolers' exposure to language stimulation in classrooms serving at-risk children: The contribution of group

size and activity context. *Early Education and Development*, *20*(1), 53-79.

Vallotton, C. D., Harewood, T., Ayoub, C. A., Pan, B., Mastergeorge, A. M., & Brophy-Herb, H. (2012). Buffering boys and boosting girls: The protective and promotive effects of Early Head Start for children's expressive language in the context of parenting stress. *Early Childhood Research Quarterly, 27*(4), 695-707.

Vallotton, C. D., Mastergeorge, A., Foster, T., Decker, K. B., & Ayoub, C. (2017). Parenting supports for early vocabulary development: Specific effects of sensitivity and stimulation through infancy. *Infancy*, *22*(1), 78-107.

Wang, Y., Williams, R., Dilley, L., & Houston, D. M. (2020). A meta-analysis of the predictability of LENA™ automated measures for child language development. *Developmental Review*, *57*, 100921.

Weiland, C., Greenberg, E., Bassok, D., Markowitz, A., Guerrero Rosada, P., Luetmer, G., Abenavoli, R., Gomez, C., Johnson, A., Jones-Harden, B., Maier, M., McCormick, M., Morris, P., Nores, M., Phillips, D., & Snow, C. (2021). *Historic crisis, historic opportunity.* University of Michigan Education Policy Initiative Brief.

Weisleder, A., & Fernald, A. (2013). Talking to children matters: Early language experience strengthens processing and builds vocabulary. *Psychological Science, 24*(11), 2143–2152. https://doi.org/10.1177/0956797613488145

Woynaroski, T., Oller, D.K., Keceli-Kaysili, B., Xu, D., Richards, J.A., Gilkerson, J., Gray, S., & Yoder, P. (2017), The stability and validity of automated vocal analysis in preverbal preschoolers with autism spectrum disorder. *Autism Research*, *10*: 508-519. https://doi.org/10.1002/aur.1667

Xu, D., Yapanel, U., & Gray, S. (2009). Reliability of the LENA™ language environment

analysis system in young children's natural home environment. LENA Technical Report.

Zauche, L. H., Thul, T. A., Mahoney, A. E. D., & Stapel-Wax, J. L. (2016). Influence of language nutrition on children's language and cognitive development: An integrated review. *Early Childhood Research Quarterly*, *36*, 318-333.

Zuniga-Montanez, C., Davies, C., Ligoxygakis, L., Kašćelan, D., & Gonzalez-Gomez, N. (2025). How did COVID-19 affect young children's language environment and language development? A scoping review. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *66*(4), 569-587. https://doi.org/10.1111/jcpp.14102

Table 1

Number of Children Assessed by Program Year and Test Period (Fall, Winter, Spring)

	Assessment Period			
	Fall	Winter	Spring	Total
2017-18	.	73	83	156
2018-19	242	204	.	446
2019-20	538	591	.	1,129
2020-21	.	260	299	559
2021-22	399	450	458	1,307
2022-23	493	488	527	1,508
2023-24	560	578	636	1,774
2024-25	543	427	.	970
Total	2,775	3,071	2,003	7,849

Notes. Each value represents the number of LENA assessments conducted during that program year and assessment period. Children were assessed twice each program year prior to the pandemic and three times each PY after the pandemic (Fall: October-November; Winter: January-March; Spring: May-June). Spring 2024-25 data not yet available.

Table 2

Descriptive Characteristics by Sample

	Full Sample		Pre-Pandemic		Post-Pandemic	
	Mean	SD	Mean	SD	Mean	SD
Female	0.47		0.46		0.47	
Non-Hispanic Black/African American	0.46		0.52		0.43	
Hispanic Black/African American	0.06		0.06		0.07	
Non-Hispanic White	0.06		0.05		0.06	
Hispanic White	0.20		0.19		0.21	
Non-Hispanic Multi/Bi-racial	0.04		0.04		0.03	
Hispanic Multi/Bi-racial	0.03		0.02		0.03	
Non-Hispanic, Other Race or Unspecified	0.03		0.02		0.03	
Hispanic, Other Race or Unspecified	0.13		0.10		0.14	
Primary Language English	0.75		0.81		0.72	
Dual Language Learner	0.26		0.19		0.29	
Child Age (Months)	25.98	(7.33)	26.49	(6.90)	25.67	(7.29)
One or More Parent Earned BA+	0.10		0.09		0.11	
Single-Parent Family	0.70		0.73		0.68	
Ever Received SSI Benefits	0.14		0.18		0.12	
Ever Received TANF Benefits	0.11		0.15		0.10	
Ever Received WIC Benefits	0.80		0.81		0.80	
Ever Received SNAP Benefits	0.79		0.76		0.80	
Number of Children	2763		943		2013	
Number of Child-Year-Assessment Observations	7849		1731		6118	

Notes. Full sample shows descriptive characteristics observed for each child in the sample. Pre-Pandemic observations consist of demographic characteristics observed at the child level in Fall 2017 and Winter 2020 for all children observed in the dataset during those years. Post-Pandemic observations consist of demographic characteristics observed at the child level between Winter 2021 and Winter 2025 for all children observed in the dataset during those years. Some children are observed in both the pre- and post-pandemic years. Hispanic is counted as an ethnicity, not race. Single-parent family is a dichotomous indicator indexing whether the parent reported that the family is a single-parent family. SSI, TANF, WIC, and SNAP refer to public assistance programs in the United States, as follows: SSI refers to Supplemental Security Income; TANF refers to Temporary Assistance for Needy Families; WIC refers to the Special Supplemental Nutrition Program for Women, Infants, and Children [WIC]; and SNAP refers to the Supplemental Nutrition Assistance Program [SNAP].

Table 3

Pairwise Correlations between LENA Outcomes of Interest and Child Age in Months

	(1)	(2)	(3)	(4)	(5)	(6)
A. Infants (2-12 months)						
(1) Conversational Turns	1.000					
(2) Adult Word Count (AWC)	0.590***	1.000				
	(0.000)					
(3) Child Vocalizations	0.790***	0.195***	1.000			
	(0.000)	(0.000)				
(4) AVA Percentiles	0.183***	0.058	0.114**	1.000		
	(0.000)	(0.130)	(0.003)			
(5) Developmental Snapshots	0.072	-0.007	0.030	-0.010	1.000	
	(0.081)	(0.858)	(0.476)	(0.822)		
(6) Child Age in Months	-0.185***	-0.213***	-0.139***	0.160***	-0.070+	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.092)	
B. Toddlers (13-42 months)						
	(1)	(2)	(3)	(4)	(5)	(6)
(1) Conversational Turns	1.000					
(2) Adult Word Count (AWC)	0.494***	1.000				
	(0.000)					
(3) Child Vocalizations	0.794***	0.108***	1.000			
	(0.000)	(0.000)				
(4) AVA Percentiles	0.201***	0.088***	0.162***	1.000		
	(0.000)	(0.000)	(0.000)			
(5) Developmental Snapshots	0.092***	0.017*	0.084***	0.336***	1.000	
	(0.000)	(0.024)	(0.000)	(0.000)		
(6) Child Age in Months	0.223***	-0.020+	0.311***	-0.197***	-0.113***	1.000
	(0.000)	(0.092)	(0.000)	(0.000)	(0.000)	

Notes. Pearson correlations. Correlations generated separately for infants and toddlers. *p*-values in parentheses. + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 4

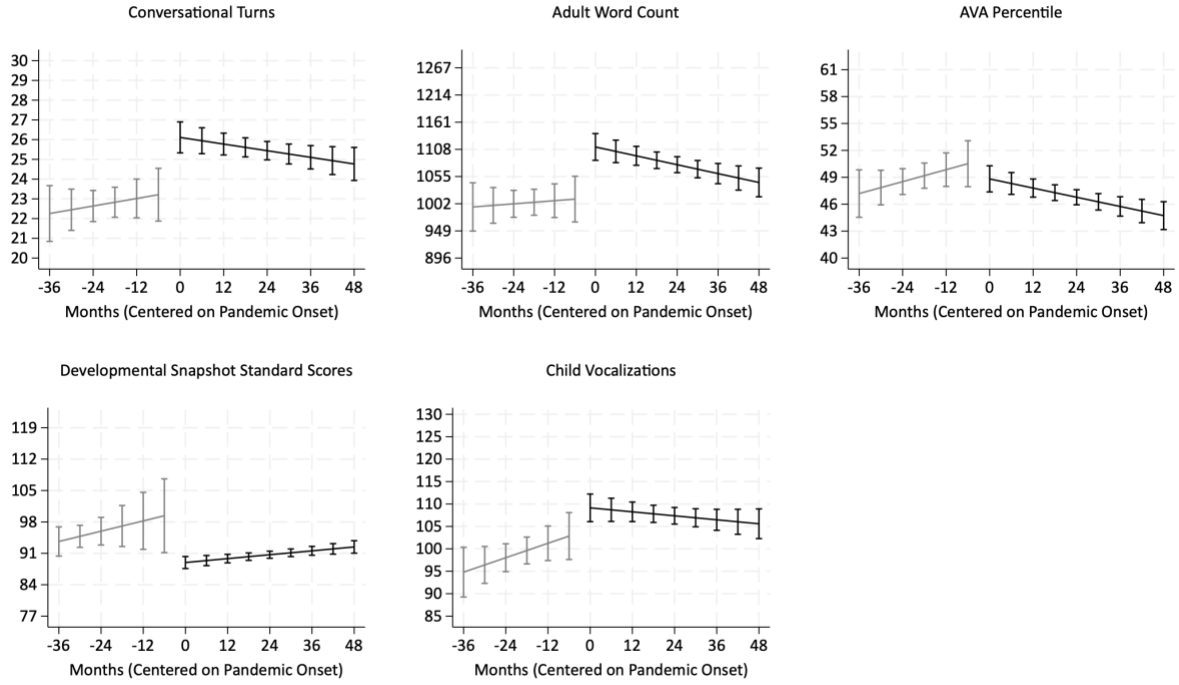
Mixed Model Estimates of Monthly Language Environment & Language Development Growth, Pre- and Post-COVID

	Conversational Turns per Hour		Adult Word Count per Hour		AVA Percentile (Age-Adjusted)		Developmental Snapshot SS		Child Vocalizations per Hour	
Months	0.0537	0.0313	-0.2498	0.5094	0.0303	0.1103	0.0967	0.1916	0.4644**	0.2669+
	(0.0393)	(0.0395)	(1.2904)	(1.3155)	(0.0758)	(0.0757)	(0.1705)	(0.1698)	(0.1587)	(0.1542)
Post-COVID	2.3968*	2.7179**	98.3135**	98.6561**	-1.5929	-2.3510	-8.3318	-11.5980*	2.5877	4.6980
	(0.9377)	(0.9429)	(30.7631)	(31.4321)	(1.8245)	(1.8262)	(5.2312)	(5.2199)	(3.7834)	(3.6811)
Months x Post-COVID	-0.0449	-0.0593	-1.8201	-1.9561	-0.1660*	-0.1953*	-0.0951	-0.1192	-0.2923+	-0.3407*
	(0.0424)	(0.0419)	(1.3915)	(1.3980)	(0.0815)	(0.0800)	(0.1720)	(0.1710)	(0.1711)	(0.1640)
Intercept	23.3245***	23.4350***	1018.8891***	1010.0740***	50.6636***	47.9650***	98.6220***	98.8084***	104.1402***	107.4713***
	(0.8937)	(1.4747)	(29.3461)	(49.2181)	(1.7298)	(2.7375)	(5.1962)	(5.5874)	(3.6093)	(5.8089)
Number of Observations	7849	7849	7849	7849	6659	6659	5821	5821	7849	7849
Child Covariates		X		X		X		X		X

Notes. Each column shows estimates from a separate mixed model. Data consists of participant-by-assessment period observations where assessments took place in the fall, winter, and/or spring from 2017-18 program year (PY) to 2024-25 PY. Assessments took place 2 or 3 times each PY. Months is centered on the month when first assessment took place after the pandemic (January 2021). Post-COVID is a dummy variable that equals one if assessment occurred after the onset of the pandemic. Child covariates (included in the models demarcated with X) include time-invariant covariates (gender, race and ethnicity) as well as time-varying covariates that vary by PY (child age in months centered on average age of participants observed in data, indicator for whether primary language is English, indicator for whether child is a dual language learner, indicator for whether one or more parent attended college, indicator for whether one or more parent were employed full time, indicator for whether child lives in a single-parent household, and indicators for ever receiving the following benefits that program year: SSI, TANF, WIC, or SNAP). Standard errors in parentheses. + $p<0.10$ * $p<0.05$ ** $p<0.01$ *** $p<0.001$.

Figure 1

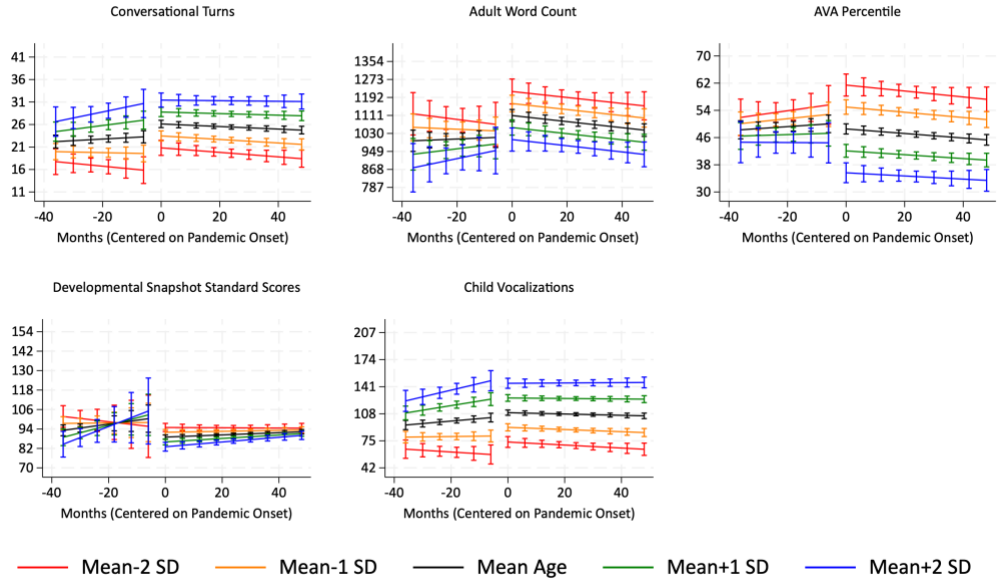
Predictive Margins of Mixed Model Estimates Predicting Language Outcomes, Pre- and Post-Pandemic



Notes. Each line shows predictive marginal estimates derived from mixed model analyses predicting language environment (Adult Word Count, Conversational Turns) and language development (AVA Percentiles, Developmental Snapshot, Child Vocalizations) measures pre- and post-pandemic. The lines represent model-predicted pre- and post-pandemic growth trajectories.

Figure 2

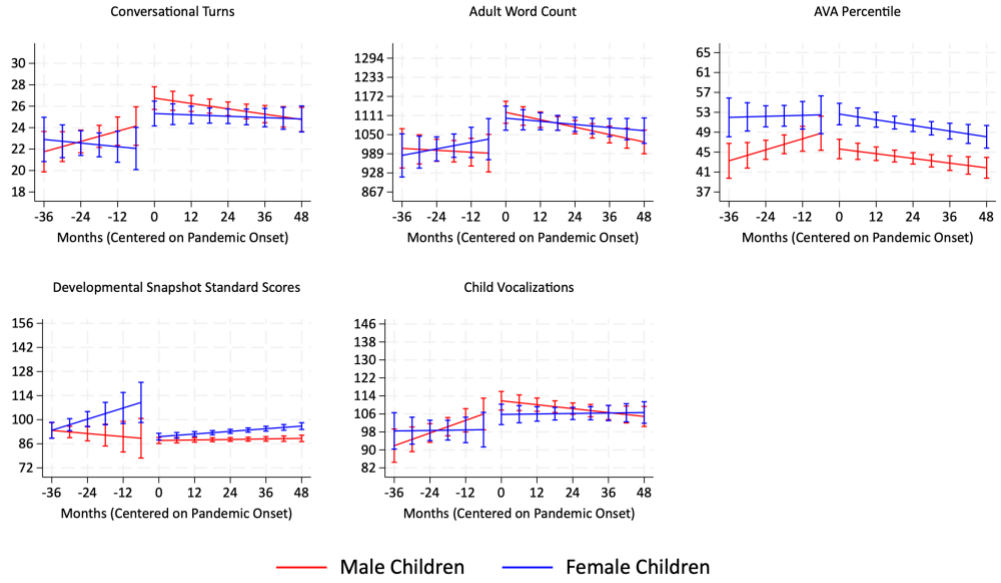
Predictive Margins of Mixed Model Estimates Predicting Language Outcomes by Child Age, Pre- and Post-Pandemic



Notes. Each line shows predictive marginal estimates derived from mixed model analyses predicting language environment (Adult Word Count, Conversational Turns) and language development (AVA Percentiles, Developmental Snapshot, Child Vocalizations) measures pre- and post-pandemic by child age at pandemic onset. Mean age of child in the sample is 24.1 months, with the standard deviation being 8.84 months. The lines represent model-predicted pre- and post-pandemic growth trajectories of reference group children at 7 months, 16 months, 24 months, 33 months, and 42 months of age.

Figure 3

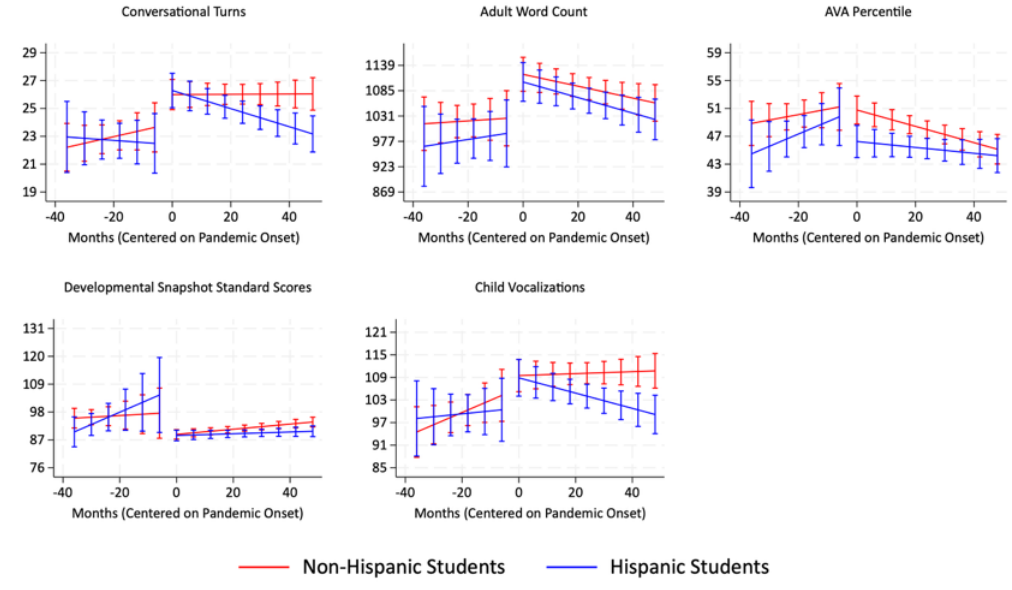
Predictive Margins of Mixed Model Estimates Predicting Language Outcomes by Child Gender, Pre- and Post-Pandemic

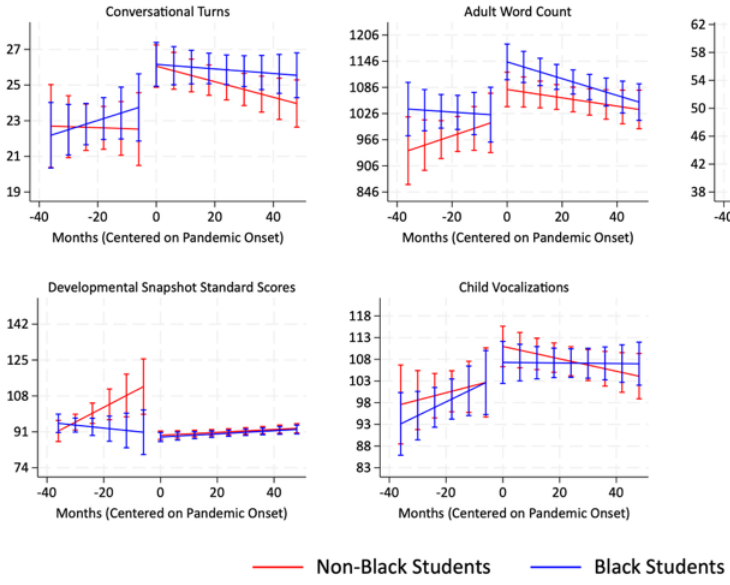


Notes. Each line shows predictive marginal estimates derived from mixed model analyses predicting language environment (Adult Word Count, Conversational Turns) and language development (AVA Percentiles, Developmental Snapshot, Child Vocalizations) measures pre- and post-pandemic for a male and female child at mean age.

Figure 4

Predictive Margins of Mixed Model Estimates Predicting Language Outcomes by Child Race and Ethnicity, Pre- and Post-Pandemic





Notes. Each line shows predictive marginal estimates derived from mixed model analyses predicting language environment (Adult Word Count, Conversational Turns) and language development (AVA Percentiles, Developmental Snapshot, Child Vocalizations) measures pre- and post-pandemic for a prototypical Hispanic or Black/African American child, relative to a prototypical non-Hispanic or non-Black child, at mean age.