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CHILD DEVELOPMENT

EMPIRICAL ARTICLE

Adult outcomes of sustained high-quality early child care and education: Do they vary by family income?

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Abstract

Experimental research demonstrates sustained high-quality early care and education (ECE) can mitigate the consequences of poverty into adulthood. However, the long-term effects of community-based ECE are less known. Using the 1991 NICHD Study of Early Child Care and Youth Development (n = 994; 49.7% female; 73.6% White, 10.6% African American, 5.6% Latino, 10.2% Other), results show that ECE was associated with reduced disparities between low- and higher-income children's educational attainment and wages at age 26. Disparities in college graduation were reduced the more months that low-income children spent in ECE (d = .19). For wages, disparities were reduced when children from low-income families attended sustained *high-quality* ECE (d = .19). Findings suggest that community-based ECE is linked to meaningful educational and life outcomes, and sustained high-quality ECE is particularly important for children from lower-income backgrounds.

Family income is a robust predictor of children's life outcomes. For those at the lower end of the income distribution, factors like stress and lack of stimulation and learning opportunities can impede brain growth and healthy development, with negative consequences greatest for children facing economic disadvantage during their earliest years of life (National Academies of Sciences, Engineering, and Medicine, 2019). The ramifications are long-lasting, with societal costs of childhood poverty estimated in the trillions through loss of productivity in adulthood and increased healthcare, crime, and social service costs (McLaughlin & Rank, 2018).

Increasingly, scholars and policy makers have argued that early care and education (ECE) protects children against the harms of growing up economically disadvantaged (e.g., Leseman & Slot, 2014; Magnuson & Shager, 2010; Organisation for Economic Co-operation and Development, 2006). Nurturing, safe, and stimulating environments outside of the home are thought to provide opportunities that disadvantaged children may not otherwise have access to, during crucial early years of development (Phillips & Shonkoff, 2000). Inherent in this logic is that the quality of ECE settings is sufficiently high, providing the types of caregiver–child interactions and enrichments that foster cognitive, social-emotional, and physical development. Conceptualized along structural and process dimensions (e.g., Burchinal, 2018), ECE structural quality includes features that can be regulated such as teacher education/training, group size, and adult:child ratio. Process quality refers to the nature of caregiver–child interactions, richness of the language and learning environment, and children's opportunities to explore their environments. Structural quality is the distal context supporting process quality (Burchinal, 2018), but

Abbreviations: ECE, early care and education; CPC, Chicago Parent-Child; SECCYD, Study of Early Child Care and Youth Development; ORCE, Observational Record of the Caregiving Environment.

process quality is believed to be the key lever by which ECE serves compensatory functions for low-income children (Yoshikawa et al., 2013).

Applicability of classic experimental studies of ECE

The provision of high-quality ECE for young children, particularly those in low-income households, was the motivation behind early experimental studies of intensive programs such as the High/Scope Perry Preschool program in the 1960s and the Carolina Abecedarian program in the 1970s. Targeting economically disadvantaged children, these programs, and others like the Chicago Parent-Child (CPC) Partnerships demonstrated impacts into adulthood in areas such as educational attainment, health, and earnings (Campbell et al., 2012; Reynolds et al., 2011; Schweinhart, 1993). In a meta-analysis of 22 high-quality experiments and quasi-experiments, including the Abecedarian, CPC, and Perry programs, lasting impacts were found on high-school graduation rate ($d = .24$; McCoy et al., 2017). Moreover, roughly two decades after program completion, children attending the CPC preschool program had higher incomes (USD 932 annually, 2007 valuation, or 9.3% higher earnings), college graduation rates (0.8 percentage points, or about 10% higher rates), and lower rates of felony arrests and incarceration relative to controls (Reynolds et al., 2007, 2011). For Perry Preschool participants, observed at ages 27 and 40, estimated impacts on lifetime earnings (18–65 years of age) exceeded $200,000 (e.g., Belfield et al., 2006; Heckman et al., 2010).

Yet, there are questions about the applicability of these findings for contemporary families whose children attend community-based ECE (McCoy et al., 2017). The initial early interventions were research-based programs that specifically served low-income children. A distinguishing characteristic was the intensity and duration of intentional, well-planned educational activities, and the per-child costs were much higher than what is typically allocated for ECE programs. For example, the Abecedarian intervention was offered 12 months a year across the first 5 years of children's lives.

In addition, social changes since these initial interventions were implemented have modified the counterfactual condition (Duncan & Magnuson, 2013). Unlike children in the control groups of the Perry and Abecedarian intervention studies who did not receive ECE, today most children spend some time in ECE settings (Rathbun & Zhang, 2016). Conditions in the home have also changed, as indexed by societal gains in low-income mothers' completed schooling (Duncan & Magnuson, 2013). Finally, because the early intervention studies were focused on exceptionally disadvantaged children, their findings may not apply to the very large number of children in the United States who, while not in deep poverty, are growing up in low-income households. Over the last 4 decades, about 40% of children in the United States have lived at or below 200% of the federal poverty threshold (United States Census, 2020); studying the long-term effects of high-quality ECE for all of these children is needed.

Convergence effects in contemporary preschool evaluations

Contemporary large-scale studies of public pre-k programs and Head Start have yielded a mixed picture of the impacts of ECE on child outcomes. While positive impacts immediately following these 1-year programs are generally found (Yoshikawa et al., 2013), some studies demonstrate converging elementary school outcomes for children assigned to preschool and their unassigned counterparts (Puma et al., 2012; Yoshikawa et al., 2016), or even a reversal of effects favoring control group children (Lipsey et al., 2015). Among the possible explanations for outcome convergence, Bailey et al. (2017) argue that preschools may build very basic literacy and numeracy skills that children who do not attend preschool can quickly learn when they enter kindergarten. They propose early childhood programs may be more likely to demonstrate persistent impacts, if they promote a "trifecta of skills" that are malleable, fundamental, and would not be developed later in absence of the program (Bailey et al., 2017). These authors also point to the role of high-quality environments *after* preschool as key to sustaining initial gains.

Interestingly, prior to their positive effects on educational attainment and adult income, some convergence for treated and untreated children was evident for some intermediate outcomes such as IQ scores during middle childhood and early adolescence in the Perry Preschool and Abecedarian studies (Campbell & Ramey, 1994). Similarly, the Effective Preschool, Primary and Secondary Education study in England found evidence of converging effects on achievement scores in middle childhood followed by later effects on academic attainment and salary in adulthood (Cattan et al., 2014; Taggart et al., 2015). It remains to be seen whether similar patterns—initial advantages for children in ECE, followed by convergence on achievement outcomes, followed by positive effects in adulthood—will be evident for children who attend community-based ECE settings in the United States. Indeed, one question motivating the current study is whether high-quality community-based ECE is associated with positive outcomes into adulthood, particularly for low-income children.

Associations between community-based ECE quality and child outcomes

Associations between community-based ECE quality and child outcomes have been summarized in meta-analyses of several large U.S. studies (e.g., Burchinal

et al., 2011, 2016; Keys et al., 2013; Perlman et al., 2016; Soliday Hong et al., 2019), and one that includes European studies (Ulferts et al., 2019). The U.S. meta-analyses focused primarily on short-term associations between ECE quality and child functioning during the preschool years, finding small associations, rarely exceeding $r < .10$, with some evidence that associations are stronger at the higher end of the quality distribution.

While the U.S. meta-analyses focused on short-term relations (e.g., Burchinal et al., 2011; Perlman et al., 2016), the meta-analysis of European studies included longer-term outcomes (up to 16 years following ECE). Here, the average effect sizes did not decrease over time (Ulferts et al., 2019). The findings from Scandinavia also suggest a connection between ECE and long-term outcomes. Havnes and Mogstad (2011, 2015), for example, showed Norway's expansion of public preschool in the late 1970s had effects on educational attainment and income (except for the highest earners) at age 26–30. Importantly, however, in a meta-analysis of quasi-experimental studies of universal preschool programs (across Europe, Scandinavia, Australia, Canada, and the United States), positive effects on educational attainment and income were limited to programs with high structural quality (van Huizen & Platenga, 2018), a point that appears consistent with the literature more generally. Consider, for example, evidence from Canada where findings have been mixed on long-term outcomes associated with ECE. In quasi-experimental studies of Quebec's scale-up of universal ECE for 0–4 year olds (e.g., Baker et al., 2019), negative effects on socioemotional and health outcomes were observed through early adulthood, while effects on achievement outcomes were mixed. Notably, the observed quality of ECE in Quebec at the time was very low, and especially so for the youngest children (Japel et al., 2005). Thus, juxtaposing these findings with those reported above, ECE quality may be an important moderator of long-term outcomes.

Differential impacts by family income?

Most of the meta-analyses and studies of community-based ECE quality have not specifically asked if these settings (or the quality therein) are more advantageous for economically disadvantaged children. One exception is the study by Keys et al. (2013), who found stronger quality effects on language development for children from families with higher levels of education, which runs contrary to the compensation hypothesis. This finding also is in contrast with two earlier reports using the SECCYD (Dearing et al., 2009; McCartney et al., 2007), in which the number of episodes in high-quality ECE measured at five ages during the first 5 years (6, 15, 24, 36, and 54 months) differentially predicted academic achievement scores as a function of family income. In these studies, more episodes of high-quality ECE positively predicted early academic achievement among low-income children, narrowing achievement disparities between these children and their higher-income peers in grades 3–5 (Dearing et al., 2009). In the current study, we expand these SECCYD studies to examine outcomes up to 26 years of age.

Current study

In the current study, we use prospective longitudinal data covering children's lives from birth through age 26 years to examine relations between sustained participation in high-quality ECE in community-based settings for children from families across the income spectrum on educational outcomes at age 15 and life outcomes in early adulthood at age 26. The data were collected as part of the NICHD Study of Early Child Care and Youth Development (SECCYD), an economically diverse sample of children who attended a variety of ECE settings for varying amounts of time in the early 1990s during their first 5 years of life.

Previous reports of longitudinal analyses of the NICHD SECCYD have found consistent, albeit small, associations between observed ECE quality and academic outcomes in middle childhood (Belsky et al., 2007), at age 15 (Vandell et al., 2010) and age 18 (Vandell et al., 2016). In addition, differential impacts favoring children in low-income families have been demonstrated with these data for achievement outcomes in early and middle childhood (Dearing et al., 2009; McCartney et al., 2007). The current study extends the literature by using the SECCYD to examine whether more exposure (i.e., months) to community-based ECE, particularly high-quality ECE, is linked to adolescent and adult educational attainment and income in the United States.

Importantly, this study examines a range of early care settings including center-based care, child-care homes (family daycare), and informal non-parental home care. By addressing the differential long-term results of ECE for children from lower- and higher-income families, we directly estimate the extent to which ECE can narrow the negative effects of early economic disparities on adult outcomes. Because we studied children attending a variety of ECE settings available to families in their communities, we can consider questions about whether typical ECE settings can be of high enough quality to be associated with lasting effects. We specifically examine the total number of months that children were in ECE, as well as months in high-quality ECE and months in lower-quality ECE.

Importantly, a critical limitation of many studies examining long-term effects of ECE, including the SECCYD, is that they are correlational, and hence vulnerable to endogeneity bias, also known as selection bias (Duncan et al., 2004). Specifically, there are potentially individual- and family-level factors that

both increase the likelihood of attending ECE (and/or ECE of a certain quality) *and* affect the outcomes of interest. If the association between the two is caused by such confounding factors, estimates will be biased unless the confounders are controlled for in the analyses. To strengthen internal validity in such studies, covariates believed to account for potential selection biases should be included in analyses, based on theory and existing empirical work (Steiner et al., 2010). Yet, there is still a threat to internal validity of unobserved (or poorly measured) factors that may account for the association between ECE quality and outcomes. Thus, in non-experimental studies of child development, there is an increasing emphasis on careful assessments of selection processes as a function of study covariates (Steiner et al., 2010), tests of the sensitivity of results to potentially omitted variables (e.g., Dearing & Zachrisson, 2019; Oster, 2019), and robustness checks using theoretically informative alternative statistical modeling strategies (Duncan et al., 2014). In the current study, we focus much of our analyses on these issues. Before conducting our primary hypothesis tests concerning the moderating effects of ECE, we examined selection into both high- and lower quality settings across the income distribution to determine what selection forces (as captured by study covariates) operated most strongly within this sample and for whom.

Hypotheses

Our primary hypotheses are confirmatory because they expand directly on Dearing et al.'s (2009) previous work examining effects of greater exposure to high-quality ECE in the SECCYD. Also, given the time span between exposure and outcome, our hypotheses are informed by experimental and quasi-experimental studies of the long-term effects of high-quality ECE interventions (e.g., Havnes & Mogstad, 2011; van Huizen & Plantenga, 2018). We hypothesized that exposure to high-quality ECE (as measured in months) would moderate associations between family income and age 15 and age 26 outcomes. Specifically, we expected that disparities between lower- and higher-income children—on achievement tests at age 15 and income, educational attainment, arrests, and likelihood of being in a committed romantic relationship at age 26—would be narrowed for low-income children who spent more months in high-quality ECE. Among children from low-income households, we anticipated that those who spent little to no time in high-quality ECE would evidence the largest disparities in outcomes when compared with children from higher-income households. Children from low-income households who spent more time in high-quality ECE during the first 5 years were expected to evidence outcomes significantly closer to those of their higher-income peers.

It is important to note, that while we did not make specific predictions about the potential moderating effects of *lower-quality* ECE, we estimated models that included this potential moderator and we also conducted analyses that asked if total months in ECE (regardless of quality) moderated relations between family income in early childhood and later outcomes. By doing so, we distinguished between ECE moderating effects that were exclusive to high-quality versus those that might generalize to any ECE, regardless of quality.

METHOD

Sample and study design

In 1991, 1364 women and their recently born children living in or near 10 sites (Little Rock, AR; Irvine, CA; Lawrence, KS; Boston, MA; Philadelphia, PA; Pittsburgh, PA; Charlottesville, VA; Seattle, WA; Morganton, NC; and Madison, WI) in the United States were recruited from hospitals to participate in the NICHD Study of Early Child Care and Youth Development (NICHD Early Child Care Research Network & Duncan, 2003). Although the sample was not recruited to be nationally representative, it was economically and geographically diverse. Using a prospective longitudinal design, data were collected using a variety of measurement tools (e.g., parent reports on family demographics and well-being, researcher observations of home and ECE settings, child achievement testing, and participant self-reports of educational, financial, and romantic partner status in adulthood) to assess children and families at 12 time points that spanned childhood (1, 6, 15, 24, 36, and 54 months of age as well as kindergarten, first, third, and fifth grade), adolescence (age 15), and adulthood (age 26).

Of the original SECCYD sample, 979 participants remained in the study through age 15 and 814 remained in the study through age 26. In the present study, our primary analytic sample consisted of 994 children who had: (a) at least one non-missing indicator of family income between 6 and 54 months (i.e., across five assessment points during early childhood), (b) at least one non-missing indicator of ECE arrangement during early childhood (i.e., across five assessment points between 6 and 54 months of age), and (c) at least one non-missing adolescent or adult outcome variable at age 15 (i.e., achievement test scores) or age 26 (i.e., educational attainment, annual salary, or romantic partner status).

Measures

Descriptive statistics for study variables are displayed in Table 1, beginning with family income and ECE variables, then the study outcome variables, and last the covariates. In this table, we display descriptive statistics for

TABLE 1 Descriptive statistics

	Original SECCYD sample (n = 1364)		Analytic sample (n = 994)	Age 26 sample (n = 814)
Variables	**% missing**	***M* (*SD*)/%**	***M* (*SD*)/%**	***M* (*SD*)/%**
Childhood family income-to-needs	5.4	3.36 (2.95)	3.60 (2.82)	3.81 (2.83)
ECE	4.3[a]			
Months in ECE		23.53 (16.72)	24.95 (15.36)	25.25 (16.45)
Months in high-quality ECE		9.13 (11.25)	9.79 (11.60)	10.28 (11.93)
Months in lower-quality ECE		14.40 (15.11)	15.16 (15.18)	14.97 (15.18)
Age 15 achievement				
Applied problems	35.0		524.57 (16.77)	525.89 (16.44)
Passage completion	34.8		520.36 (12.47)	521.73 (11.34)
Picture vocabulary	34.7		518.60 (13.15)	519.87 (12.34)
Verbal analogies	34.6		525.55 (14.18)	527.03 (13.46)
Mean composite of subscales	40.8		522.26 (12.29)	523.63 (11.44)
Age 26 educational attainment				
No high school diploma				1.2%
GED				2.3%
High school diploma				11.7%
Some college				21.9%
Associate's degree				7.5%
Bachelor's degree				41.4%
Some graduate school				3.9%
Master's degree				8.0%
Doctoral degree				2.1%
Age 26 annual salary	43.6			$44,397 (3793)
Age 26 criminality	38.9			18.4%
Age 26 partner status	41.1			40.1%
Child characteristics				
Gender = boy	0.0	51.7%	50.3%	47.6%
African American	0.0	11.1%	10.6%	7.7%
European American	0.0	70.5%	73.6%	76.0%
Latino American	0.0	5.6%	5.6%	5.0%
Other race/ethnicity	0.0	12.8%	10.2%	11.2%
Birth order	0.0	1.83 (0.95)	1.80 (0.92)	1.80 (0.89)
Maternal characteristics				
Age	0.0	28.11 (5.63)	28.58 (5.58)	29.07 (5.40)
Years of education	<1.0	14.23 (2.51)	14.44 (2.45)	14.66 (2.42)
Average partner status	0.0	0.81 (0.30)	0.82 (0.28)	0.85 (0.27)
Sensitivity	6.7	9.21 (1.78)	9.28 (1.78)	9.37 (1.74)
Separation anxiety	6.4	66.42 (13.84)	66.01 (13.91)	65.22 (13.56)
Neuroticism	6.7	29.77 (7.16)	29.82 (7.10)	29.68 (7.02)
Agreeableness	6.7	46.28 (5.29)	46.42 (5.24)	46.71 (5.23)
Extraversion	6.7	42.49 (5.83)	42.41 (5.78)	42.54 (5.84)
Employment attitudes	<1.0	.85 (7.11)	.93 (7.12)	.91 (7.20)
Intelligence (PPVT)	14.4	99.01 (18.35)	99.77 (18.50)	101.49 (18.20)
Household characteristics				
Six-month HOME	6.2	36.55 (4.65)	36.72 (4.51)	37.17 (4.09)

Abbreviations: ECE, early care and education; GED, General Equivalency diploma; HOME, Home Observation Measure of the Environment (Bradley & Caldwell, 1984); PPVT, Peabody Picture Vocabulary Test; SECCYD, Study of Early Child Care and Youth Development.

[a]Across the five time points at which ECE quality was observed, 4.3% of children were missing all five observations; for those with at least one non-missing observation, 5.9% had complete data for only one observation, 7.9% had complete data for two observations, 13.2% had complete data for three observations, 24.6% had complete data for four observations, and 44.1% had complete data on at all five time points.

the: (1) 1364 participants in the original sample, (2) 994 participants in our primary analytic sample, and (3) 814 participants who were retained through age 26.

Family income

At five time points during early childhood (i.e., 6, 15, 24, 36, and 54 months), mothers reported annual household income from all sources. From these data, an income-to-needs ratio was computed at each time point, defined as family income divided by the poverty threshold for the appropriate family size, as established by the U.S. Census Bureau. Note that an income-to-needs ratio of 1.0 denotes the poverty level, and 2.0 is often considered the threshold for "near-poverty" or low-income in the SECCYD sample (e.g., Dearing et al., 2009). For our analyses, we computed families' average income-to-needs from the time children were 6–54 months of age (see Table 1). The average income-to-needs during early childhood was 3.53 (SD = 2.83), with approximately one-third of the original (n = 447) and analytic samples (n = 325) being low-income and a little more than half of those children living below the poverty line (n = 244 for the original sample and n = 174 for the analytic sample).

ECE quality

For children in any form of non-parental care for at least 10 h per week, the setting was observed and the quality of that care was assessed using the Observational Record of the Caregiving Environment (ORCE), a live observational instrument designed for the SECCYD (NICHD Early Child Care Research Network, 1996, 2000). Two half-day visits were conducted at 6, 15, 24, and 36 months, and one half-day visit was conducted at 54 months. During these visits, observers made multiple 40-min observation sweeps, with the total number of observations varying as a function of children's naps and other non-observable activities.

Caregiver sensitivity to the study children's non-distress expressions, positive regard, stimulation of cognitive development, detachment (reflected), intrusion (reflected), and flat affect (reflected) were the focus of the 6-, 15-, and 24-month observations. At 36 months, an additional category, fostering exploration, was added. At 54 months, ratings were focused on sensitivity and responsivity, stimulation of cognitive development, intrusiveness, and detachment. All domains were assessed using 4-point ratings (1 = not at all characteristic, 2 = somewhat not characteristic, 3 = characteristic, 4 = highly characteristic). Items were developed theoretically with scores of 3.0 or higher (and 2.0 or lower on reverse scored items) indicating high-quality caregiving. Prior SECCYD studies (Vandell et al., 2010) have found overall ratings of 2.75 to be the threshold above which increasingly high scores were related to better child outcomes into adolescence.

In this study, we used the ORCE quality composite scores, calculated by averaging item scores (across domains) at each age. Internal consistencies for the composite quality indicators were above 0.80 at each age. For our analyses, "*High-quality*" care was defined as composite scores of >3, and "*Lower-quality*" was defined as composite scores below this threshold. In Table S1, we report descriptive statistics for ECE quality composite scores as well as the percentage of children in high- and lower-quality ECE, at each time point, according to the high-quality threshold of scores above 3.0.

To capture children's cumulative exposure to high- versus lower-quality ECE, we estimated the number of months that children were in these settings: (1) treating consecutive time points at which children were in high- or lower-quality ECE as sustained exposure to that level of quality, and (2) assuming that the number of months in high- or lower-quality ECE at any given observation point lasted at least 6 months (as detailed in Supporting Information, maternal reports collected at 3- to 4-month intervals between ECE observations indicted most children remained in observed ECE settings for at least 6 months). For consecutive episodes, the length of time between those time points was totaled, plus 6 months (i.e., assuming the child was in the first setting for 3 months prior to the observation and in the last consecutive setting for 3 months after the observation). Thus, for a child observed to be in high-quality ECE at 6, 15, and 24 months (but not at 36 or 54 months), we estimated sustained high-quality ECE for 24 months (i.e., from 3 months of age until 27 months of age). A child in high-quality ECE at 36 and 54 months (but not at 6, 15, or 24 months) was estimated to be in high-quality ECE for 24 months (i.e., from 33 to 57 months). When children were observed to be in high- or lower-quality ECE at non-consecutive time points, each time point was estimated to represent a 6-month duration. For example, a child coded as being in high-quality ECE at 6 and 24 months, but not at any other time, was estimated to be in high-quality ECE for a total of 12 months.

The mean number of estimated months in high-quality ECE was 9.14 (SD = 11.25), the estimated months in lower-quality ECE was 14.40 (SD = 15.11), and, the total estimated months in ECE 23.54 (SD = 16.73). To avoid outliers having undue leverage in our analyses, we capped the number of months in high-quality at 36 months and lower-quality at 45 months, their respective 95th percentile values. In Figures 1 and 2, the estimated number of months that children were in high- and lower-quality ECE are displayed as a function of early childhood income-to-needs. Further details on stability of ECE and type of ECE are provided in Supporting Information (Tables S1 and S2).

The validity of our estimated months in high- and lower-quality ECE variables was supported by two

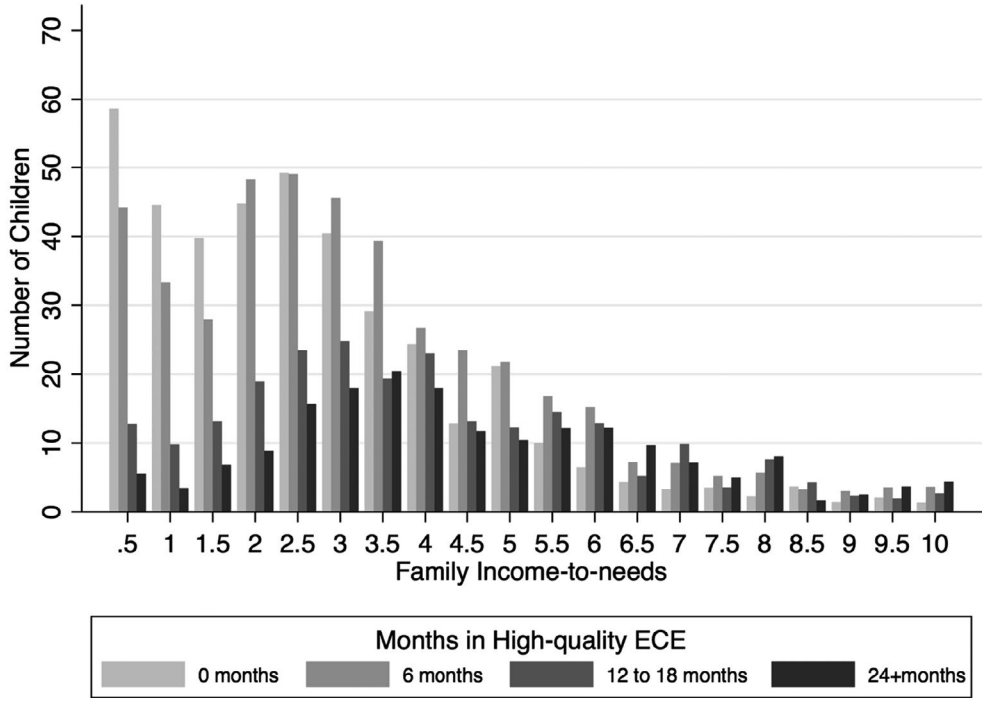

FIGURE 1 Distribution of number of episodes in high-quality ECE by family income. ECE, early care and education

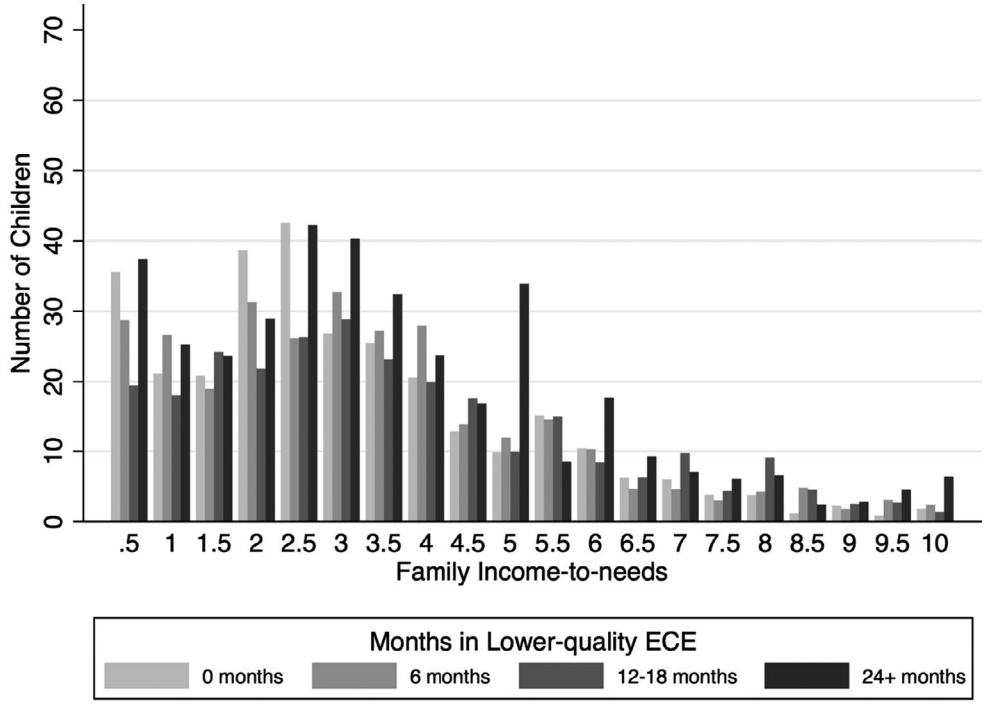

FIGURE 2 Distribution of number of months in lower-quality ECE by family income. ECE, early care and education

additional sets of analyses (see the "Sensitivity and Robustness Analyses" results section, below) in which we: (a) used a simple count of the number of time points (6, 15, 24, 36, and 54 months) in which children were in high- or lower-quality ECE, the approach previously used by Dearing et al. (2009); and (b) created broad categories of duration in ECE (i.e., children estimated to be in <1 year, between 1 and 2 years, and 2 or more years of ECE). As reported in the Supporting Information, we also conducted validation checks of our high-quality thresholds by examining alternative (increasingly lower) cut points for determining high-quality ECE, including average items scores of >2.9, >2.75, and >2.5, respectively.

Age 15 outcome

Achievement and cognitive ability scales from the *Woodcock–Johnson Psycho-educational Battery—Revised* (Woodcock, 1989) were administered at age 15. The reliability and validity of the WJ-R have been well documented. We examined four WJ-R scales: *applied problems* which assess the ability to solve practical mathematical problems, *passage completion* which assesses the ability to select the most appropriate word missing from a passage of text, *picture vocabulary* which measures the ability to correctly identify the names of objects in pictures, and *verbal analogies* which measures the ability to complete an analogy using rules of logic (i.e., *a* is to *b* as *c* is to __?). In our analyses, we used W scores from these tests (Rasch-scaled scores), examining both a mean composite of W scores for the four WJ scales as well as analyzing each scale, individually.

Age 26 outcomes

Educational attainment was measured with the question "What is the highest degree you earned?" Response options were as follows: No High School diploma, General Equivalency diploma, High School diploma, Some College but no College degree, Associate's degree (e.g., AA, AS), Bachelor's degree (e.g. BA, BS), Some Graduate School but no Graduate, Master's degree (e.g., MA, MS, MBA), doctoral degree (e.g., PhD, MD, EdD). In our primary analyses, we used these data to form a dichotomous indicator of whether participants had a college degree (Associate's degree or higher =1) or not (0). In follow-up analyses, we also examined a dichotomous indicator of whether participants had a 4-year college degree (i.e., Bachelor's degree or higher =1) or not (0), and we also examined the full set of ordered levels of educational attainment from no High School diploma through the doctoral degree.

Participants reported their *annual salary* by responding to the following question: "What is your pre-tax salary?" which could be answered by providing weekly, biweekly, monthly, or annual wages, which were converted to an annual income. To avoid outliers having undue leverage in our analyses, we capped age 26 salary at the 95th percentile, which was $105,000.

Participants' *partner status* was determined with two questions. The first asked about present marital status (responses were Married, Separated/Divorced, Widowed, Engaged, Single). For participants who reported they were separated/divorced, widowed or single, a follow-up question was asked to describe their *current* romantic relationship situation. A dichotomous score was created if participants reported they were married or engaged or living with someone in a steady relationship (1) or not (0).

Participants responded to a series of questions about *arrests* or *time in jail*. Participants who reported a 0 on both the arrested and jailed were given a 0 on the dummy variable. All others received a score of 1.

Covariates

When children were 1 month of age, mothers reported child gender, ethnicity, and birth order. At this time, mothers also reported their own age and level of education. We also used maternal reports of their partner status when the study children were 6, 15, 24, 36, and 54 months of age to form summary indicators for the proportion of assessment points at which mothers were married or partnered and the mean household size across that time.

Data also were collected pertaining to maternal attitudes, behaviors, intelligence, and personality as well as the quality of the home environment. At 1 month, mothers reported their beliefs about the potential benefits/costs of maternal employment (*Beliefs about the Consequences of Maternal Employment for Children* scale; Greenberger et al., 1988). At 6 months, they reported maternal separation anxiety (*Maternal Separation Anxiety Scale*; Hock et al., 1988) and extraversion, agreeableness, and neuroticism (*NEO Personality Inventory*; McCrae & Costa, 1989).

At 6 months, mother–child interactions were videotaped and rated (NICHD Early Child Care Research Network, 2008) for sensitivity using three, four-point items: sensitivity to non-distress, positive regard, and intrusiveness (reverse scored). In addition, the quality of the home environment was observed and rated using the *Home Observation Measure of the Environment* (Bradley & Caldwell, 1984), which assesses multiple home environment domains, including parental responsiveness toward the child, parental acceptance of the child, organization of the environment, presence of learning materials, parental involvement, and the variety of experiences provided to the child. At 36 months, maternal verbal intelligence was assessed using the *Peabody Picture Vocabulary Test—Revised* (Dunn & Dunn, 1981).

Attrition and missing data

Given the long-term nature of the SECCYD, we closely examined attrition in the sample. While the means for our study variables were very similar when comparing the original sample of 1364 with our analytic sample of 994 (Tables 1–3), we examined the potential for differential attrition in two ways. First, in bivariate analyses, we examined whether the covariates were, one by one, associated with likelihood of being retained in the analytic sample. In these models, there were some small but statistically significant ($p < .05$) differences in rates of

TABLE 2 Selection into high-quality ECE episodes as a function of study covariates

	Months in high-quality ECE	
	Low-income sample (n = 289)	Full analytic sample (n = 994)
	R^2 = .08 b (SE)	R^2 = .16 b (SE)
Participant characteristics		
Gender is female	0.79 (1.11)	0.96 (0.86)
White race	1.32 (1.42)	0.45 (0.98)
Black race	1.44 (1.38)	−0.30 (1.32)
Latin/x ethnicity	2.46 (1.76)	0.63 (1.16)
Birth order	−0.55 (0.40)	−0.92 (0.32)**
Maternal characteristics		
Age at child birth	−0.02 (0.11)	0.10 (0.07)
Years of education	0.01 (0.29)	0.34 (0.18)
Partner status	−2.76 (1.31)*	−2.09 (1.19)
Employment attitudes	−0.00 (0.07)	−0.04 (0.05)
Agreeableness	−0.05 (0.10)	−0.11 (0.07)
Extraversion	0.13 (0.11)	0.08 (0.08)
Neuroticism	0.03 (0.06)	−0.05 (0.06)
Sensitivity	−0.05 (0.31)	−0.12 (0.22)
Separation anxiety	−0.01 (0.04)	−0.06 (0.02)*
Verbal IQ	0.05 (0.03)	0.01 (0.02)
Family characteristics		
Home environment	0.10 (0.12)	0.10 (0.11)
Income-to-needs	0.70 (0.84)	0.82 (0.12)***

Note: Children with early childhood family income-to-needs ≤2.0 were designated as low-income for these analyses.

Abbreviation: ECE, early care and education.

*$p \leq .05$; **$p < .01$; ***$p < .01$.

TABLE 3 Selection into lower-quality ECE episodes as a function of study covariates

	Months in lower-quality ECE	
	Low-income sample (n = 289)	Full analytic sample (n = 994)
	R^2 = .22 b (SE)	R^2 = .12 b (SE)
Participant characteristics		
Gender is female	−0.54 (1.41)	−0.19 (0.96)
White race	4.75 (2.50)	3.76 (1.98)
Black race	4.13 (2.86)	3.78 (1.51)*
Latin/x ethnicity	2.67 (1.87)	2.80 (2.50)
Birth order	1.29 (0.70)	−1.02 (0.52)
Maternal characteristics		
Age at child birth	−0.51 (0.16)**	0.08 (0.09)
Years of education	0.70 (0.58)	0.37 (0.26)
Partner status	−14.78 (2.23)***	−8.86 (1.81)***
Employment attitudes	0.33 (0.11)**	0.41 (0.07)***
Agreeableness	−0.01 (0.16)	0.04 (0.09)
Extraversion	0.09 (0.15)	0.09 (0.09)
Neuroticism	0.17 (0.11)	0.12 (0.06)*
Sensitivity	−0.92 (0.44)*	−0.46 (0.19)*
Separation anxiety	−0.00 (0.05)	−0.06 (0.04)
Verbal IQ	0.00 (0.05)	−0.01 (0.04)
Family characteristics		
Home environment	0.05 (0.16)	−0.26 (0.08)**
Income-to-needs	5.36 (2.18)*	0.23 (0.20)

Note: Children with early childhood family income-to-≤2.0 were designated as low-income for these analyses.

Abbreviation: ECE, early care and education.

*$p \leq .05$; **$p < .01$; ***$p < .01$.

attrition. Specifically, in the following groups, children were more likely to be retained through age 26: girls; children with older, more educated, more sensitive, and more agreeable mothers; and children whose mothers had higher Peabody Picture Vocabulary Test scores. In addition, early childhood family income-to-needs was positively, but again modestly, associated with likelihood of retention. Next, we examined the 16 covariates simultaneously, in a multivariate model. Combined, the 16 covariates explained <9% of the variance in retention rate. Despite this evidence that differential attrition was fairly modest, we examined the robustness of our results using alternative sample restriction strategies (see Supporting Information).

Within our analytic sample of 994, most of the data (93.7% across variables and observation points) were complete, and our models were estimated using multiple imputation for missing values. Within this sample, we also examined whether there were differential rates of missing data. Our focus within the analytic sample was on the likelihood of children having complete versus missing observations for our ECE predictors. Using a count indicator of the number of missing observations across 6, 15, 24, 36, and 54 months, we found no evidence our covariates were related to the number of complete versus missing observations that children had for ECE arrangement (i.e., parental care vs. ECE) or ECE quality. Combined, the 16 covariates explained <2% of the variance in rate of missing observations. In summary, retention in the sample was not completely at random (e.g., those retained were somewhat more advantaged on socioeconomic and parent psychological variables than those who dropped out) but rates of selective attrition were small in degree. To account for missing data in our statistical analyses, we used multiple imputation (20 data sets).

Statistical analyses

Our primary statistical analyses proceeded in three steps. First, we examined patterns of selection into high- and lower-quality ECE, focusing on the extent to which family income and the child and family covariates predicted time in ECE. Second, we examined the moderating effects of ECE for associations between family income in early childhood and the study outcomes assessed at ages 15 and 26. Third, we ran a series of sensitivity and robustness checks for the moderator analyses estimated in the second step.

When examining the moderating effects of ECE in the second and third analytic steps, we estimated random-effects regression models, adjusting standard errors for nesting within study sites (models with fixed effects for study site were also estimated in our third analytic step with details provided in Supporting Information). All model specifications included the 16 child, mother, and family covariates described above. For all outcomes, we report linear estimates; thus, in the case of the dichotomous outcomes (i.e., college graduation, criminality, and partner status), the estimates are linear probabilities. Robustness checks using logit models are presented in Supporting Information.

For our moderator analyses in the second and third steps, we examined: (a) total months in ECE *summed across* both high- and lower-quality settings as a single moderator and (b) months in high-quality ECE and months in lower-quality ECE as distinct moderators. Doing so allowed us to address two alternative hypotheses: (a) cumulative months in ECE, regardless of quality, may moderate early childhood income or (b) high-quality versus lower-quality ECE may have unique moderating effects.

For the moderator analyses of total time in ECE, regardless of quality, our models took the following form (ignoring our covariate set):

$$\begin{aligned} Y_{ij} &= \beta_{0j} + \beta_1 \text{Family Income}_{ij} \\ &\quad + \beta_2 \text{Total Months in ECE}_{ij} \\ &\quad + \beta_3 (\text{Family Income}_{ij} \times \text{Total Months in ECE}_{ij}) \\ &\quad + u_{ij}. \end{aligned} \tag{1}$$

For the moderator analyses of the unique roles of high- versus lower-quality ECE, our models took the following form (ignoring our covariate set):

$$\begin{aligned} Y_{ij} &= \beta_{oj} + \beta_1 \text{Family Income}_{ij} \\ &\quad + \beta_2 \text{Highquality ECE}_{ij} \\ &\quad + \beta_3 \text{Lowerquality ECE}_{ij} \\ &\quad + \beta_4 (\text{Family Income}_{ij} \times \text{Highquality ECE}_{ij}) \\ &\quad + \beta_5 (\text{Family Income}_{ij} \times \text{Lowerquality ECE}_{ij}) \\ &\quad + \beta_6 (\text{Highquality ECE}_{ij} \times \text{Lowerquality ECE}_{ij}) \\ &\quad + \beta_7 (\text{Family Income}_{ij} \times \text{Highquality ECE}_{ij} \times \text{Lowerquality ECE}_{ij}) \\ &\quad + u_{ij}. \end{aligned} \tag{2}$$

Note that the second equation (i.e., model specification for the distinct moderating effects of high- vs. lower-quality ECE) included three two-way interaction terms as well as the three-way interaction between time in high-quality ECE, time in lower-quality ECE, and early childhood income.

RESULTS

Selection into ECE

As a first step in our analyses, we examined patterns of selection into ECE by examining multivariate patterns of association between months in ECE and our collection of child and family covariates including family income. To do so, we estimated ordinary least-squares regression models with months in high-quality ECE as the outcome (see Table 2), and another set of models with months in lower-quality ECE as the outcome (see Table 3). Our 16 covariates and family income-to-needs were the predictors in these models. We ran these models for low-income children and for the whole analytic sample.

Within the low-income sample, the 16 predictors explained only 8% of the variance in number of months in high-quality ECE, and the only significant predictor of months in high-quality ECE was mothers' partner status: Children whose mothers were partnered spent fewer months in high-quality ECE than children whose mothers were not partnered. For the sample as a whole, selection into high-quality ECE was more strongly associated with the predictors, albeit still modestly so. Combined, the covariates and family income explained 16% of the variance in number of months in high-quality ECE with three predictors reaching statistical significance: Family income positively predicted months in high-quality ECE, and child birth order and maternal separation anxiety negatively predicted months in high-quality ECE. With regard to effect size, the income-to-needs coefficients in Table 2 corresponded to an r of .21, and no other predictor had an effect size larger than $r = .09$.

When looking at selection into lower-quality ECE settings, model predictors explained 22% of the variance for low-income children's months in lower-quality ECE. Within the sample of low-income children, five variables were significant predictors of months in lower-quality ECE. Family income and mothers' employment attitudes were positively associated with months in lower-quality ECE. Maternal partner status, age, and sensitivity were negatively associated with months in lower-quality ECE for these children. In terms of effect size for low-income children, maternal partner status was most strongly associated with months in lower-quality ECE ($r = .37$) with effect sizes for the other significant predictors ranging from approximately $r = .13$ to .21. For the full analytic sample, 12% of the variance was explained for months in lower-quality ECE settings, with six variables reaching

statistical significance. For selection into lower-quality ECE for the sample as a whole, effect sizes were largest for employment attitudes (r = .18 for months in lower-quality ECE) and maternal partner status (r = −.16 for months in lower-quality ECE).

To summarize, selection effects into high- versus lower-quality ECE settings did not appear to be large when we considered an extensive covariate set. This was particularly true for selection into high-quality ECE for low-income children for which <10% of the variance in months in ECE was explained; these results indicate that children from low-income families who received high-quality ECE did not differ, for the most part, on our broad set of 16 covariates from low-income children who did not. In comparison, more than twice as much variance in months in lower-quality ECE was explained for low-income children, and a similar amount of variance was explained for high-quality ECE when looking at the full analytic sample.

Moderating effects of ECE

To investigate whether ECE-moderated associations between family income and the outcomes at ages 15 and 26, we estimated random-effects regression models adjusting standard errors for nesting within study site. We first estimated models examining the total months in ECE *summed across* both high- and lower-quality settings as a moderator, and next we estimated models in which months in high-quality ECE and months in lower-quality ECE were treated as distinct moderators. In all models, we controlled for the 16 covariates that appear in Table 1. Results are summarized for the main effects and moderators of interest in Table 4 for achievement at age 15, Table 5 for college graduation and salary at age 26, and Table 6 for criminality and partner status at age 26. Results for the model covariates are provided in the Supporting Information (Table S3).

Age 15 achievement

For the Woodcock–Johnson achievement scores at age 15 (Table 4), none of the moderating effects of ECE reached statistical significance at $p < .05$, regardless of whether we considered total months of ECE (column 2) or whether we examined distinct moderating effects of months of high-quality and lower-quality ECE (column 3). Interestingly, the lack of moderation was likely due, at least in part, to the fact that family income in early childhood was not related to academic achievement at age 15. The only significant predictor for age 15 achievement was a negative main effect for months of lower-quality ECE in our model examining the unique moderating effects of high- and lower-quality ECE. More months in lower-quality ECE settings was associated with lower levels of Age 15 academic achievement.

While not significant (p = .07), the direction of the three-way interaction indicated that the negative association between lower-quality ECE and achievement was somewhat stronger for the low-income children, if they were never in high-quality ECE. Specifically, for low-income children who were never in high-quality ECE, the average estimated effect of each additional 12 months of lower-quality ECE (b = −.98, $p < .05$) amounted to about 8% of a standard deviation decrease in achievement. In comparison, this association amounted to <2% of a standard deviation decrease in achievement and was null for both higher-income children and for lower-income

TABLE 4 Moderating effects of ECE for age 15 achievement scores

	Total months in ECE	Months in high- versus lower-quality ECE
Main effects		
Family income	0.19 (0.29)	0.23 (0.34)
Total ECE	−0.24 (0.36)	
High-quality ECE		0.08 (0.08)
Lower-quality ECE		−1.08 (0.48)*
Two-way interactions		
Total ECE × income	−0.02 (0.08)	
High-quality × income		0.01 (0.12)
Lower-quality × income		0.12 (0.11)
High-quality × lower-quality		0.08 (0.08)
Three-way interaction		
High-quality × lower-quality × income		−0.02 (0.01)+

Abbreviation: ECE, early care and education.

+$p \leq .10$.

*$p < .05$.

TABLE 5 Moderating effects of ECE for college graduation and salary

	College graduation		Salary	
	Total months in ECE	High- versus lower-quality ECE	Total months in ECE	High- versus lower-quality ECE
Main effects				
Family income	0.04 (0.02)**	0.04 (0.02)**	0.42 (0.08)***	0.43 (0.20)**
Total ECE	0.04 (0.01)**		0.12 (0.13)	
High-quality ECE		0.12 (0.04)*		0.61 (0.29)*
Lower-quality ECE		0.06 (0.03)*		0.24 (0.20)
Two-way interactions				
Total ECE × income	−0.01 (0.003)**		−0.07 (0.02)**	
High-quality × income		−0.02 (0.01)**		−0.14 (0.04)**
Lower-quality × income		−0.01 (0.006)*		−0.10 (0.06)+
High-quality × lower-quality		−0.00 (0.00)		−0.03 (0.02)
Three-way interaction				
High-quality × lower-quality × income		0.00 (0.00)		0.01 (0.003)*

Note: ECE coefficients and standard errors are reported in 12-month units (i.e., a one-point increase corresponds to one additional year). Salary is reported in $10,000 units (e.g., the coefficient of .43 for family income corresponds to $4300).

Abbreviation: ECE, early care and education.

+$p \leq .10$.

*$p < .05$; **$p < .01$; ***$p < .001$.

TABLE 6 Moderating effects of ECE for criminality and romantic partnerships

	Arrested or jailed		Partnered	
	Total months in ECE	High- versus lower-quality ECE	Total months in ECE	High- versus lower-quality ECE
Main effects				
Family income	−0.02 (0.02)	−0.01 (0.02)	−0.00 (0.03)	0.00 (0.02)
Total ECE	−0.01 (0.05)		−0.00 (0.04)	
High-quality ECE		0.04 (0.08)		−0.04 (0.07)
Lower-quality ECE		0.03 (0.04)		−0.02 (0.06)
Two-way interactions				
Total ECE × income	0.01 (0.01)		−0.00 (0.01)	
High-quality × income		−0.00 (0.01)		−0.01 (0.02)
Lower-quality × income		−0.00 (0.01)		−0.01 (0.02)
High-quality × lower-quality		−0.04 (0.04)		0.04 (0.06)
Three-way interaction				
High-quality × lower-quality × income		0.01 (0.01)		0.01 (0.01)

Note: ECE coefficients and standard errors are reported in 12-month units (i.e., a one-point increase corresponds to one additional year). Salary is reported in $10,000 units (e.g., the coefficient of .43 for family income corresponds to $4300).

Abbreviation: ECE, early care and education.

children who experienced at least 12 months of high-quality ECE.

Age 26 college graduation

For college graduation rates (left side of Table 5), we found that participants whose families had higher incomes during early childhood were more likely to be college graduates (defined as an AA or BA degree; see "Sensitivity and Robustness Analyses" for alternative definitions). For models of both Total ECE Months and High- versus Lower-Quality ECE, we found that months in ECE moderated the effect of family income. In the analyses of Total ECE Months, as indicated by the main effect for early childhood income, each one-point difference in income-to-needs was associated with a 4- to 5-percentage point difference in the likelihood of

graduating from college for children who did not attend ECE. Yet, months in ECE reduced the size of this disparity by raising graduation rates for low-income children as evident in the significant two-way interactions between income and ECE (d = .19).

Two-way interactions between family income and ECE were significant for the model estimating total months in ECE as the moderator and the model estimating high- and lower-quality ECE as unique moderators. Three key findings point toward the model with total months in ECE settings as the preferred specification. First, consider that when examining the distinct moderating effects of high- versus lower-quality ECE, the two-way interactions were statistically significant and similar in direction for high and lower quality. Second, while the main effect coefficient for high-quality ECE (.12; d = .16) appeared somewhat larger in absolute magnitude than that for lower-quality ECE (.06; d = .14), both were statistically significant and they were not significantly different from one another. Third, high- and lower-quality ECE experiences did not significantly moderate the effects of one another, and there were no significant three-way interactions with income.

As a result, we graphed the association between number of total months in ECE and graduation rates for those who lived in low-income (i.e., income-to-needs ≤2.0) and higher-income (i.e., income-to-needs above 2.0) households during early childhood in Figure 3. In the graph, we plot graduation rates from 0 to 36 months in ECE; those values represent the 15th and 85th percentiles for months in ECE for low-income children and the 10th and 70th percentiles for higher-income children. While there was approximately a 10 percentage-point gap in graduation rates for those who grew up in low- versus higher-income households if they attended 6 or fewer months of ECE, this disparity was reduced to <2 percentage points given 36 months in ECE.

For this plotted interaction, we computed the region of significance to determine the range of values on months in ECE across which college graduation rates significantly differed for those who grew up in low- versus higher-income households. Graduation rates significantly differed (p < .05) for those from low- versus higher-income households given fewer than 24 months in ECE. Given 24 or more months of ECE (i.e., the 65th percentile for those from low-income backgrounds, and the 50th percentile for those from higher-income backgrounds), the college graduation rates of these groups were no longer statistically distinguishable.

Age 26 salary

Similar to college graduation rates, we observed disparities in salaries at age 26 as a function of early childhood income, and these too were moderated by months in ECE (see right side of Table 5). As indicated by the main effect of early childhood income, each one-point increase in income-to-needs in early childhood was associated with about $4000 additional salary at age 26 (i.e., main effect coefficients ranging from .42 to .43 multiplied by $10,000), for children who were never in ECE.

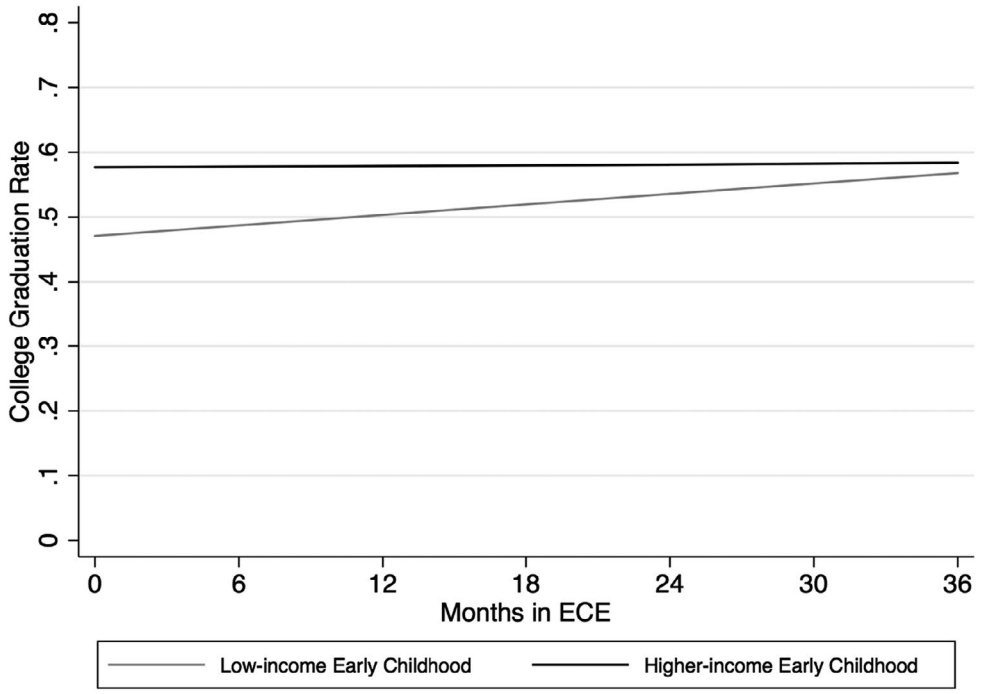

FIGURE 3 Estimated college graduation rate at age 26 as a function of low- versus higher-income childhood and months in ECE, regardless of quality. ECE, early care and education

However, salary gaps between those who grew up in low- versus higher-income households were increasingly smaller given increasing months in ECE, particularly high-quality ECE.

While two-way interactions between early childhood income and months in ECE were statistically significant in each of our model specifications, three key findings point toward the model with distinct moderating effects for high- versus lower-quality ECE being the preferred specification. First, in the model with distinct moderators for high- and lower-quality settings, only high-quality settings significantly moderated associations between early childhood income and age 26 salary (d = .19). Second, the unique role of high-quality ECE, compared with lower-quality ECE, is also evident in the main effect terms for these two types of settings. Specifically, the significant (p < .05) main effect for months in high-quality ECE corresponded to salary gains of $6100 for each year in high-quality settings (i.e., 0.61 multiplied by $10,000), which was about three times larger than gains in salary associated with lower-quality ECE ($2400 salary gains per year). Third, the three-way interaction term was statistically significant indicating that the moderating effect of months in high-quality ECE was dependent on how many months children spent in lower-quality ECE (d = .14). To interpret these results, we graphed the age 26 salaries of those who grew up low versus higher income with varying ECE experiences.

For illustrative purposes, in Figure 4, we graphed the association between months in ECE and salary for those who grew up low or higher income for three distinct ECE experience: (1) children who were exclusively in high-quality ECE settings; (2) children who were in a mix of high- and lower-quality ECE settings; and (3) children who were exclusively in lower-quality ECE settings. For the graph, the upper limit of months in ECE was set at 24 months, so as not to exceed a reasonable range of months in high-quality ECE for the low-income group (i.e., 24 months in high-quality ECE was the 95th percentile for this group).

As evident at the far left of Figure 4, the salary gap at age 26 between those from low- versus higher-income early childhoods was more than $12,000 (i.e., $32,577 vs. $44,933), if they did not attend ECE. Yet, gaps between these groups were increasingly smaller given increasing time in ECE, particularly when those with low-income early childhoods attended exclusively high-quality ECE (e.g., rather than a mix of high- and lower-quality ECE). While months in exclusively high-quality ECE predicted small increases in salary for children who grew up in higher-income families (i.e., each 12-month increment was associated with approximately $300 additional salary), each 12-month increment of exclusively high-quality ECE predicted a $4525 gain in salary for those who grew up in low-income households.

We estimated regions of significance for this interaction to determine at what points (along the continuum of number of months in high-quality ECE) the salaries of low-income children became statistically indistinguishable from those of high-income children. Specifically, we used regions of significance to answer two questions: (1) How many months of high-quality ECE does it take for low-income children to have salaries that are statistically indistinguishable from *the average salary of high-income children*? And (2) How many months of high-quality ECE does it take for low-income children to have salaries that are statistically indistinguishable from the *highest earning high-income children*? The region of significance for this interaction indicated that the salaries of those from low-income early childhoods were no longer statistically distinguishable (i.e., p > .05) from *the average salary of those from higher-income early childhoods* if those from lower-income backgrounds experienced 15 months or more of exclusively high-quality ECE. Specifically, the salaries of those from lower-income backgrounds with 15 months of exclusively high-quality ECE ($38,233) were an estimated $4800 ($p$ = .09) below the average salary of those from high-income backgrounds (i.e., the average salary across all ECE conditions of those from high-income backgrounds was $43,033). Compared with *the highest salaries of those who grew up in higher-income families* (i.e., higher-income childhood combined with exclusively high-quality ECE), the salaries of those who were low-income and in exclusively high-quality ECE were no longer significantly different given 24 or more months of ECE. That is, as indicated at the far right of Figure 4, given 24 months of high-quality ECE, the salary gap between those from low- and higher-income backgrounds was $3877 ($p$ = .06).

Turning to exclusively lower-quality ECE, associations with salary appeared to be somewhat positive for those from low-income families and somewhat negative for those from higher-income families. These associations, however, were not significantly different from zero, and salary gaps between those from low- and higher-income backgrounds remained significant (p < .05) at all levels of ECE exposure to lower-quality ECE. Moreover, for children who experienced a mixture of high- and lower-quality ECE, the lower-quality ECE appeared to offset much of the positive association between high-quality ECE and increases in salary (e.g., the plotted association between months of ECE and salary for low-income children who were in a mix of high- and lower-quality ECE trends similarly to this association for those who were in exclusively lower-quality ECE).

Age 26 criminality

The likelihood of being arrested or jailed by age 26 was unrelated to early childhood income in this sample. Moreover, we found no evidence that total months in ECE-moderated early income effects, and no evidence

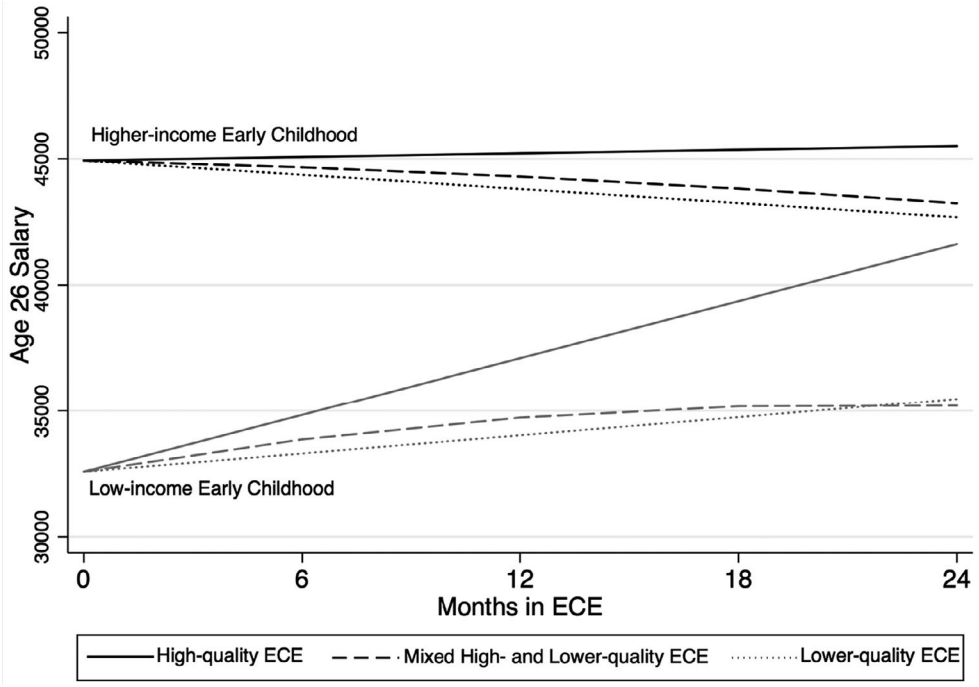

FIGURE 4 Estimated salary at age 26 as a function of low- versus higher-income childhood and months in high-, mixed, and lower-quality ECE. For mixed high- and lower-quality ECE, the plotted slope represents equal numbers of months split between these quality levels (e.g., at 12 months, estimates are plotted given 6 months of both high- and lower-quality ECE). ECE, early care and education

that high- or lower-quality ECE settings moderated early income effects. The only significant predictors in our models of criminality were covariates (see Supporting Information for complete details): older mothers and high-quality early home environment were associated with lower likelihoods of being arrested or jailed, later birth orders and boys were more likely to be arrested or jailed.

Age 26 partner status

The likelihood of being in a committed romantic relationship at age 26 was unrelated to early childhood income in this sample, and months in ECE did not moderate this null association. The only significant predictors in our models of partner status were two covariates (see Supporting Information for complete details): birth order and being of white race/ethnicity were both positively associated with the likelihood of being partnered.

Sensitivity and robustness analyses

For the third step in our analytic plan, we investigated the sensitivity of our results to potential omitted variable bias and the robustness of our results to theoretically and empirically meaningful alternative model specifications. Given the non-experimental design of the study, one goal of these follow-up analyses was to examine the internal validity of the moderating effects of ECE. These analyses provided a measure of how confident, or how skeptical, we can be that the estimates are valid. Importantly, these follow-up analyses are logically connected to the selection models presented at the outset of our results. With our extensive covariate set and its alignment with theory and prior empirical work, the selection models provided an indication of the size (or, said differently, the seriousness) of selection effects into high- and lower-quality ECE for these children. Yet, knowing that our covariates did *not* strongly explain selection into ECE, there are at least two possible explanations: selection into ECE was fairly random for these children (particularly selection into high-quality ECE for low-income children) or we failed to observe (or accurately measure) important sources of bias. In light of these alternatives, sensitivity analyses helped us determine how strong unobserved sources of bias would need to be to invalidate our results.

We examined the sensitivity of our results to potential omitted variable bias using the coefficient of proportionality method (Oster, 2019), focusing on the sensitivity of the significant interaction terms. The method is based on changes in model estimates and changes in R^2 (relative to the assumed maximum R^2), prior to and after adjusting for observed covariates. The amount of omitted selection bias necessary to invalidate a result is benchmarked against the multivariate contributions of observed covariates; this ratio is the coefficient of proportionality. In models for which observed covariates decrease the strength of association between the predictor and outcome while increasing R^2, larger ratios indicate less sensitivity to omitted variables (Oster, 2019).

In Table 7, we report coefficients of proportionality as well as changes in R^2 (the conditional model R^2 values correspond to models in Table 5; unconditional model results are summarized in Table S4). In the table, coefficients of proportionality were averaged across the 20 multiple imputation data sets. We assume maximum R^2 values based on existing empirical evidence of the maximum variance explainable on our study outcomes (Dearing & Zachrisson, 2019). Specifically, twin studies of monozygotic twins raised together (e.g., Johnson et al., 2006) indicate a maximum R^2 in the .50–.60 range for educational attainment and the .40–.50 for salary; to be conservative, we selected the top of these ranges for our sensitivity analyses.

For college graduation, the average coefficient of proportionality was .83. Thus, omitted selection effects would need to be 83% as strong as the observed covariates to nullify the two-way interaction effect of family income by total number of months in ECE for this outcome. For salary, the average coefficient of proportionality was .81 for the two-way interaction of family income by high-quality ECE and 1.26 for the three-way interaction of family income by high-quality by lower-quality ECE. Thus, omitted selection effects would need to be 83%–126% as strong as the observed covariates to nullify the interaction effects for salary. Note, however, that these values for salary may overestimate the true average sensitivity to omitted variables (i.e., underestimate robustness) given that 15% of the coefficients of proportionality—across the two interactions repeatedly estimated in 20 imputed data sets (i.e., 6 of 40)—were negative and excluded from the averages; these negative coefficients of proportionality indicated that inclusion of covariates *increased* the effect sizes for interactions. In the Supporting Information (Tables S5–S10), we further examine the robustness of our results to alternative model specifications. In sum, our results are robust to alternative specifications, including models (a) estimated with study site fixed effects, (b) examining a raw count of the number of episodes children were in ECE rather than number of months, and (c) using alternative approaches to handling attrition (e.g., multiple imputation using the original sample of 1364). Results for high-quality ECE as a moderator of associations between family income and age 26 salary were, however, increasingly less robust at increasingly lower thresholds for high-quality (Table S10), underscoring the importance of quality for this result.

DISCUSSION

Our results add to existing evidence on the role that ECE can play in improving long-term parity in children's life chances. With a focus on community-based ECE settings of varying quality, we examined adolescent (age 15) and adult (age 26) outcomes of children who grew up in a range of household economic conditions, from low to high income. We found that more months in ECE was associated with mitigated disparities between those who grew up in low- versus high-income households in college graduation. Additionally, more months in *high-quality* ECE was associated with mitigated disparities by childhood family income in salary at age 26. Exposure to *lower-quality* ECE, on the other hand, had mixed associations with long-term outcomes. Just as high-quality ECE did, more months in lower-quality ECE mitigated disparity in college graduation rates, but this was less true for salaries at age 26. With respect to salary, exposure to lower-quality ECE limited the positive relation between sustained high-quality ECE and salary for children who grew up in low-income households. Juxtaposed with the positive consequences of exceptionally high-quality ECE interventions (e.g., Abecedarian, Perry), findings from the present study indicate that high-quality community-based ECE is also linked to long-term impacts for children from low-income families.

TABLE 7 Sensitivity to omitted variable bias: model R^2 and coefficient of proportionality

	Graduated college	Salary
	R^2	
Unconditional model	.11	.07
Fully conditional model	.23	.11
	Coefficients of proportionality	
	(R^2_{max} = .6)	(R^2_{max} = .5)
Total months in ECE × family income	.83	
High-quality ECE × family income		.81
High-quality × lower-quality × family income		1.26

Note: R^2 values and coefficients of proportionality were averaged across 20 multiple imputation data sets. These values may overestimate the true average sensitivity to omitted variables for salary given that 15% of the coefficients of proportionality—across the two interactions repeatedly estimated in 20 imputed data sets (i.e., 6 of 40)—were negative and excluded from the averages; negative coefficients of proportionality indicate that inclusion of covariates *increased* the effect sizes for interactions.

Abbreviation: ECE, early care and education.

Income disparities and the moderating effects of ECE

Consistent with the extensive literature on associations between family income and children's growth and life chances (National Academies of Sciences, Engineering, and Medicine, 2019), children who grew up in lower-income families in the SECCYD displayed, on average, lower rates of college graduation and lower salaries at age 26 compared with those who grew up in higher-income families. For example, when comparing low- versus higher-income children who never attended ECE (arguably the counterfactual condition for understanding income effects absent ECE), there was more than a 10-percentage point gap in college graduation rate and more than $12,000 gap in salary. However, for children who grew up in low-income households, we found that more months of community-based ECE were associated with college graduation rates that closely approach those of children who grew up in higher-income households. The same was true for months of *high-quality* ECE and earnings at age 26. And, the magnitude of these associations appeared to be of considerable practical significance. For example, using the average graduation rate and salary of those from higher-income backgrounds as a benchmark: the graduation rates for individuals who grew up low-income and had 24+ months in ECE were statistically indistinguishable from their higher-income peers. Furthermore, participants from low-income homes with 15+ months of *high-quality* ECE had salaries at age 26 that were statistically equivalent to their higher-income peers.

It is important to note, however, that months of *lower-quality* ECE also appeared to mitigate disparities in college graduation rates. In fact, both high- *and* lower-quality ECE significantly moderated associations between family income and graduation rates. Compared with children who did not attend ECE, both high-quality and lower-quality ECE were associated with graduation rates for the low-income group that were significantly closer to those evidenced by the higher-income group. It is important to remember that "lower-quality" ECE in this study was defined as care <3.0 on the ORCE scale, meaning that it included "moderate" quality care as well as care that was "low-quality." Mixed effects of lower-quality ECE may be the result of this broader definition of quality. Future work to identify "good enough" quality thresholds for mitigating income disparities in adult outcomes will be useful, although it is important to note that our analyses did indicate that the buffering role of ECE for salaries grew increasingly smaller at increasingly lower thresholds for "high-quality."

This finding for lower-quality ECE is also tempered by the fact that at age 15, time in lower-quality ECE appeared to exacerbate achievement differences between low- and higher-income groups. Children whose families had lower incomes during early childhood demonstrated increasingly lower achievement scores with increasing months in lower-quality ECE. The achievement risk of exposure to lower-quality ECE was offset (albeit not quite significantly so) by exposure to high-quality ECE. Yet, we detected no mitigating effects of high-quality ECE for associations between income and age 15 achievement, presumably because early childhood family income was not significantly associated with this outcome. It is also possible to have long-term impacts on educational attainment without effects on adolescent standardized test scores if attainment is facilitated by other outcomes of ECE, including improved grades, noncognitive skills, or parental income.

The educational attainment and salary findings are consistent with existing studies of long-term outcomes of high-quality ECE, both internationally and in the United States. For example, van Huizen and Platenga (2018), in their meta-analyses of quasi-experimental studies of universal programs, found longitudinal relations between early care and long-term outcomes were largely driven by studies of programs with high structural quality and by effects for children from low-income families. The findings also are consistent with the 30-year longitudinal Canadian study that reported positive associations between formal child care during the first 5 years of life and educational attainment and earnings in adulthood, with larger effects for children who entered care as infants (Domond et al., 2020). In the United States, prior studies of long-term outcomes have been restricted to socially or developmentally disadvantaged samples (Campbell et al., 2012; Reynolds et al., 2011; Schweinhart, 1993).

Our study adds to the current evidence base in two ways. First, by including families across the socioeconomic spectrum, as opposed to exclusively low-income children in targeted programs, we can more validly address the true compensatory effect of ECE quality, as opposed to studies including targeted programs exclusively. This allows us, in a more ecologically valid framework, to strengthen our understanding of the socioeconomic subgroups benefiting the most from high-quality ECE. Second, by having repeated observed measures of ECE quality rather than (in many cases) inferring this from program characteristics and/or structural quality measures, and thus addressing the experienced quality, rather than the inferred quality, allows us to pinpoint some of the active ingredients in shaping the development of the participating children. By exploiting a sample with a range of ECE quality, and hence more closely reflecting the reality of experiences children have in ECE, we are able to determine more specifically the "dosage" of quality it takes to move the needle. In the current study, 15 months or more of ECE was needed to achieve parity for educational attainment and Age 26 salaries.

Interestingly, we detected no income-related differences, or moderating effects of ECE for either partner status or arrests at age 26. It is important to keep

in mind that age 26 is still relatively early in adulthood and the trend in society is for people to partner, marry, and have children later than previous generations. The null findings for arrests run contrary to the CPC and Perry Preschool studies, which showed reduced arrests in adulthood for children who attended (Reynolds et al., 2007; Schweinhart, 2000). These studies, however, focused exclusively on very low-income families, for whom arrests might be a more salient outcome, whereas the SECCYD had a more diverse sample in regard to income. It is possible that the participants in this study were not provided the dosage or level of quality required to reproduce the findings from prior studies.

Selection effects

Because ECE arrangements were not randomly assigned in the SECCYD, selection bias is a concern. Due to the possibility that families who placed their children in ECE are different from other families, we examined the difference between children who experienced different months of high-quality and lower-quality ECE on family income and 16 covariates including child (e.g., gender, race/ethnicity, birth order), maternal (education, sensitivity, vocabulary) and household (home environment quality) characteristics. Among low-income families, we found negligible differences in these factors for high-quality ECE use, suggesting that low-income families who use high-quality ECE differ little from those who do not. While it is possible that we left key selection factors unmeasured, it may also be the case that selection bias is limited by lack of access to high-quality ECE for low-income families (Burchinal et al., 2008; Johnson et al., 2012); in other words, luck may play a considerable role in use of high-quality ECE among low-income families. This possibility is underscored by the fact that we detected stronger selection effects–about twice as large–for low-income families' use of lower-quality ECE as well as higher-income families use of both high- and lower-quality ECE. In all of our analyses, we held constant the 16 covariates. In addition, sensitivity analyses indicated that our results were considerably robust to potential omitted variable problems. Even so, our attention to potential selection bias is neither a panacea nor a replacement for longitudinal examinations of community-based ECE impacts using experimental data.

Implications of the present study

The current findings are consistent with early experimental studies demonstrating impacts on adult outcomes from sustained ECE that was intensive, highly funded, and targeted at families living in deep poverty. Although the effects in the current study are smaller than these early experiments, we look to the field of public health to contextualize their practical significance: Rose's Theorem posits that a smaller-dose intervention to a larger population can have a greater net impact than a highly intensive intervention in a small group (Rose, 1981). Compared with early experimental studies, our analyses included children growing up in a range of economic conditions, in community-based ECE settings similar to those available to contemporary families. In doing so, this study is relevant for considering long-term effects of high-quality ECE broadly implemented, for narrowing achievement and human capital disparities. Our results are encouraging in this regard: sustained high-quality ECE had its largest long-term associations for children from low-income homes, narrowing sizable earning gaps.

Additionally, given our focus on ECE settings available to families, naturalistically, our findings indicate that typical community ECE settings *can* be of high enough quality to garner lasting impacts. The children in the current study were not enrolled in specially designed early childhood programs like the Abecedarian or Perry Projects, but care settings in their communities that nonetheless were providing sensitive-responsive, warm, cognitively stimulating care. Children who received more months of high-quality care during their first 5 years achieved higher educational outcomes and earnings more than 20 years later.

Furthermore, we note the differential predicted benefits of high-quality ECE over a more sustained period. While there is increasing momentum at the state and national levels to provide 1 year of high-quality public prekindergarten, our results indicate that exposure beyond 1 year was increasingly related to better outcomes in adulthood. This raises the question of whether 1-year of pre-K or Head Start is sufficient to produce lasting effects. Expansion of high-quality public programs to provide additional years of coverage may be necessary to realize lasting impacts. It is worth noting that the Abecedarian program, for example, spanned the first 5 years of life. In the current study, sustained exposure to high-quality ECE settings—located in communities throughout the United States (and not just a specially designed program in one community)—was also key to predicting positive adult outcomes for children from a range of low-income backgrounds. Our findings also reaffirm the importance of ECE that is high quality. Process quality involves teachers and caregivers providing a warm and organized environment, characterized by teacher–child interactions that encourage children to ask questions, explore their surroundings, and engage in rich exchanges with teachers and peers. The measure of ECE quality used in the current study, the ORCE, focuses on individual children's experiences in their ECE setting and the extent to which the setting was sensitive-responsive and cognitively stimulating for that child. Most of the commonly used quality assessments like the CLASS and the ECERS-R measure

quality at the classroom level (Burchinal, 2018), not at the level of individual children's experiences. These classroom-level assessments have not been consistently related to child outcomes in the short- or long-term (e.g., Guerrero-Rosada et al., 2021). In contrast, studies using quality measures like the ORCE [also see the Optimizing Learning Opportunities for Students observational assessment; Connor et al., 2020) are having more success in predicting child learning and development.

Limitations

A key limitation to the present study was the fact that families selected their children's ECE settings. Potential unobserved selection bias is a threat to internal validity, despite our efforts to assess this issue. The results appear robust when faced with multiple approaches to address selection effects, but we cannot rule out this potential bias. Exposure to high-quality ECE is likely related to dynamic factors such as housing stability and job quality in ways we could not fully control, a challenge we must leave open for future studies.

Regarding external validity, the SECCYD is a large and diverse sample, but was not drawn to be nationally representative (NICHD Early Child Care Research Network & Duncan, 2003). The racial/ethnic composition of the SECCYD sample in 1990 is similar to the United States in 1990 (80% White; 12% Black; 9% Hispanic; 6% Other; United States Census, 2000), but both are less ethnically diverse than the United States in 2020 (U.S. Census Bureau, 2021). In addition, the study sample is, on average, higher achieving than national averages in the United States. The national average for graduating from a 4-year college by age 26 for Americans born in 1991 is approximately 33% (Statistica, 2021), whereas the average for this sample was closer to 50%. Furthermore, the median annual earnings for individuals 25–34 in 2016 (the year this sample was 26) was 39,078 (Bureau of Labor Statistics, 2016), which means the SECCYD sample earned, on average, about $5000 above the national median. Three potential reasons for this are participants retained through age 26 could evidence some positive selection for higher salaries, the low number of Latino and Black participants likely raises the average salary of this sample above national numbers, and the income benefits of high-quality ECE for the participants from low-income families, as documented by our findings. These factors could limit generalizability.

In addition, we were not able to examine timing of ECE (e.g., infant & toddler vs. preschool) or type of care (e.g., grandparent care, family daycare, center care) while simultaneously examining quality due to the many combinations of income by quality by timing by type that children experience. Examining effects by timing and setting of care are important future directions for researchers interested in the long-term impacts of ECE for children from low-income backgrounds.

Finally, we note an unavoidable reality of longitudinal research: studying impacts of preschool 20 years after children complete the program necessitates programs being over 20 years old. The ECE landscape in the United States has changed since the 1990s, serving a far greater number of children and more commonly providing center-based care or public preschools in elementary school buildings. In addition, children from low-income families are more likely experiencing higher quality care now than 20 years ago because of increased access to Head Start and public prekindergarten programs that have quality performance standards (Friedman-Krauss et al., 2021). Quality of care also might be higher on average for children from middle-class families due to more stringent regulations and quality improvement efforts like the Quality Rating Improvement System (Bassok et al., 2019). The implication here is that the modern-day counterfactual children are more likely to have access to some kind of preschool programming (vs. no programming) and higher quality programs. Still, our results suggest that sustained exposure to high-quality ECE is linked to meaningful long-term impacts, particularly for children from low-income families.

CONCLUSION

Considering recent policy efforts both nationally (National Academies of Sciences, Engineering, and Medicine, 2019) and internationally (United Nations Organization, 2015) focused on eradicating childhood poverty, these findings are timely as they identify sustained high-quality ECE as a potential lever for enhancing long-term outcomes for children from low-income households. Indeed, this study suggests that sustained high-quality ECE warrants attention as a mechanism for creating a more equitable society for economically disadvantaged families.

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SUPPORTING INFORMATION

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