Three Essays on Publicly Funded Pre-kindergarten Policy

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Abstract

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This dissertation comprises three papers that explore the role of public pre-K policies in shaping access to early education, families' economic well-being, and child development. The first paper examines whether the income-based preschool enrollment gap narrowed between 1994 and 2023 and identifies the factors contributing to the gap. The second paper evaluates the effects of New York City's universal pre-K expansion for three-year-old children on maternal employment, household income, and material hardship. The third paper investigates how pre-K attendance predicts children's cognitive development and educational transitions across developmental stages—early childhood, middle childhood, adolescence, and young adulthood. The findings from this dissertation demonstrate the dual role of publicly funded pre-K programs in supporting both parents and children.

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Dedication

This dissertation is dedicated to all children who deserve the best opportunities to grow and thrive.

Introduction

Access to high-quality early childhood education and care (ECEC) is essential for families seeking to balance work and caregiving responsibilities while fostering their children's development. However, child care affordability remains a major barrier, especially for lower-income families. These families often face constrained options: reducing employment to care for children, relying on informal care arrangements, or making financial sacrifices to afford formal care. The developmental implications of these coping strategies depend on how they affect parenting practices and the quality of care children receive.

Despite the increasing policy interest in early childhood education, the United States continues to invest less than 0.5% of its GDP in early childhood programs—placing it among the lowest-spending high-income nations (OECD Social Expenditure Database, 2023). In the absence of a national universal child care system, states and cities have taken the lead since the 1980s in expanding public investments in preschool to enhance and equalize access. As of 2023, 44 states and the District of Columbia operated state-funded pre-kindergarten (pre-K) programs with varying designs, reaching approximately 35% of four-year-olds and 7% of three-year-olds (Friedman-Krauss et al., 2025). To inform the design and implementation of state programs—and to guide the development of a federal universal early education system—research is needed to examine how public pre-K expansion affects the early education landscape and the well-being of children and families—both in the short and long term.

This dissertation comprises three papers that explore key dimensions of public pre-K policies and their implications for equity, maternal employment, and child development. The first paper, "Income-Based Preschool Enrollment Gap in the U.S. Then and Now: 1994–2023,"

revisits the long-standing issue of income-based disparities in preschool enrollment. Updating prior research, it examines whether the narrowing trends observed in the 1990s and 2000s persisted into the 2010s and early 2020s. Using decomposition methods, it identifies the changing factors that explain the gap across decades, offering insights into the drivers that sustain or mitigate disparities in access to early education.

The second paper, “The Effects of Universal Pre-kindergarten for Three-Year-Old Children on Mothers’ Employment and Families’ Economic Well-being,” evaluates the effects of New York City’s universal pre-K expansion for three-year-olds on maternal employment, household income, and material hardship. It addresses a key gap in the literature: while evidence on universal pre-K’s effects on maternal employment is mixed, little is known about how long the employment effects last and how improved access to early education affects broader measures of family economic well-being.

The last paper, “Pre-kindergarten Attendance and Children’s Cognitive Development in the Short, Middle, and Long Term," investigates how pre-K attendance is associated with children’s cognitive outcomes and educational transitions across developmental stages—early childhood, middle childhood, adolescence, and young adulthood. It responds to a critical research gap that, while short-term cognitive gains from pre-K are well-documented, less is known about their persistence into later life and the mechanisms that explain long-term benefits.

Together, these papers provide a comprehensive understanding of how early education policies shape access, parental economic outcomes, and children's development. They aim to inform policy design by highlighting who benefits from expanded public pre-K access and under what conditions the returns can be more robust and equitable.

Paper 1: Income-Based Preschool Enrollment Gap in the U.S. Then and Now: 1994-2023

1.1 Abstract

This study examines trends in income-based disparities in center-based early childhood education (ECE) enrollment in the United States from 1994 to 2023, using nationally representative data from the October Current Population Survey. It investigates whether enrollment gaps between income groups have narrowed over time and assesses the demographic and structural factors that contribute to these disparities. Results indicate that the income-based gap in preschool enrollment narrowed throughout the late 1990s and early 2010s, reaching the lowest gap during the post–Great Recession years, driven largely by declining enrollment among high-income children and stable or increasing enrollment among low- and middle-income peers. Supplemental analysis suggests that the expansion of publicly funded pre-K programs contributed to this convergence for 4-year-olds but not for 3-year-olds, where secular trends likely played a larger role. Oaxaca-Blinder decomposition reveals that maternal education remains the largest driver of the explained gap, while the influence of maternal employment status on enrollment has become more similar across income groups over time. These findings highlight the importance of expanding availability of pre-K programs and broader structural changes in reducing early education disparities.

1.2 Introduction

Preschool enrollment in the United States has long reflected income-based disparities (Magnuson & Waldfogel, 2016), driven in part by the high cost of nonparental child care. Among available care options, center-based early childhood education (ECE) is among the most expensive. In 2022, the average annual cost of full-day center-based ECE for preschool-age

children ranged from $7,155 to $12,849 (National Database of Childcare Prices, 2024)—a substantial burden given that the median annual earnings of workers were approximately $49,860 that year (U.S. Census Bureau, 2024). With child care prices remaining persistently high over time (Herbst, 2018), federal and state governments have implemented policy reforms since the 1990s aimed at expanding access for low- and moderate-income families.

During the 1990s and 2000s—a period of growing public investment in early education—research shows that the income-based gap in preschool enrollment, which exceeded 30 percentage points between the top and bottom income quintiles in the 1980s, narrowed substantially (Magnuson & Waldfogel, 2016). This convergence was especially notable given rising inequality during the 1960s through 1980s in other domains of parental investment, including financial expenditures on children (Kornrich & Furstenberg, 2013) and the time parents spent on developmentally enriching activities (Altintas, 2016).

Yet it remains an open question whether these converging trends in enrollment persisted throughout the 2010s and early 2020s. Several developments suggest continued progress. Following rapid expansion in the 1990s and 2000s—from 20 states offering public pre-K in the early 1990s to 40 states plus the District of Columbia by 2010 (Barnett et al., 2010; Cascio, 2021)—four additional states launched pre-K programs in the 2010s. Nationally, the share of 4-year-old children enrolled in public pre-K increased from 28% in 2010 to 35% in 2023 (Friedman-Krauss et al., 2025), reflecting sustained policy support. At the same time, however, the Great Recession (2007–2009) and the COVID-19 pandemic may have disrupted these gains, particularly for lower-income families, potentially stalling or reversing prior progress.

Recent changes in women's labor force participation further motivate a reassessment of preschool enrollment gaps. While women's employment rose steadily from the 1960s through

the 1990s, it has plateaued or declined since the early 2000s, especially among those with less education (Black et al., 2019). Relatedly, low-educated mothers have reported increasing time spent with their children during the 2010s—a trend not observed among more highly educated mothers (Cha & Park, 2021; Prickett & Augustine, 2021). Although preschool participation is not contingent on maternal employment, weaker workforce attachment may reduce access to ECE, particularly for low-income families (Pilarz et al., 2019).

This study updates and extends prior work by examining trends in the income-based ECE enrollment gap from 1994 to 2023 using data from the October Current Population Survey, a nationally representative, annually repeated cross-sectional dataset. Given that most early childhood policy initiatives over the past four decades have prioritized low-income families—and that state pre-K expansions have primarily targeted 4-year-olds—this study separately examines enrollment disparities for 3- and 4-year-olds across low-, middle-, and high-income groups to assess how targeted policy efforts have shaped ECE access across the income distribution.

To better understand the demographic and structural drivers of these disparities, the study uses Oaxaca-Blinder decomposition methods to partition the enrollment gap into components attributable to compositional characteristics (e.g., maternal education, employment) versus differential associations of these characteristics with enrollment. This approach enables a comparison between two distinct periods—1994–2008 and 2009–2023—bracketing eras before and after the Great Recession. The analysis provides insights into whether the factors contributing to enrollment disparities have shifted, persisted, or changed in salience over time.

This study contributes to the literature in three key ways. First, it updates the empirical record on income-based preschool enrollment disparities through 2023, extending prior analyses

that ended in the early 2010s (Magnuson & Waldfogel, 2016). Second, it advances decomposition research on ECE access (Jessen et al., 2020; Pilarz et al., 2019) by enabling temporal comparisons of explanatory factors across decades. Third, it situates these findings in the broader context of shifting maternal employment patterns and early education policy expansions, offering a timely assessment of both progress and setbacks in the effort to ensure equitable early learning opportunities for American children.

1.3 Background

Over the past several decades, non-parental child care became a normative aspect of early childhood in the United States. By 2023, 67% of preschool-aged children spent time in the care of someone other than a parent—including extended family members, neighbors, home-based child care providers, and formal early education programs such as preschools and community-based centers (Hanson et al., 2024). Families frequently rely on multiple care arrangements to meet their caregiving and work needs (Morrissey, 2008; National Center for Education Statistics, 2021). Among these options, high-quality child care plays a dual role: it supports children's early development while enabling parental labor force participation, especially among mothers.

Children's developmental needs vary by age and temperament, and no single arrangement is universally optimal. Nonetheless, research consistently shows that center-based care during the preschool years—particularly at ages 3 and 4—offers important developmental benefits. These settings promote peer interaction and school readiness and provide structured learning environments that support early cognitive and language growth (Gormley et al., 2005; Weiland & Yoshikawa, 2013). Compared to informal care, center-based programs are especially effective in preparing children from disadvantaged backgrounds for kindergarten (Duncan & Magnuson, 2013; Weiland & Yoshikawa, 2013).

Despite these benefits, center-based care remains among the most expensive forms of non-parental care. As a labor-intensive service requiring trained professionals, regulatory compliance, and substantial infrastructure, its cost is inherently high (Borowsky et al., 2021). These high costs render it inaccessible to many low- and moderate-income families, making affordability a central driver of enrollment disparities. Public policy responses—including subsidies for low-income working parents and the expansion of state-funded pre-K—have aimed to improve access, with evidence linking increased public investment to higher enrollment rates among low-income children (Crosby et al., 2010; Magnuson et al., 2007; Pilarz, 2018; Washbrook et al., 2011).

However, income alone does not fully explain persistent gaps in center-based enrollment. Income is closely tied to parental education, a key socioeconomic marker that influences early education decisions through multiple pathways (Crosnoe et al., 2016; Fuller et al., 1996; Greenberg, 2011). Parents with higher educational attainment can place greater value on formal education for their children (Lareau, 2003; Weininger et al., 2015), even controlling for income. They are also more likely to have access to information about child development and the long-term benefits of preschool, along with information about the application process, whereas informational barriers may limit the decision-making of less-educated parents (Burns et al., 2025; Hermes et al., 2021). Furthermore, parents with lower educational attainment are more likely to hold jobs with nonstandard hours and inconsistent schedules (Hepburn, 2019), making participation in center-based care more difficult logistically and less compatible with their work demands.

Structural inequalities in access to employment and care availability can further shape these enrollment gaps. Employment characteristics—including job stability, schedule regularity,

and flexibility—influence families' ability to enroll in center-based programs (Coley et al., 2014; Pilarz et al., 2019). Mothers with standard daytime schedules are more likely to use center-based care, while those with nonstandard hours face greater constraints (Han, 2004). Geographic variation in the supply of licensed providers also restricts access, especially in low-income or rural communities (Sipple et al., 2020).

Understanding how parental education, employment conditions, and geographic access contribute to the income-based preschool enrollment gap is essential for explaining persistent disparities or converging trends. Yet few studies have quantified the relative contributions of these sociodemographic and structural factors over time.

This study focuses on children ages 3 and 4—a developmental window when center-based care is particularly beneficial and when policy interventions have increasingly aimed to expand access. By examining both trends and explanatory factors across income groups, this study evaluates whether access to center-based early education has become more equitable and whether changes in maternal employment and structural constraints help explain the persistence—or narrowing—of enrollment disparities.

1.4 Data

This study uses data from the October Current Population Survey (CPS), an annual supplement to the monthly CPS that has been fielded every October since 1968. The October supplement collects school enrollment information for household members aged three or older. Prior work has documented income-based gaps in preschool enrollment using this dataset through 2013 (Magnuson & Waldfogel, 2016). To extend the trend analysis into the 2010s and early 2020s, I use October CPS data from 1994 to 2023.

When analyzing time trends in early childhood education (ECE) enrollment, I exclude two years—2020 and 2021—due to pandemic-related school and child care disruptions. The analytic sample includes 102,629 children aged 3 or 4. After excluding 5,008 observations from 2020–2021, 6,412 cases with missing family income data, and 2,969 children not residing with a mother (defined as a biological, step, or foster mother, or a female partner of the father), the final sample consists of 88,240 children.

Early Education Enrollment

Children's early education enrollment is measured using a binary indicator for school attendance among preschool-aged children in the October CPS. From 1968 to 1993, the survey asked whether the child was enrolled in school, and if so, followed up with a question about the grade level. One of the response options was "nursery school," which included both full-day and part-day enrollment. Starting in 1994, the CPS clarified the school enrollment question by adding a prompt that defined "regular school" to include nursery school, kindergarten, elementary school, and schooling that leads to a high school diploma. This was followed by a question on the specific grade level, which included a response category labeled "nursery (preschool, prekindergarten)." This change aimed to standardize how respondents understood and reported early school enrollment, likely improving the accuracy of preschool attendance measures over time. Considering this change in the measurement, this study limits the analysis to the trend in preschool enrollment from 1994 to 2023.

The reliability of the October CPS in capturing center-based ECE enrollment has been evaluated in earlier work. Magnuson and Waldfogel (2016) compared preschool enrollment rates from the October CPS to estimates from other national datasets, including the National Household Education Survey (NHES), the Early Childhood Longitudinal Study Kindergarten

Cohort (ECLS-K), and the National Survey of America's Families (NSAF), and found general consistency in enrollment trends. Building on this, I compare the 2019 CPS preschool enrollment estimate to those from more recent data sources, including the 2018 American Community Survey (ACS), the 2018 panel of the Survey of Income and Program Participation (SIPP), the 2019 NHES, and the 2019 National Survey of Early Care and Education (NSECE).

In 2019, the October CPS reported a preschool enrollment rate of 48% among 3- and 4-year-olds. This estimate aligns closely with the 48% reported in the ACS, which similarly asks about school enrollment for all household members aged three and older and collects responses throughout the calendar year. It is slightly higher than the 44% reported by the SIPP, which asks parents about child care arrangements during a typical week in the fall when the parent was working, attending school, or otherwise unavailable. The SIPP includes center-based care, nursery school, preschool, and Head Start programs. The CPS estimate is slightly lower than the 52% reported in the NSECE among children aged 3 to 5 not yet in kindergarten; the NSECE measures regular care arrangements of at least five hours per week and covers formal care types such as Head Start, prekindergarten, and community-based centers, based on data collected primarily between January and May. The NHES reported a higher enrollment rate of 61% among children aged 3 to 5 not yet in kindergarten, based on surveys administered from January to August. The NHES measures whether the child currently attends a day care center, preschool, or prekindergarten not located in a private home, including a broad array of center-based programs such as Head Start and other early childhood settings.

Taken together, these comparisons suggest that the October CPS estimate lies within the expected range across national surveys and is broadly consistent with more detailed measures of center-based ECE enrollment. This indicates that respondents in the October CPS are unlikely to

systematically misclassify informal or family child care as school enrollment, or fail to recognize formal early education programs as "school," lending credibility to the CPS as a data source for tracking trends in preschool participation.

Income

Family income is measured using categorical responses indicating total household income over the previous 12 months. To account for inflation and maintain comparability over time, I classified families into income groups based on their relative position in the annual income distribution—an approach consistent with prior work that used income quartiles or quintiles (Greenberg, 2010; Magnuson et al., 2007; Magnuson & Waldfogel, 2016). In this study, I divide the sample into income tertiles (low-, middle-, and high-income), which ensures that each group includes approximately one-third of the sample. This approach improves statistical power and stability of estimates.

Because the income distribution shifted considerably over the study period, the income cutoffs for each tertile also changed. In 1994, families in the bottom tertile reported incomes below $20,000, while in 2023 this threshold rose to $60,000. To contextualize these thresholds, the U.S. federal poverty guideline for a family of four was $14,800 in 1994 and $30,000 in 2023—meaning the bottom-middle cutoff spanned roughly 1.5 to 2 times the poverty line across the period. The middle tertile ranged from $20,000 to $40,000 in 1994 and from $60,000 to $150,000 in 2023. Families in the top tertile earned more than $40,000 in 1994 and more than $150,000 in 2023, with these cutoffs ranging from approximately 3 to 5 times the poverty line over time.

Covariates

This study includes a set of covariates capturing both child- and household-level characteristics that prior research has found to influence families' child care decisions (Coley et al., 2014; Crosnoe et al., 2016; Fuller et al., 1996; Greenberg, 2011; Joshi et al., 2025; Meyers & Jordan, 2006; Pilarz et al., 2019; Weber et al., 2018). At the child level, the covariates include the child's gender and race or ethnicity. At the household level, the model controls for the number of children under age 13 in the household, which may shape the affordability and need for child care services. It also includes the educational attainment of mother, categorized as high school or less, some college or associate's degree, and bachelor's degree or higher, as well as the parent's immigrant status, distinguishing between U.S.-born and foreign-born respondents. The parental partnership status is also included, coded as a binary variable indicating whether the parent resides with a spouse or partner in the household—regardless of whether the partner is a spouse or an unmarried partner, and regardless of gender.

To account for maternal labor supply, a three-category variable is constructed indicating whether the mother is not working (including those not in school or training), working part-time (fewer than 40 hours per week), or working full-time (40 or more hours per week). This categorization reflects the fact that ECE programs—often operating on limited schedules (e.g., 8 a.m. to 3 p.m. for full-day program and 8 a.m. to 12 p.m. for part-day) with inflexible drop-off and pick-up times—can be less accessible to full-time working mothers than to part-time workers, especially when compared to more flexible informal child care arrangements. Mothers who report being out of the labor force due to attending school or training are grouped with the part-time work category, as CPS does not provide detailed information about hours spent in education or training programs.

In addition to child and household characteristics, the analysis includes a full set of state fixed effects (indicators for the 50 states and the District of Columbia) to account for unobserved, time-invariant differences across states that may influence the availability and demand for center-based ECE. Including state fixed effects enables the identification of within-state trends in income-based preschool enrollment disparities by controlling for state-specific baseline differences. As a supplemental analysis, I incorporate annual state-level data on pre-K availability from the National Institute for Early Education Research (NIEER), available from 2002 to 2023. This allows for examining whether changes in the supply of publicly funded pre-K slots within states help explain trends in the income-based enrollment gap over time.

Table 1-1 presents descriptive statistics for the child and household-level covariates, disaggregated by income tertile and study period (1994–2008 and 2009–2023). The table shows significant differences across income groups within each time period for nearly all covariates except for child gender. The three rightmost columns of the table display average changes over time within each income group, with asterisks marking statistically significant differences in change for the lowest and middle-income groups relative to the highest-income group. Notably, the most substantial demographic shift over time is the pronounced increase in the share of mothers working full-time among high-income families.

1.5 Analytic Approach

To address the first research question—whether the income-based gap in preschool enrollment has narrowed between 1994 and 2023—I begin by descriptively illustrating trends in the enrollment rate gaps between high- and low-income and between high- and middle-income families. I then estimate the following linear probability models:

$$Y_{ist} = \alpha + \beta_1 low_{it} + \beta_2 mid_{it} + \beta_3 year_t + \beta_4 low_{it} \times year_t + \beta_5 mid_{it} \times year_t + \epsilon_{ist} \quad (1)$$

$$Y_{ist} = \alpha + \beta_1 low_{it} + \beta_2 mid_{it} + \beta_3 year_t + \beta_4 low_{it} \times year_t + \beta_5 mid_{it} \times year_t + \beta_6 X_{it} + \epsilon_{ist} \quad (2)$$

$$Y_{ist} = \alpha + \beta_1 low_{it} + \beta_2 mid_{it} + \beta_3 year_t + \beta_4 low_{it} \times year_t + \beta_5 mid_{it} \times year_t + \beta_6 X_{it} + \delta_s + \epsilon_{ist} \quad (3)$$

In these equations, Y_{ist} is a binary indicator of whether child *i* in state *s* and year *t* is enrolled in early education. The variables $low_{it}$and $mid_{it}$are dummy indicators for children in the bottom and middle tertiles of the family income distribution, respectively, with the top tertile (high-income) as the omitted reference group. Thus, β_1 and β_2 represent the average (unconditional or conditional) enrollment gaps between low- and high-income and between middle- and high-income children, respectively.

The variable $year_t$ is a continuous measure ranging from 1994 to 2023 indicating how ECE enrollment evolved over time between 1994 and 2023. Coefficient β_3 captures the linear time trend in enrollment among high-income children. The interaction terms (Low × Year and Mid × Year) allow the slope of the enrollment trend to vary by income group. The coefficients β_4 and β_5 represent whether enrollment among low- and middle-income children grew at a different rate than among their high-income counterparts. In Equation (2), I include a vector of child and household-level covariates X_{it} (described earlier) to estimate the conditional trend in enrollment disparities. Equation (3) presents the preferred specification, which includes state fixed effects (δ_s) to account for time-invariant differences across states. As a supplemental analysis, I augment this model by incorporating a state-year measure of public pre-K enrollment rates. For models estimating center-based ECE enrollment among 4-year-old children, I include the percentage of 4-year-olds enrolled in public pre-K in the state, scaled from 0 to 100 and interpreted as a percentage-point change. Likewise, for the 3-year-old models, I include the percentage of 3-year-olds enrolled in the state public pre-K.

Because data on state-level public pre-K enrollment is only available from 2002 to 2023, this supplemental model uses a restricted sample covering those years. To ensure comparability, I re-estimate the preferred model (Equation 3) on the same 2002–2023 subsample. I then compare the estimated income-group-specific time trends across these models. The supplemental model includes both the main effect of public pre-K coverage and its interactions with indicators for low- and middle-income groups. In this setup, the coefficient on the pre-K coverage variable reflects its association with center-based ECE enrollment among high-income children, while the interaction terms capture differential associations for low- and middle-income children.

I estimate all equations using ordinary least squares (OLS) for ease of interpretation and consistency with the Oaxaca-Blinder decomposition framework, which is also based on OLS. For all analyses, standard errors are clustered at state levels.

To address the second research question—what factors contributed to the income-based enrollment gap during the early and later periods— I estimate Oaxaca-Blinder decomposition models to directly examine the extent to which observed sociodemographic and work-related characteristics explain the income-based enrollment gap in the earlier (1994-2008) and later (2009-2023) periods. The decomposition separates the total difference in enrollment between low- and high-income (or middle- and high-income) children into two parts: the explained component, which reflects differences in group characteristics (e.g., maternal employment, education), and the unexplained component, which reflects differences in coefficients or unobserved factors (Blinder, 1973; Oaxaca, 1973; Blau & Kahn, 2017). In describing the decomposition results, I will explore whether the strength of association between household characteristics and ECE enrollment varies by income group in the two periods. I estimate the

following regression separately for each income group ($j \in$ {low, middle, high}) and time period ($k \in$ {1994–2008, 2009–2023}):

$$Y_{ist}^{j,k} = \alpha^{j,k} + \beta^{j,k} X_{it}^{j,k} + \delta_s + \epsilon_{ist}^{j,k} \quad (3)$$

In this study, I interpret the unexplained component as reflecting contextual or preferential differences in enrollment behavior between income groups—that is, the portion of the gap that remains even if low-income families had the same average characteristics as high-income families. This may capture differing viable options, cultural preferences, access barriers, or institutional constraints. However, it is important to emphasize that the decomposition is a descriptive, accounting exercise and not intended for causal inference.

1.6 Results

Descriptive Results

Before turning to the multivariate regression and decomposition analyses, I begin with descriptive trends in ECE enrollment by income group. Figure 1-1 plots the center-based ECE enrollment rates among 4-year-olds in each income tertile. The first panel of Table 1-2 presents average enrollment rates across time periods: the study period spanning from 1994 to 2023 is divided into seven-year intervals, but the last interval is separated into a three-year period before the COVID-19 pandemic (2016-2019), a two-year period for the pandemic (2020–2021), and a two-year post-pandemic period (2022–2023).

Enrollment increased for 4-year-olds across all income groups from 1994 to 2008. Since then, however, enrollment among the lowest-income children plateaued at around 53%, and for the middle-income group, around 58%. Enrollment among the highest-income group has fluctuated slightly since the late 2000s—declining during the Great Recession, then hovering around 70% until a dip during the COVID-19 period. Gaps between income groups narrowed

between the late 1990s and early 2010s, reaching their lowest point during 2009–2015, but widened again in the late 2010s and further during the post-pandemic years.

ECE enrollment for 3-year-olds (Figure 1-2 and the second panel of Table 1-2) is generally lower than 4-year-olds, and income-based gaps are larger. The enrollment rose steadily from 1994 to 2019 among low- and middle-income 3-year-old children. Among high-income children, enrollment increased until 2005, then declined during the Great Recession and did not recover to pre-recession levels. As a result, income-based gaps narrowed through the early 2010s, reaching a minimum around 2016–2019, before widening again during 2022–2023. This pattern mirrors the trend observed for 4-year-olds.

OLS regression results

Table 1-3 presents estimates from linear probability models. In Model 2, which adjusts for child and household characteristics, 4-year-olds in the lowest income tertile are 14 percentage points (pp) less likely to attend center-based ECE than their high-income peers ($p < .001$). Children in the middle tertile are 10.7 pp less likely ($p < .001$). Model 3, which adds state fixed effects, yields similar results: the enrollment gap is 13.8 pp ($p < .001$) for low-income and 10.4 pp ($p < .001$) for middle-income children relative to their high-income peers. These conditional gaps are smaller than the unconditional differences in Model 1 (21.9 pp and 15.4 pp, respectively), suggesting that demographic and household covariates explain a meaningful portion of the observed disparities.

The coefficient on the continuous year variable in Model 3, which captures the linear time trend, indicates a marginally significant decline in enrollment among high-income 4-year-olds over time—about 0.1 pp per year ($p < .10$) from 1994 to 2023 (excluding 2020–2021). More notably, the interaction terms between year and income groups indicate that enrollment among

low- and middle-income children increased relative to high-income peers, narrowing the enrollment gap over time. Specifically, the low-high gap decreased by 0.2 pp annually ($p < .001$), and the middle-high gap by a similar magnitude ($p < .05$).

Results for 3-year-olds follow a similar pattern. In Model 2, conditional enrollment gaps are 19.7 pp (low vs. high, $p < .001$) and 16.7 pp (middle vs. high, $p < .001$); in Model 3, these decrease slightly to 17.8 pp and 15.5 pp, respectively (both $p < .001$). Compared to the unconditional differences in Model 1 (26.4 pp and 21.3 pp), these reductions again suggest meaningful contributions from covariates. The year coefficient in Model 3 reveals a 0.2 pp annual decline in enrollment among high-income children ($p < .01$), while the significant positive interaction terms (+0.3 pp; $p < .001$) for both low- and middle-income groups indicate a narrowing gap over time.

Several covariates show strong associations with ECE enrollment. For both age groups, Black children are more likely, and Hispanic children less likely, to attend center-based ECE than white peers. Children in larger families and those with less educated or immigrant mothers are less likely to enroll. Children of unpartnered mothers are more likely to attend. Interestingly, children of part-time working mothers have higher enrollment than those with full-time working mothers, while children of non-working mothers have lower enrollment. For 3-year-olds, girls are more likely than boys to attend ECE—a pattern not observed among 4-year-olds.

Overall, these results suggest that income-based disparities in center-based ECE enrollment have narrowed between 1994 and 2023 for four- and three-year-old children, driven largely by declining enrollment among high-income families. In contrast, enrollment among low- and middle-income children remained stable or increased, contributing to the convergence. The

results also highlight the importance of child and family characteristics in explaining enrollment patterns.

Before turning to the decomposition analysis, I present supplemental results assessing whether these differential trends by income group are explained by the expansion of state pre-K programs. Appendix Table 1-A1 reports the estimates. The first column replicates Model 3 using a sample restricted to 2002–2023, consistent with the availability of state-level pre-K enrollment data. During this period, ECE enrollment among high-income 4-year-olds declined by 0.3 pp per year ($p < .001$), on average. The interaction term for low-income children indicates a narrowing of the gap by 0.2 pp per year ($p < .10$), though marginally significant. The interaction for middle-income children is not statistically significant, suggesting their trend closely parallels that of high-income peers.

When the model includes the state pre-K enrollment rate and its interactions with income group, the time trend for low-income children is no longer significantly different from that of high-income children, meaning their trend is statistically not different from high-income children's trend once we account for pre-K expansion. Additionally, a one percentage-point increase in pre-K enrollment is associated with a 0.1 pp decline in center-based ECE enrollment among high-income children ($p < .05$), while the corresponding differences for low- and middle-income children are 0.1 pp higher ($p < .01$ and $p < .10$, respectively). These findings suggest that the narrowing income-based gap in the post-2000 period may be partially explained by expanded state pre-K coverage, particularly by buffering low-income children from the broader decline in center-based ECE participation seen among other income groups.

In the parallel analysis for 3-year-olds, Model 3 (2002–2023 sample) shows a 0.4 pp annual decline in enrollment among high-income children ($p < .001$), contributing to gap

reductions of 0.3 pp ($p < .01$) with low-income children and 0.5 pp ($p < .001$) with middle-income children. Notably, incorporating state-level pre-K enrollment rates for 3-year-olds does not alter this pattern, consistent with the limited expansion of pre-K access for 3-year-olds during this period (NIEER, 2024). Also, the pre-K enrollment variable shows little association with ECE enrollment across the three income groups.

Decomposition Results

Table 1-4 presents Oaxaca-Blinder decomposition results for the enrollment gap between low- and high-income children, estimated separately for 4- and 3-year-olds and across two time periods: 1994–2008 and 2009–2023. All results are based on Model 3, which includes state fixed effects.

Among 4-year-olds, the average enrollment gap declined from 20.7 percentage points (pp) in 1994–2008 to 17.2 pp in 2009–2023. The explained portion of the gap grew from 12.0 pp ($p < .001$; 58% of the total gap) to 15.3 pp ($p < .001$; 89%), while the unexplained portion shrank from 8.8 pp ($p < .001$) to 1.9 pp (not statistically significant). This shift suggests that the narrowed enrollment gap is primarily due to a reduction in differences in how characteristics translate into enrollment (i.e., smaller coefficient differences), rather than major changes in group composition.

At the variable level, maternal education remains the largest contributor to the explained component, accounting for 7.7 pp ($p < .001$) in the earlier period and 9.3 pp ($p < .001$) in the later period. Other compositional factors—such as higher proportions of Hispanic children, larger families, and greater immigrant representation—explain smaller but consistent shares of the enrollment gap.

Within the unexplained component, differences in the effect of maternal non-employment are particularly noteworthy. In 1994–2008, this variable accounts for 2.9 pp of the gap ($p < .01$), reflecting that children of non-working mothers in low-income families were less likely to attend center-based ECE, whereas the opposite was true in high-income families. By 2009–2023, this difference had narrowed (1.5 pp; not statistically significant), suggesting a convergence in how maternal employment status relates to enrollment across income groups. (See Appendix Table 1-A2 for income-stratified OLS estimates.)

Among 3-year-olds, the total gap declined from 25.5 pp to 21.3 pp. The explained component increased modestly—from 14.1 pp ($p < .001$; 55.3% of the gap) to 16.2 pp ($p < .001$; 76.1%)—while the unexplained portion declined from 11.4 pp ($p < .001$) to 5.1 pp ($p < .01$). Again, maternal education was the most significant contributor to the explained gap, accounting for 11.1 pp ($p < .001$) in the earlier period and 8.6 pp ($p < .001$) in the later. Within the unexplained component, differences in the coefficient of maternal non-employment explain 6.7 pp ($p < .05$) of the gap in 1994–2008 and 3.9 pp ($p < .05$) in 2009–2023. As shown in Appendix Table 1-A3, this finding reflects a stark divergence: for low-income 3-year-olds, having a non-working mother was associated with lower enrollment, while among high-income peers, it was associated with higher enrollment—particularly in the earlier period.

Table 1-5 reports parallel decomposition results comparing middle- and high-income children. Among 4-year-olds, the total enrollment gap narrowed from 14.2 pp to 12.0 pp. The explained portion increased slightly (6.0 pp to 6.9 pp, both $p < .001$), while the unexplained portion declined from 8.2 pp ($p < .001$) to 5.1 pp ($p < .001$). For 3-year-olds, the gap declined more substantially—from 19.7 pp to 14.4 pp—primarily due to a reduction in unexplained components (from 11.5 pp to 6.9 pp, both $p < .001$). As with the low-high comparisons, maternal

education consistently explains the largest share of the explained gap, and differences in the coefficients for maternal employment status remain a key contributor to the unexplained component.

1.7 Discussion and Conclusion

This study examined trends in income-based disparities in center-based early childhood education (ECE) enrollment from 1994 to 2023, using nationally representative data from the October CPS. It addressed two key questions: (1) whether the enrollment gap between income groups has narrowed over time, and (2) what demographic and household factors account for these disparities in early versus later decades.

The results show that significant disparities by income persist, with larger gaps among 3-year-olds than 4-year-olds. The enrollment gap between high-income and low- or middle-income children narrowed between the mid-1990s and the early 2010s. This convergence was especially pronounced following the Great Recession, when enrollment among low-income children increased while high-income enrollment plateaued or declined. However, this narrowing trend stalled—and slightly reversed—during the late 2010s and post-pandemic period, suggesting that access to center-based ECE remains limited for many low-income families.

Multivariate regression analyses estimated annual trend from 1994 to 2023 across income groups, showing that ECE enrollment decreased among those in the top income tertile, while remaining stable or increasing among children in the bottom and middle income tertiles, even after adjusting for family characteristics and states. Decomposition analyses further revealed that the narrowing income-based gap was largely driven by a reduction in unexplained differences—suggesting that differences in how household characteristics translate into enrollment diminished over time. In contrast, the share of the gap explained by observable compositional differences—

particularly maternal education—remained large and stable over time. The consistent contribution of maternal education to explaining income-based disparities in ECE enrollment indicates the need for policies that address the unique barriers faced by low-income mothers with limited post-secondary education. These may include limited access to information, differing perceived value of formal early education, and incompatibility with their work schedules—all of which can shape decisions around early childhood education.

Supplemental analyses highlight the importance of publicly funded pre-K, particularly for 4-year-old children. The narrowing gap in this age group appears partially attributable to the expansion of state pre-K, which helped sustain enrollment among low-income children while enrollment declined among their higher-income peers. In contrast, the narrowing gap among 3-year-olds was not explained by pre-K expansion, suggesting that secular trends—such as increasing parental demand, shifting cultural norms, or the growth of non–state-funded center-based programs—may have driven rising or stable enrollment in lower-income families. These findings underscore the need for continued investment in early education access for younger preschoolers and suggest that efforts beyond state pre-K—such as expanded subsidies, mixed-delivery systems, or targeted outreach—may be critical for reducing disparities at age 3.

This study makes two contributions to the literature. First, it extends prior work (e.g., Bainbridge et al., 2005; Magnuson & Waldfogel, 2016) by updating trends through 2023 and by incorporating the post-COVID period, providing timely insight into how pandemic-era disruptions may have affected inequality in early education access. Second, the use of Oaxaca-Blinder decomposition illuminates that maternal education remains the strongest compositional driver of persistent disparities, while heterogeneity in the effects of maternal employment has narrowed over time—contributing to a modest reduction in unexplained enrollment gaps.

The findings underscore that maternal education remains the single most consistent predictor of enrollment disparities, accounting for a substantial share of the explained gap in both decades. Moreover, the role of maternal employment is particularly dynamic: for low-income families, mothers' work status strongly predicts ECE enrollment, while for high-income families, the relationship is weaker or even reversed. These diverging patterns suggest that work-care trade-offs and parental decision-making are shaped by family resources. They also highlight the importance of ECE programs as not only child development but also supports for maternal employment, particularly among disadvantaged families.

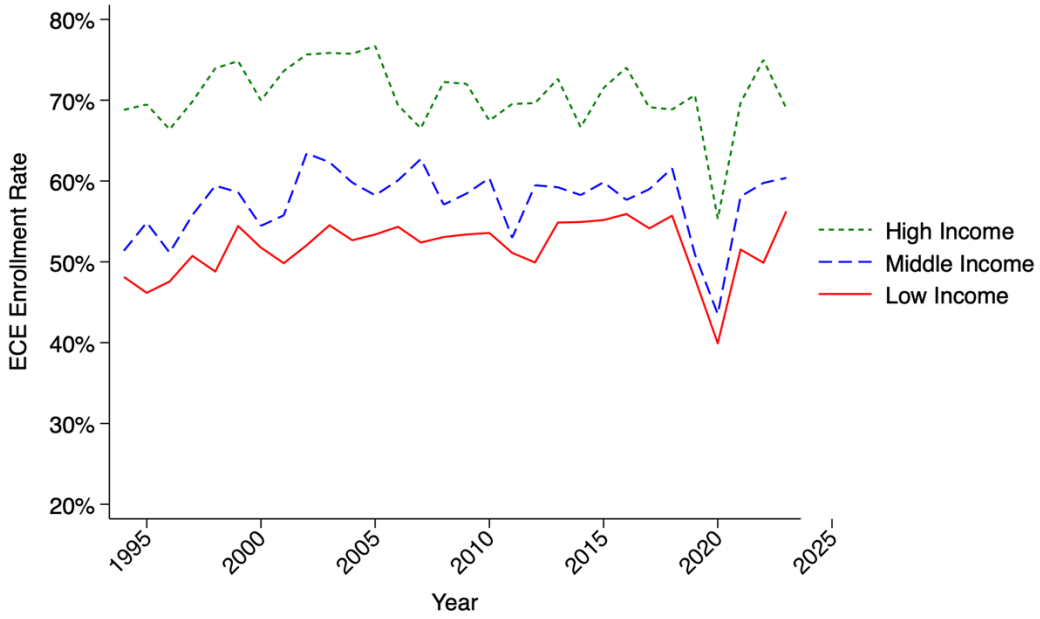
Despite these contributions, several limitations should be noted. First, although decomposition techniques are useful for partitioning observed disparities, they do not inform causal relationships. Second, omitted variables can overestimate the unexplained portion of the ECE enrollment gaps across income groups. Namely, this study could not consider the work schedules of parents—which are known to affect ECE enrollment decisions (Han, 2004; Pilarz et al., 2019)—due to data limitations in the October CPS. It also could not take child care supply-side factors into consideration. Third, the income tertile approach, while effective for tracking relative inequality over time, may mask variation within income groups and growing income disparity between high-, middle-, and low-income families over time (Duncan et al., 2017).

Future research should continue to monitor post-pandemic trends in ECE access and inequality. Greater attention to the factors driving increased enrollment among low- and middle-income 3-year-olds—such as changes in the child care market or normative preferences—would enhance understanding of secular shifts in ECE enrollment. Moreover, future studies should examine the role of specific policy interventions—such as universal pre-K expansions, changes in Head Start funding, or child care subsidy programs—in shaping these enrollment trends.

Finally, linking early enrollment patterns to long-term developmental outcomes would provide valuable insight into the broader implications of convergence or persistence in early education inequality.

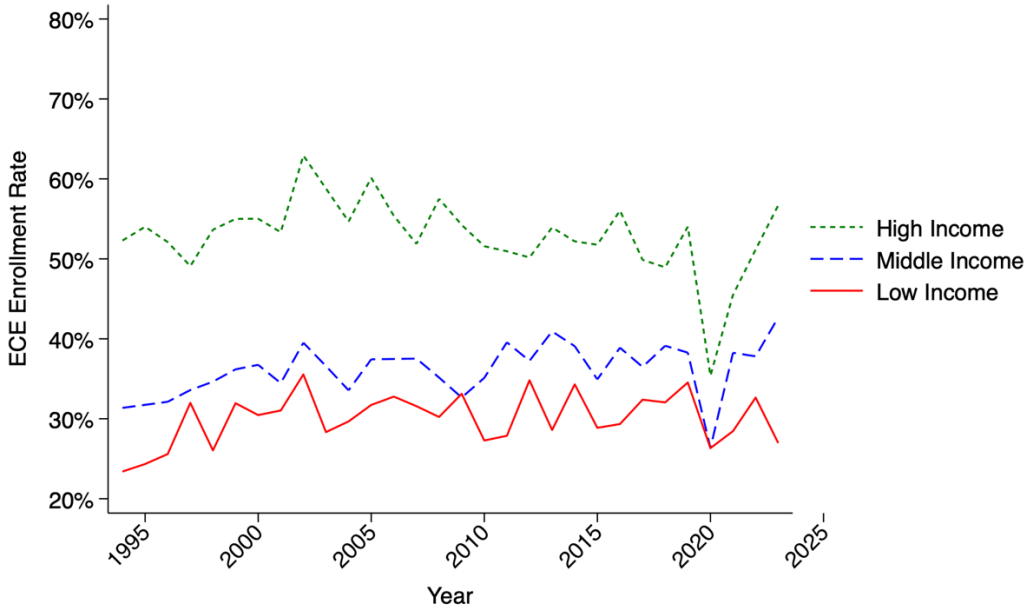
Figures

Figure 1-1. Percent of children enrolled in ECE by income tertile, 4-year-olds



Source: October Current Population Survey (1994-2023). **Note:** Estimates are weighted.

Figure 1-2. Percent of children enrolled in ECE by income tertile, 3-year-olds



Source: October Current Population Survey (1994-2023). **Note:** Estimates are weighted.

Tables

Table 1-1. Demographic composition of families with preschool-age children, by income tertile and early and later periods

	1994-2008			2009-2023			Changes between periods		
Income tertile	Lowest Mean / %	Middle Mean / %	Highest Mean / %	Lowest Mean / %	Middle Mean / %	Highest Mean / %	Lowest	Middle	Highest
Female child	50%	49%	49%	49%	48%	48%	-1 pp	-1 pp	-1 pp
Child race and ethnicity									
White non-Hispanic	40%	68%	81%	36%	60%	70%	-4 pp*	-8 pp*	-11 pp
Black, non-Hispanic	26%	11%	6%	24%	12%	7%	-2 pp*	+1 pp	+1 pp
Asian/Pacific Islander and other, non-Hispanic	4%	4%	6%	5%	6%	11%	+1 pp*	+2 pp*	+5 pp
Hispanic/Latino	30%	16%	7%	35%	22%	12%	+5 pp	+6 pp	+5 pp
Number of children (<age 13)	2.33	2.21	2.20	2.32	2.21	2.17	-0.01	0.00*	-0.03
Mother's education									
Highschool or less	70%	43%	16%	60%	31%	10%	-10 pp*	-12 pp*	-6 pp
Some college	25%	34%	27%	30%	33%	19%	+5 pp*	-1 pp*	-8 pp
Bachelor's degree or more	5%	23%	57%	10%	36%	71%	+5 pp*	+ 13 pp	+14 pp
Immigrant mother	26%	17%	13%	29%	21%	20%	+3 pp*	+4 pp*	+7 pp
Single mother	43%	11%	3%	39%	12%	4%	-4 pp*	+1 pp	+1 pp
Mother's work status									
No work	54%	39%	38%	54%	38%	31%	0 pp*	-1 pp*	-7 pp
Part-time work (<40 h)	24%	29%	30%	23%	26%	26%	-1 pp*	-3 pp	-4 pp
Full-time work (>=40h)	23%	32%	33%	22%	36%	44%	-1 pp*	-4 pp*	+11 pp
N	17,711	17,388	13,863	14,520	14,064	10,694			

Source: October Current Population Survey (1994-2023). **Note:** Estimates are weighted. The sample is restricted to families with children ages 3 to 4. Asterisk indicates the statistically significant differences at a 95% confidence level in changes across time periods for the lowest and middle-income groups relative to the highest-income group.

Table 1-2. Percent of children enrolled in ECE by income tertile

	1994-2000	2001-2008	2009-2015	2016-2019	2020-2021	2022-2023
4-Year-Olds Preschool Enrollment Rate						
Lowest Tertile (T1)	50%	53%	54%	53%	47%	52%
Middle Tertile (T2)	55%	60%	58%	57%	50%	60%
Highest Tertile (T3)	70%	74%	70%	72%	57%	72%
T3-T1 difference	20 pp	21 pp	16 pp	19 pp	10 pp	20 pp
T3-T2 difference	15 pp	14 pp	12 pp	15 pp	7 pp	12 pp
T2-T1 difference	5 pp	7 pp	4 pp	4 pp	3 pp	8 pp
N	11,811	12,639	11,745	5,858	2,568	2,081
3-Year-Olds Preschool Enrollment Rate						
Lowest Tertile (T1)	27%	30%	30%	31%	27%	29%
Middle Tertile (T2)	34%	37%	38%	40%	32%	41%
Highest Tertile (T3)	54%	57%	52%	52%	38%	55%
T3-T1 difference	27 pp	27 pp	22 pp	21 pp	11 pp	26 pp
T3-T2 difference	20 pp	20 pp	14 pp	12 pp	6 pp	14 pp
T2-T1 difference	7 pp	7 pp	8 pp	9 pp	5 pp	12 pp
N	11,658	12,854	11,639	5,830	2,285	2,125

Source: October Current Population Survey (1994-2023). **Note:** Estimates are weighted. The differences in early childhood education (ECE) enrollment rates are shown in percentage-points terms (pp).

Table 1-3. OLS regression predicting ECE enrollment

	4-year-olds			3-year-olds		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$
Child and household-level controls	No	Yes	Yes	No	Yes	Yes
State fixed effects control	No	No	Yes	No	No	Yes
Income group *(ref=highest income tertile)*						
Lowest income tertile	-0.219***	-0.140***	-0.138***	-0.267***	-0.197***	-0.178***
	(0.011)	(0.012)	(0.012)	(0.011)	(0.011)	(0.012)
Middle income tertile	-0.154***	-0.107***	-0.104***	-0.214***	-0.167***	-0.155***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Year (1994-2023)	0.000	-0.001*	-0.001+	-0.001	-0.002***	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Lowest income tertile X year	0.002**	0.003***	0.002***	0.002**	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Middle income tertile X year	0.002*	0.002*	0.002*	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Child female		-0.004	-0.005		0.009+	0.009*
		(0.005)	(0.005)		(0.004)	(0.004)
Child race (ref=white)						
Black		0.023**	0.019*		0.036***	0.016*
		(0.008)	(0.008)		(0.008)	(0.008)
Asian/other/unknown		-0.038***	-0.017		0.007	0.010
		(0.010)	(0.011)		(0.010)	(0.010)
Hispanic		-0.042***	-0.038***		-0.062***	-0.066***
		(0.007)	(0.008)		(0.007)	(0.008)
Number of children (age < 13)		-0.019***	-0.019***		-0.021***	-0.019***
		(0.003)	(0.003)		(0.002)	(0.002)
Mother's education (*ref=bachelor's degree+)*		-0.150***	-0.145***		-0.164***	-0.159***

High school or less						
		(0.007)	(0.007)		(0.007)	(0.006)
Some college degree		-0.078***	-0.074***		-0.091***	-0.083***
		(0.006)	(0.006)		(0.006)	(0.006)
Immigrant mother (*ref=US born)*		-0.039***	-0.043***		-0.026***	-0.041***
		(0.007)	(0.007)		(0.007)	(0.007)
Single mother (*ref=partnered mother*)		0.033***	0.031***		0.066***	0.059***
		(0.007)	(0.007)		(0.007)	(0.007)
Mother's work status (*ref=full-time work*)						
Not working		-0.023***	-0.021***		-0.014*	-0.020***
		(0.006)	(0.006)		(0.006)	(0.006)
Part-time work		0.043***	0.043***		0.049***	0.043***
		(0.006)	(0.006)		(0.006)	(0.006)
Intercept	0.718***	0.816***	0.808***	0.549***	0.642***	0.629***
	(0.008)	(0.011)	(0.011)	(0.009)	(0.011)	(0.011)
N	44,134	44,134	44,134	44,106	44,106	44,106

Source: October Current Population Survey (1994-2023), excluding 2020 and 2021. Standard errors are clustered at the state level and presented in parentheses.
*** p<.001, ** p<.01, * p<.05, + p<.1

Table 1-4. Oaxaca-Blinder decomposition of ECE enrollment gap between low-income and high-income families

	4-year-olds				3-year-olds			
	1994-2008		2009-2023		1994-2008		2009-2023	
	Coef	s.e.	Coef	s.e.	Coef	s.e.	Coef	s.e.
Overall								
ECE enrollment rate among T1	0.720***	0.005	0.704***	0.006	0.551***	0.006	0.523***	0.007
ECE enrollment rate among T3	0.513***	0.005	0.532***	0.006	0.296***	0.005	0.310***	0.005
T3-T1 difference	0.207***	0.008	0.172***	0.009	0.255***	0.008	0.213***	0.009
T3-T1 explained difference	0.120***	0.016	0.153***	0.016	0.141***	0.017	0.162***	0.016
T3-T1 unexplained difference	0.088***	0.017	0.019	0.018	0.114***	0.019	0.051**	0.018
Explained								
Child female	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Race/ethnicity - Black	0.007+	0.004	0.002	0.004	0.004	0.004	0.004	0.004
Race/ethnicity – Asian/others	0.000	0.000	-0.001	0.001	0.000	0.000	-0.002+	0.001
Race/ethnicity - Hispanic	0.010+	0.005	0.016**	0.005	0.008	0.005	0.025***	0.005
Number of children	0.002*	0.001	0.003**	0.001	0.004***	0.001	0.003*	0.001
High school degree or less	0.077***	0.008	0.093***	0.010	0.111***	0.009	0.086***	0.011
Some college degree	0.000	0.001	0.010***	0.002	-0.001	0.001	0.010***	0.002
Immigrant mother	0.004+	0.002	0.005*	0.002	0.006*	0.003	0.001	0.002
Single mother	0.009	0.012	0.019+	0.011	0.001	0.013	0.017	0.012
Non-working mother	-0.004+	0.002	0.001	0.004	-0.010***	0.003	-0.005	0.004
Part-time working mother	0.003***	0.001	0.001	0.000	0.004**	0.001	0.001*	0.001
Unexplained								
Child female	-0.006	0.022	0.001	0.025	0.041+	0.023	-0.005	0.026
Race/ethnicity - Black	-0.025***	0.007	-0.011	0.007	-0.022**	0.007	-0.013+	0.007
Race/ethnicity – Asian/others	-0.007**	0.002	-0.004	0.002	-0.008**	0.002	-0.006*	0.002
Race/ethnicity - Hispanic	-0.016*	0.008	-0.017+	0.009	-0.002	0.008	-0.025**	0.009
Number of children	-0.001	0.020	-0.043+	0.023	-0.028	0.020	-0.039+	0.023
High school degree or less	-0.026	0.019	-0.065***	0.017	-0.084***	0.019	-0.020	0.017
Some college degree	-0.012+	0.007	-0.023**	0.008	-0.027***	0.007	-0.005	0.008
Immigrant mother	0.006	0.006	-0.004	0.007	-0.004	0.006	0.005	0.007
Single mother	-0.032*	0.014	-0.035**	0.013	-0.034*	0.015	-0.040**	0.014
Non-working mother	0.029**	0.010	0.015	0.011	0.067***	0.010	0.039**	0.012

Part-time working mother	0.003	0.005	0.000	0.006	0.009+	0.005	0.012*	0.006
Constant	0.170*	0.076	0.097**	0.037	0.041	0.023	-0.005	0.026
N	15,767		12,630		15,807		12,584	

Source: October Current Population Survey (1990-2023), excluding 2020 and 2021. **Note:** T1 and T3 refer to the lowest and highest income tertiles, respectively. The decomposition is based on Model 3 that controls for state fixed-effects. Standard errors are clustered at the state level and presented in parentheses. *** p<.001, ** p<.01, * p<.05, + p<.1

Table 1-5. Oaxaca-Blinder decomposition of ECE enrollment gap between middle-income and high-income families

	4-year-olds				3-year-olds			
	1994-2008		2009-2023		1994-2008		2009-2023	
	Coef	s.e.	Coef	s.e.	Coef	s.e.	Coef	s.e.
Overall								
ECE enrollment rate among T2	0.720***	0.005	0.704***	0.006	0.551***	0.006	0.523***	0.007
ECE enrollment rate among T3	0.578***	0.005	0.584***	0.006	0.354***	0.005	0.379***	0.006
T3-T2 difference	0.142***	0.008	0.120***	0.009	0.197***	0.008	0.144***	0.009
T3-T2 explained difference	0.060***	0.006	0.069***	0.006	0.083***	0.006	0.075***	0.006
T3-T2 unexplained difference	0.082***	0.009	0.051***	0.010	0.115***	0.010	0.069***	0.011
Explained								
Child female	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Race/ethnicity - Black	0.002+	0.001	0.000	0.001	0.001	0.001	0.001	0.001
Race/ethnicity – Asian/others	-0.001*	0.000	-0.001	0.001	-0.001+	0.000	-0.002+	0.001
Race/ethnicity - Hispanic	0.004+	0.002	0.007**	0.002	0.003	0.002	0.009***	0.002
Number of children	0.000	0.000	0.001	0.000	0.000	0.001	0.001*	0.001
High school degree or less	0.038***	0.004	0.039***	0.004	0.052***	0.004	0.034***	0.004
Some college degree	0.007***	0.001	0.014***	0.002	0.009***	0.001	0.014***	0.003
Immigrant mother	0.001+	0.001	0.000	0.000	0.002*	0.001	0.000	0.000
Single mother	0.002	0.002	0.004+	0.002	0.000	0.002	0.004	0.002
Non-working mother	0.000	0.000	0.000	0.001	-0.001+	0.001	-0.001	0.001
Part-time working mother	0.000	0.000	0.000	0.000	0.001+	0.000	0.000	0.001
Unexplained								
Child female	0.011	0.022	-0.007	0.025	0.029	0.023	-0.012	0.026
Race/ethnicity - Black	-0.005+	0.003	0.002	0.003	-0.002	0.003	-0.003	0.003

Race/ethnicity – Asian/others	-0.001	0.002	-0.003	0.002	-0.003	0.002	-0.006*	0.002
Race/ethnicity - Hispanic	0.002	0.004	-0.004	0.005	0.006	0.004	-0.009+	0.006
Number of children	0.065**	0.020	-0.011	0.023	-0.027	0.020	-0.006	0.023
High school degree or less	0.005	0.009	-0.011	0.008	-0.015+	0.009	-0.018*	0.008
Some college degree	-0.005	0.007	-0.002	0.007	-0.007	0.007	-0.008	0.008
Immigrant mother	-0.001	0.004	-0.006	0.005	-0.002	0.004	0.007	0.005
Single mother	-0.004	0.004	-0.006	0.004	-0.004	0.004	-0.008*	0.004
Non-working mother	0.020**	0.007	0.021**	0.008	0.037***	0.007	0.026**	0.008
Part-time working mother	0.003	0.006	-0.004	0.006	0.003	0.006	0.009	0.006
Constant	0.002	0.077	-0.070	0.080	0.065	0.083	0.138	0.084
N	15,642		12,429		15,609		12,329	

Source: October Current Population Survey (1990-2023), excluding 2020 and 2021. **Note:** T2 and T3 refer to the middle and highest income tertiles, respectively. Standard errors are clustered at the state level and presented in parentheses. *** p<.001, ** p<.01, * p<.05, + p<.1

Appendix

Table 1-A1. OLS regression models predicting ECE enrollment without and with accounting for yearly state pre-K coverage (2002-2023)

	4-year-olds		3-year-olds	
	Model 3	**Supplement Model**	**Model 3**	**Supplement Model**
	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$
Household-level controls	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
State-year pre-K coverage rate	No	Yes	No	Yes
Income group *(ref=highest income tertile)*				
Lowest income tertile	-0.130***	-0.135***	-0.184***	-0.185***
	(0.023)	(0.024)	(0.022)	(0.022)
Middle income tertile	-0.079**	-0.081**	-0.191***	-0.191***
	(0.024)	(0.023)	(0.023)	(0.023)
Year (2002-2023)	-0.003***	-0.002*	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Lowest income tertile X year	0.002+	0.001	0.003**	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Middle income tertile X year	0.000	0.000	0.005***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Pre-K coverage rate		-0.001*		0.001
		(0.000)		(0.001)
Lowest income tertile X Pre-K coverage		0.001**		0.001
		(0.000)		(0.001)
Middle income tertile X Pre-K coverage		0.001+		0.001
		(0.000)		(0.001)
Child female	-0.004	-0.005	0.006	0.006
	(0.004)	(0.004)	(0.006)	(0.006)
Child race (ref=white)				
Black	0.002	0.001	0.012	0.012
	(0.013)	(0.013)	(0.013)	(0.013)
Asian/other/unknown	-0.022	-0.021	0.012	0.012
	(0.015)	(0.015)	(0.018)	(0.018)
Hispanic	-0.033***	-0.033***	-0.063***	-0.063***
	(0.009)	(0.009)	(0.009)	(0.009)
Number of children (age < 13)	-0.016***	-0.016***	-0.015***	-0.015***
	(0.004)	(0.004)	(0.004)	(0.004)
Mother's education (*ref=bachelor's degree+)*	-0.147***	-0.148***	-0.151***	-0.151***

High school or less				
	(0.013)	(0.013)	(0.008)	(0.008)
Some college degree	-0.078***	-0.078***	-0.086***	-0.087***
	(0.010)	(0.010)	(0.008)	(0.008)
Immigrant mother (*ref=US born)*	-0.043**	-0.043**	-0.041***	-0.041***
	(0.015)	(0.015)	(0.008)	(0.007)
Single mother (*ref=partnered mother*)	0.027**	0.027**	0.051***	0.051***
	(0.010)	(0.010)	(0.009)	(0.009)
Mother's work status (*ref=full-time work*)				
Not working	-0.031***	-0.031***	-0.024*	-0.024*
	(0.007)	(0.007)	(0.009)	(0.009)
Part-time work	0.034***	0.033***	0.049***	0.049***
	(0.006)	(0.006)	(0.008)	(0.008)
Intercept	0.843***	0.847***	0.673***	0.673***
	(0.021)	(0.020)	(0.020)	(0.020)
N	30,649	30,649	30,742	30,742

Source: October Current Population Survey (2002-2023), National Institute for Early Education Research (2002-2023) excluding 2020 and 2021. Pre-K coverage rate is measured as percentage of 4-year-olds (or 3-year-olds) attending pre-K in state. Standard errors are clustered at the state level and presented in parentheses. *** p<.001, ** p<.01, * p<.05, + p<.1

Table 1-A2. OLS regression predicting ECE enrollment for 4-year-olds, by income tertile and periods

	1994-2008			2009-2023		
	T1 Lowest Tertile	T2 Middle Tertile	T3 Highest Tertile	T1 Lowest Tertile	T2 Middle Tertile	T3 Highest Tertile
	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$
Year	0.005***	0.006***	0.001	-0.001	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Child female	-0.006	-0.019+	-0.011	0.002	0.008	0.004
	(0.010)	(0.010)	(0.011)	(0.012)	(0.012)	(0.012)
Child race and ethnicity (ref=white)						
Black	0.068***	0.010	-0.043+	0.037*	-0.037+	-0.014
	(0.016)	(0.019)	(0.025)	(0.017)	(0.021)	(0.027)
Asian/other/unknown	0.038	-0.052*	-0.079**	0.017	-0.002	-0.041
	(0.025)	(0.026)	(0.026)	(0.027)	(0.027)	(0.025)
Hispanic	0.009	-0.071***	-0.047+	-0.020	-0.055**	-0.075***
	(0.017)	(0.019)	(0.025)	(0.017)	(0.018)	(0.022)
Number of children (age<13)	-0.015**	-0.045***	-0.016*	-0.005	-0.018**	-0.023**
	(0.005)	(0.006)	(0.007)	(0.006)	(0.006)	(0.008)
Mother's education (ref=Bachelor's degree or more)						
Highschool or less	-0.103***	-0.150***	-0.144***	-0.081***	-0.158***	-0.191***
	(0.023)	(0.014)	(0.015)	(0.020)	(0.015)	(0.021)
Some college	-0.029	-0.059***	-0.077***	-0.021	-0.091***	-0.096***
	(0.025)	(0.014)	(0.013)	(0.021)	(0.014)	(0.016)
Immigrant mother	-0.064***	-0.032+	-0.036+	-0.032*	-0.015	-0.049*
	(0.016)	(0.018)	(0.020)	(0.016)	(0.018)	(0.019)
Single mother	0.055***	0.017	-0.023	0.033**	0.000	-0.055+
	(0.012)	(0.018)	(0.031)	(0.013)	(0.019)	(0.031)

Mother's work status (ref=full-time work)						
No work	-0.031*	-0.031*	0.023+	-0.033*	-0.061***	-0.005
	(0.013)	(0.013)	(0.013)	(0.015)	(0.014)	(0.015)
Part-time work (<40 h)	0.044**	0.050***	0.058***	0.021	0.036*	0.022
	(0.015)	(0.013)	(0.014)	(0.017)	(0.015)	(0.015)
Intercept	0.575***	0.747***	0.785***	0.622***	0.761***	0.814***
	(0.029)	(0.021)	(0.020)	(0.042)	(0.038)	(0.039)
N	8,808	8,683	6,959	7,255	7,054	5,375

Source: October Current Population Survey (1994-2023), excluding 2020 and 2021. **Note:** Standard errors are clustered at the state level and presented in parentheses. *** p<.001, ** p<.01, * p<.05, + p<.1

Table 1-A3. OLS regression predicting ECE enrollment for 3-year-olds, by income tertile and periods

	1994-2008			2009-2023		
	T1 Lowest Tertile	T2 Middle Tertile	T3 Highest Tertile	T1 Lowest Tertile	T2 Middle Tertile	T3 Highest Tertile
	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$	β $(S.E.)$
Year	0.006***	0.005***	0.002+	-0.001	0.003*	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Child female	0.003	0.011	0.030*	0.004	0.009	0.001
	(0.009)	(0.010)	(0.012)	(0.011)	(0.011)	(0.013)
Child race and ethnicity (ref=white)						
Black	0.073***	-0.002	-0.027	0.030+	-0.002	-0.032
	(0.014)	(0.019)	(0.027)	(0.016)	(0.021)	(0.028)
Asian/other/unknown	0.059**	-0.007	-0.062*	0.043+	0.045	-0.056*
	(0.022)	(0.026)	(0.029)	(0.026)	(0.027)	(0.028)
Hispanic	-0.042**	-0.091***	-0.042	-0.038*	-0.066***	-0.114***
	(0.016)	(0.019)	(0.026)	(0.016)	(0.018)	(0.024)

Number of children (age<13)	-0.023***	-0.024***	-0.036***	-0.004	-0.018**	-0.021*
	(0.005)	(0.006)	(0.007)	(0.006)	(0.006)	(0.008)
Mother's education (ref=Bachelor's degree or more)						
Highschool or less	-0.086***	-0.168***	-0.210***	-0.146***	-0.116***	-0.178***
	(0.022)	(0.013)	(0.017)	(0.018)	(0.015)	(0.023)
Some college	-0.003	-0.084***	-0.105***	-0.078***	-0.069***	-0.095***
	(0.023)	(0.013)	(0.014)	(0.019)	(0.014)	(0.018)
Immigrant mother	-0.034*	-0.043*	-0.054**	-0.028+	-0.046**	-0.009
	(0.015)	(0.017)	(0.021)	(0.015)	(0.018)	(0.021)
Single mother	0.081***	0.038*	-0.002	0.054***	0.028	-0.052
	(0.010)	(0.018)	(0.034)	(0.012)	(0.019)	(0.035)
Mother's work status (ref=full-time work)						
No work	-0.062***	-0.037**	0.061***	-0.050***	-0.045**	0.024
	(0.012)	(0.013)	(0.015)	(0.014)	(0.014)	(0.016)
Part-time work (<40 h)	0.013	0.042**	0.051***	0.025	0.043**	0.076***
	(0.014)	(0.013)	(0.015)	(0.016)	(0.015)	(0.017)
Intercept	0.361***	0.485***	0.637***	0.457***	0.430***	0.592***
	(0.027)	(0.020)	(0.022)	(0.038)	(0.036)	(0.043)
N	8,903	8,705	6,904	7,265	7,010	5,319

Source: October Current Population Survey (1994-2023), excluding 2020 and 2021. **Note:** Standard errors are clustered at the state level and presented in parentheses. *** p<.001, ** p<.01, * p<.05, + p<.1

Paper 2: The Effects of Universal Pre-kindergarten for Three-year-old Children on Mothers' Employment and Families' Economic Well-being

2.1 Abstract

This study examines the effects of New York City's 3-K for All (3K) program, a universal pre-kindergarten (pre-K) initiative for three-year-olds, on maternal employment, income-to-needs ratio, and material hardship among families. By leveraging the staggered rollout of 3K across school districts, I apply a difference-in-difference (DiD) framework using data from the Early Childhood Poverty Tracker (2017–2023), a longitudinal survey of New York City families with young children. The analysis estimates within-family changes in outcomes after children became eligible for the 3K program among those who lived in districts offering 3K, compared to those without access, employing an event-study design to assess dynamic effects over time. The findings show a significant increase in maternal employment among two-parent households by 6.6 percentage points once their children became eligible for 3K. Single mothers experienced a delayed but significant increase in employment by 13.3 percentage points one year later. Additionally, the likelihood of material hardship decreased significantly for families facing greater constraints to employment, such as those with younger children and low-income families, as well as U.S.-born parents, by 11-19 percentage points. These results suggest that universal pre-K supports maternal employment and improves the economic well-being of certain family subgroups.

2.2 Introduction

Universal pre-kindergarten (pre-K) programs have gained considerable attention as key policy tool for expanding access to high-quality early childhood education. Unlike other early care and education programs such as child care subsidies, Head Start, or targeted pre-K initiatives, universal pre-K programs are unique in that eligibility is determined solely by children's age, regardless of parents' income status. While these programs' primary goal is fostering children's human capital development, it can also produce substantial social benefits through enabling greater parental workforce participation.

Robust evidence demonstrates the benefits of universal pre-K on children's short-term school readiness (Gormley et al., 2005; Lipsey et al., 2018; Weiland & Yoshikawa, 2013), but research on its effects on parental employment remains relatively limited and inconclusive. Earlier studies have investigated programs in Georgia and Oklahoma which serve four-year-olds, and tend to report minimal or inconsistent effects on maternal employment. For instance, some studies find no significant increases in mothers' employment (Fitzpatrick, 2010; Li, 2020), while others report small, non-robust effects primarily among less-educated mothers (Cascio & Schanzenbach, 2013). However, evidence from Washington D.C. (Malik, 2018) and New Haven (Humphries et al., 2024), programs that serve both three- and four-year-olds, find positive gains in employment outcomes.

This study aims to extend the literature by investigating the effects of expanding universal pre-K eligibility from four-year-olds to three- and four-year-olds. Although the age group served by the universal pre-K program may significantly influence mothers' labor supply decisions, yet this factor has been largely overlooked in previous studies. There are two reasons to expect universal pre-K programs for three- and four-year-olds to have more substantial effects

on mothers' labor supply decisions compared to programs exclusively for four-year-olds. First, a child's age is a critical determinant in a mother's labor supply decisions (Blau, 2001). Mothers with younger children face greater barriers to workforce participation due to higher child care needs and costs. Therefore, universal pre-K for younger children may have a stronger maternal employment effect, as these mothers are more likely to remain non-employed without access to such programs. Second, the longer a mother remains out of the workforce, the more difficult it becomes for her to return, and the lower her potential earnings (Alessandra & Salvatore, 2023; Waldfogel, 1997). Universal pre-K program that provides earlier support after childbirth may reduce the time spent away from the labor market, allowing mothers to retain higher earning potential and significantly increasing labor supply.

Moreover, the narrow geographical scope of existing research further limits our understanding of the broader effects of universal pre-K programs. The focus on a small set of states leaves open questions about how such programs perform in different settings. Additionally, most studies have used cross-sectional data (except for Humphries et al., 2024), which only captures the immediate effects of universal pre-K of women with any children eligible for pre-K, and could not examine the potential for lasting or delayed impacts on parental employment and family well-being.

This study addresses these gaps in several important ways. First, it investigates New York City's 3-K for All, universal pre-K program for three-year-olds, thus addressing the geographic and program design limitations of prior research. Second, the use of longitudinal data enables a more comprehensive analysis of both the immediate and longer-term effects of universal pre-K on maternal employment. Third, this study broadens the scope of inquiry by examining the program's effect on families' economic well-being, including income-to-needs

ratio and material hardship, which have been underexplored in previous research. Finally, this study offers a nuanced analysis by exploring heterogeneous effects across different subgroups, such as family structure (two-parent vs. single-parent), presence of younger children, income levels, and immigrant status, providing a deeper understanding of how universal pre-K may differentially affect families.

This study seeks to answer the following research questions: (1) Does the availability of universal pre-K increase maternal employment? (2) Does this employment effect persist after children are no longer age-eligible for the program? (3) Does universal pre-K improve families' economic well-being by increasing income or reducing material hardship? (4) How do these effects vary across different demographic and socioeconomic groups?

This study utilizes data from the Early Childhood Poverty Tracker (ECPT), a longitudinal study that follows a sample of New York City families with young children from 2017 to 2023. This dataset includes detailed information on child care arrangements, parental employment, and family economic insecurity, including measures of poverty and material hardship. The focal child in each family is defined as any child whose mother's employment status was observed in the data when the child was between one and three years old.

This study employs a quasi-experimental design, taking advantage of the staggered rollout of New York City's 3-K for All (3K) program across school districts. I examine the changes in outcomes when the focal child turned three within a family, comparing families in districts where 3K was available and those in districts where it was not yet available, using a difference-in-difference (DiD) approach with family fixed-effects (or unit fixed-effects as the outcomes are reported at family level in the data) in an event-study framework. This design identifies the

effects of universal pre-K by tracking changes in outcomes as children become eligible for 3K, while controlling for all time-invariant family-level characteristics.

Findings from the full sample do not indicate that the availability of 3K significantly increased maternal employment or raised family income-to-needs ratio. However, there is suggestive evidence that the program reduced the likelihood of experiencing material hardship by 8 percentage points during the 3K year, though these estimates are marginally significant ($p < .10$). These effects do not appear to persist in the years following 3K eligibility.

Subgroup analyses reveal important differential effects. Partnered mothers experienced a significant rise in employment. In contrast, single mothers exhibited delayed employment gains, with significant effects emerging one year after 3K eligibility. Additionally, reductions in material hardship were most pronounced among families facing greater childcare-related constraints on workforce participation, such as low-income families and those with younger children. Notably, U.S.-born parents were likely to benefit from reduced material hardship, but not immigrant parents, highlighting potential barriers immigrant families face in accessing labor market opportunities.

This study provides new evidence on the role of universal pre-K for three-year-olds in supporting maternal employment and improving economic security. The findings suggest that the employment gains from universal pre-K should be factored into broader cost-benefit analyses of such programs, alongside the benefits for children. Moreover, the heterogeneous effects observed underscore the importance of tailoring policy design to meet the diverse needs and constraints of different family types. Finally, the use of longitudinal data provides a more complete picture of the program's effects, pointing to the need for future research to examine both the immediate and delayed outcomes of universal pre-K policies.

The structure of the paper is as follows. Section 2.3 provides an overview of New York City's 3-K for All program. Section 2.4 reviews the theoretical framework and empirical evidence on the effects of universal pre-K on maternal employment in the U.S. Sections 2.5 and 2.6 detail the data and identification strategy. Section 2.7 presents the estimated effects of 3K availability on maternal employment and family economic well-being. Section 2.8 discusses the results of robustness checks and placebo tests. Finally, Section 2.9 concludes.

2.3 New York City's 3-K for All

Between 1998 and 2013, New York City offered publicly subsidized pre-K for a limited number of four-year-old children at no cost to parents. In 2014, the city expanded this initiative, transforming the program into a universal, full-day pre-K available to all four-year-olds over a two-year period, ultimately serving nearly 65% of the city's four-year-olds. Building on this success, New York City launched the 3-K for All (3K) program in 2017, extending the universal pre-K framework to include three-year-old children. Unlike the pre-K expansion for four-year-olds, the 3K program began on a smaller scale, with citywide access achieved five years later.

Initially, in 2017, the 3K program was available in only two districts. By 2018, the program expanded to six districts, then to 12 in 2019, 16 in 2020, and finally all 32 districts by 2021, ensuring universal availability across the city. In 2022, approximately 40,000 three-year-old children enrolled in the 3K program, accounting for about 40% of all New York City children aged three (Gossett, 2024). Figure 2-1 illustrates the variation in years that 3K was rolled out across school districts. Families could apply for 3K regardless of their district, but priority was given to those residing in districts offering the program. The rollout plan prioritized economically disadvantaged districts with lower average incomes, targeting areas with greater child care needs.

The 3K program provides a full school-day schedule (6.5 hours per day, five days a week) throughout the academic year. Families can choose from a variety of settings when applying for 3K, including: (1) District schools (public, charter, and private), (2) Community-based early childhood education centers like child care centers and Head Start programs that contract with the NYC Department of Education (DOE), (3) Pre-K centers directly operated by NYC DOE, and (4) Licensed home-based child care programs monitored by NYC DOE and the Family Child Care Network. Eligibility for 3K is determined by the child's birth year. For instance, a child who turns three in 2024 becomes eligible to enroll in September of that year. Families can apply for 3K in different school districts. However, when the number of applicants for 3K exceeds that of available slots, the priority is given to children who live near the 3K program.

Families can also apply for free or low-cost extended-day and year-round seats, which are offered in center-based or home-based care settings. However, the number of extended-day and extended-year seats are limited in number, accounting for only 10% of 3K seats. The eligibility for these seats follows the same rule as child care vouchers funded by the Child Care and Development Block Grant (CCDBG) (Office of the New York City Comptroller Brad Lander, 2025).

As I will further explain in the method section, the staggered rollout of 3K created a quasi-experiment, allowing for a comparison between families in treatment and comparison groups during the program's expansion period. Families in some districts had access to 3K when their child turned three, while others—either in districts without 3K or with slightly older children—did not. Importantly, the city's selection of early rollout districts was based on child care needs, requiring the study's design to control for observed and unobserved differences

between districts and families, ensuring that estimated effects reflect the program itself rather than district or family characteristics.

Additionally, it is important to note that families in both treatment and comparison groups could enroll their four-year-olds in the existing universal pre-K program. Thus, the key difference between the groups is that the treatment group had access to universal pre-K starting at age three, while the comparison group only had access starting at age four.

2.4 Literature Review

The static labor supply theory suggests that a mother's decision to work is influenced by the availability of free or low-cost childcare options, such as a universal pre-K program, as these affect her net earnings (Blau, 2001). Additionally, the labor supply model posits that policies altering individuals' budget constraints can have varying effects depending on their position in the income distribution (Bitler et al., 2006), Therefore, the impact of universal pre-K is expected to differ based on a mother's employment status. For instance, for mothers working fewer than pre-K hours or those currently out of the labor force, subsidized childcare effectively raises their net hourly wage by removing work-related costs of additional hours of work. This creates an incentive to enter or increase participation in the workforce, especially for those who might otherwise defer labor market participation due to high childcare expenses. In contrast, for mothers working more hours than those covered by pre-K, the program would give less incentive to increase work but rather increase disposable income through reducing fixed childcare costs. Therefore, labor supply theory predicts minimal changes in labor force participation for these mothers. Overall, the theory suggests that averaging these effects may mask the positive impact of universal pre-K on mothers whose labor market decisions are heavily constrained by childcare

availability—an important consideration for policy evaluation. This section reviews studies that estimate both the average and heterogeneous effects of universal pre-K.

Numerous studies emphasize that extended time away from the workforce following childbirth reduces mothers' wages and weakens their labor force attachment (Aisenbrey et al., 2009; Lundberg & Rose, 2000). This literature suggests that a universal pre-K program offering an earlier, additional year of subsidized care could have a stronger effect on increasing maternal employment, compared to programs for older children. As hypothesized by Lefebvre et al. (2009), earlier access to subsidized preschool may shorten career breaks and reduce the depreciation of human capital accumulated through prior education or work experience. Additionally, the short-term incentive to re-enter the labor market may generate long-term benefits if the extra year of work experience leads to higher wages and improved career prospects over time.

Effects of universal pre-K on mother's employment

Early evaluations on universal pre-K programs suggest limited maternal employment effects, particularly at the extensive margin (See Morrissey, 2017 for review). Fitzpatrick (2010) was among the first to examine mothers' labor supply effects of universal pre-K in the U.S., focusing on Georgia and Oklahoma—the first two states to implement state-funded pre-K for all four-year-old children in the late 1990s. The findings indicated that while universal pre-K significantly increased preschool enrollment across various subgroups, its impact on maternal labor outcomes—including labor force participation, employment, hours worked, and earnings—was minimal. Subsequent studies that evaluated the same programs also found little increase in maternal employment. For example, Li (2020) employed a synthetic control method and found no significant increase in employment at the extensive margin in either state. However, they did

observe that Georgia's mandate for a full-day pre-K program led to an increase in weekly hours worked and a higher proportion of full-time working mothers.

In contrast, studies focusing on programs in other regions documented positive parental labor supply effects. Malik (2018) finds that introducing universal pre-K for 3- and 4-year-olds in Washington D.C. significantly increased mothers' labor force participation, using synthetic control method and a difference-in-difference approach. Also, Humphries et al. (2024) reported significant gains in parental employment and earnings induced by universal pre-K program in New Haven, Connecticut, which also serve 3- and 4-year-olds, employing a randomized control trial. These studies underscore the importance of evaluating various universal pre-K programs across different regions to understand how maternal employment response is dependent on program design and local context.

Most prior studies have focused on contemporaneous employment of mothers when their children were age-eligible for universal pre-K, which has limited our ability to measure the full benefits of the program, including potential delayed or sustained employment effects (Lefebvre et al., 2009; Schiman, 2022). One notable exception is the recent work of Humphries et al. (2024). They examined parental labor supply both during and after the pre-K years and found an increase in employment rate and in parental earnings during the pre-K year. While the employment effect was short-lived, the increase in earnings continued for six more years.

This paper builds on the existing literature by evaluating New York City's 3-K for All, a universal pre-K program for three-year-olds. It provides a unique chance to examine how mothers make employment decisions in response to a free, full school-day, high-quality pre-K program for three-year-olds in a major metropolitan area. This study also examines both the

immediate and extended effects of universal pre-K on mothers' employment, utilizing a longitudinal panel data.

Effects of universal pre-K on family's economic well-being

If universal pre-K programs effectively lower child care costs and allow more mothers to work, it can have downstream implications for a family's economic security. The additional mothers' earnings or saved child care expenditures may increase household disposable income, helping families meet their basic material needs. However, to my best knowledge, the potential effects of universal pre-K on improving families' economic security has not yet been fully examined.

The most relevant evidence comes from examination on earnings (Fitzpatrick, 2010; Humphries et al., 2024), on likelihood of welfare receipt (Fitzpatrick, 2010), and on child care expenses (Cascio and Schanzenbach, 2013; Humphries et al., 2024). While Fitzpatrick (2010) did not find significant association between universal pre-K eligibility and mothers' wage earnings and the likelihood of welfare receipt, Humphries et al. (2024) found that universal pre-K increased parental earnings by $5,461, on average. Cascio and Schanzenbach (2013) and Humphries et al. (2024) found evidence that universal pre-K lowers out-of-pocket child care costs. Cascio and Schanzenbach (2013) reported ITT estimates in range of $450-$500 for the 9-month academic year among higher-educated families. Humphries et al. (2024) found substantial TOT estimate of $375 monthly costs reduction associated with universal pre-K enrollment.

While these studies provide insights into parental wage earnings, welfare receipt, and child care costs, they leave unanswered questions about whether universal pre-K improves total household disposable income or a family's ability to meet basic needs. This study addresses these gaps by assessing the effect of universal pre-K on families' economic well-being using two

key measures: income-to-needs ratio and material hardship. Recognizing that universal pre-K can affect various income sources (e.g., earnings, cash or near-cash public transfers) and work-related essential costs (e.g., child care costs, and commuting costs), this study evaluates whether universal pre-K increased families' after-tax and transfer income resources net of work-related expenses relative to the poverty line, which can be measured by Supplemental Poverty Measure (SPM) income-to-needs ratio. To further investigate the effects of universal pre-K on families' experiences of economic insecurity beyond income, the study also measures material hardship.

Heterogeneous effects of universal pre-K

Prior research has investigated whether the employment outcomes of different subgroups of mothers are differentially affected by the availability of universal pre-K programs. However, the literature remains limited, with findings often inconsistent. This section reviews key studies that examine differential effects of universal pre-K, focusing on variations by family structure, the age of the youngest child, maternal education level, and parental immigrant status.

Family structure

Fitzpatrick (2010) and Li (2020) investigated whether the labor supply of single mothers and married mothers in Georgia and Oklahoma responded differently to the availability of universal pre-K. Fitzpatrick (2010) found that while universal pre-K increased preschool enrollment across both groups, there was no statistically significant increase in labor supply outcomes for either single or married mothers. In contrast, Li (2020) reported divergent effects when analyzing the states separately: Oklahoma saw a significant increase in employment among married mothers and a significant decrease among single mothers, while Georgia yielded no significant results for either group.

Age of the youngest child

Fitzpatrick (2010) and Li (2020) also examined whether labor supply responses to universal pre-K differ by the age of the youngest child in the household. The rationale behind this approach is that mothers with an additional younger child may face greater challenges in transitioning to work, as they must secure childcare for the younger child in addition to enrolling their older child in pre-K (Cascio, 2009; Fitzpatrick, 2012; Gelbach, 2002). Fitzpatrick (2010) found no significant increase in labor supply outcomes among mothers with or without children younger than four. Li (2020) expanded this analysis by categorizing mothers into three groups: those with only a 4-year-old child, those with both a 4-year-old and a younger child, and those with a 4-year-old and an older child. Like Fitzpatrick (2010), Li (2020) also found no significant employment effects across these groups in either state.

Maternal education level

Cascio and Schanzenbach (2013) and Li (2020) considered maternal education as a key factor that could moderate the labor supply effects of universal pre-K, given the close relationship between education level, wage potential, and family income. Cascio and Schanzenbach (2013) highlighted that universal pre-K in Georgia and Oklahoma increased employment primarily among mothers with a high school degree or less. Similarly, Li (2020) found a significant increase in employment among less-educated mothers in Georgia, though Oklahoma showed no such effects for mothers with lower education levels.

Parental immigrant status

A notable gap in the literature concerns the differential effects of universal pre-K by parental immigrant status. Research indicates that immigrant families are less likely to enroll their children in early childhood education programs (Magnuson et al., 2006; Cui & Natzke,

2021), possibly due to limited access to information and greater commuting burdens to publicly funded programs (Neidell & Waldfogel, 2009). These barriers may suppress the effects of universal pre-K on maternal employment among immigrant families. Yet, existing research has not adequately addressed this issue. Understanding whether and how immigrant mothers respond to the availability of universal pre-K remains an important area for research.

Contribution of the present study

Building on these prior studies, the present study examines which subgroups of mothers are most affected by the availability of universal pre-K by stratifying the sample by family structure, presence of younger children, family income level, and parental immigrant status. By conducting these subgroup analyses, this research aims to advance our understanding of which groups of mothers are most responsive to universal pre-K programs, as well as what barriers may inhibit some families from increasing employment in response to these programs.

2.5 Data

This study uses data from the Early Childhood Poverty Tracker (ECPT), a longitudinal panel dataset collected between 2017 and 2023. The ECPT follows a representative sample of New York City families with at least one child aged 0-3 in 2017, with a baseline sample of 1,516 families recruited via random sampling, alongside oversampling from selected low-income neighborhoods. The ECPT's longitudinal design tracks these families with multiple surveys conducted per year, providing detailed information on family demographics, employment, and economic well-being.

The ECPT is well-suited for this analysis for several reasons. First, it focuses specifically on New York City residents, offering a large, diverse sample, ideal for analyzing the effects of the 3-K for All (3K) program using within-city comparisons. Second, the timing of data

collection coincides with the expansion of the 3K program between 2017 and 2021. This allows for analyzing natural variation in exposure: while some families lived in districts where the 3K program was available when their child turned three, others resided in areas where the program had not yet been implemented. Third, the ECPT provides longitudinal records of mothers' employment before, during, and after their child's 3K eligibility, enabling a detailed analysis of dynamic employment effects. Finally, the ECPT includes rich data on families' economic well-being, including income poverty and material hardship measures, which are central to assessing the broader economic impacts of 3K availability (Neckerman et al., 2019).

Sample Selection

The analytic sample was restricted based on the following criteria to enhance the validity and relevance of the study. First, 296 families were excluded for not providing information on the mother's employment when the focal child was age three—the eligible age for the 3K program—due to either not being in waves or item non-response. Additionally, 521 families were excluded due to missing employment information when the focal child was age one or younger, as this data is essential for testing the parallel trend assumption in the event-study design. Finally, 167 families whose children were eligible for the 3K program during the peak of the COVID-19 pandemic (2020–2021 academic year) were excluded, considering the potential confounding effects of the pandemic on employment outcomes.[1]

To supplement the sample size, data of families with young children from the Poverty Tracker (PT), a parallel longitudinal study to the ECPT that includes the same outcome measures, was incorporated. The PT tracked a representative sample of adults living in New York City from 2015 to 2020, enhancing the robustness of the analysis.

[1] Most results are robust to the inclusion of these families. See Tables 2-A9 – 2-A19 in the Appendix for robustness checks.

These exclusion criteria resulted in a final analytic sample of 637 families, each contributing repeated observations across multiple time points spanning before, during, and after 3K eligibility, covering child ages 1 to 3 and beyond. The unit of analysis is wave-by-family observation, meaning each row in the dataset represents one family at one survey wave. The final sample includes 8,055 wave-family observations for maternal employment, drawn from 15 surveys (five annual and ten interim surveys) collected between 2017 and 2023. For outcomes available only in annual surveys, such as income-to-needs and material hardship, the sample includes 2,874 wave-family observations. Table 2-A2 in the appendix details how the sample size changed with each exclusion criterion.

Measurements for key variables

Treatment status was identified using the residential school district when the focal child was age one and the child's birth year. The residential information at age one was used instead of age three to minimize selection bias from families relocating to school districts offering 3K programs. Families' zip code information was used to determine their residential school districts. A treatment identifier was assigned a value of one if a family had access to a 3K program in their residential school district when the focal child turned three, and zero if no 3K program was available in the district at that time.

The key outcome variables in this study are: (1) mothers' employment, (2) families' income-to-needs ratio, and (3) families' material hardship. A mother was considered employed (coded as one) if she worked full-time, part-time, freelance, or was self-employed; and coded as zero if unemployed or not participating in the labor force. Families' income-to-needs ratio is a continuous variable of household total annual post-tax and transfer income net of work-related expenses as a proportion of the poverty line measured by the Supplemental Poverty Measure

(SPM).[2] The income-to-needs ratio is standardized to have a mean of 0 and a standard deviation of 1.

Material hardship was defined as a binary variable, coded as one if the family experienced at least one type of hardship in the past 12 months. The hardship indicators include food insecurity, being behind on rent, unmet medical needs due to cost, utility cutoffs, and financial insecurity.[3] Considering that each hardship indicator identifies a distinct type of hardship and empirical evidence that households respond differently to lump-sum versus monthly regular income support (Parolin et al., 2023), five individual hardship indicators were separately examined as a supplemental analysis. The results are presented in the Appendix (Table 2-A8).

It is important to note that families' income and material hardship were reported retrospectively for the past 12 months, meaning the effects of 3K availability on economic well-being outcomes could be observed when the child is age 4, in the year following their 3K eligibility.

Descriptive summary

Table 2-1 presents the unweighted summary statistics of household characteristics of the main analytic sample, stratified by 3K treatment status.[4] The table reveals no statistically significant differences between the treatment and comparison groups in the average parent's age,

[2] The Supplemental Poverty Measure (SPM) is a more comprehensive method for determining poverty that accounts for a broader range of income net of work-related expenses. It measures resources by adding earnings, cash, and noncash public benefits as resources, then subtracting necessary expenses like taxes, medical costs, and work-related expenses (e.g., commuting costs and child care costs capped at the income of the lowest-earning family member). The poverty threshold is determined based on basic needs such as food, clothing, shelter, utilities, telephone, and internet access. This threshold is adjusted for geographic differences in housing costs.

[3] Specific question wording and definition of the five material hardship indicators is presented in Table 2-A3 in the Appendix.

[4] The descriptive statistics of the supplemental sample, which includes 167 families with children who were eligible for the 3K program during the COVID-19 pandemic, are presented in the Table 2-A1 in the Appendix.

the proportion of immigrant parents, the proportion of low-income families (with income below 200% of the SPM poverty line), or the proportion of families with female focal children. However, the treatment group is characterized by a higher proportion of single-parent households (0.27 vs. 0.20), a lower proportion of families with younger children when the focal child was age three (0.26 vs. 0.36), a lower proportion of parents with only a high school or General Education Development (GED) degree (0.12 vs. 0.21), and a lower proportion of white parents (0.22 vs. 0.34). These demographic differences likely reflect New York City's nonrandom 3K rollout plan, which prioritized districts with higher needs for regulated childcare.[5] Additionally, the treatment group had a higher proportion of families with children born in 2016 (1 vs. 0.85) compared to those born in 2014 or 2015, consistent with the staggered rollout of the program. Importantly, the treatment group in the analytic sample consists entirely of children born in 2016, who became eligible for 3K in 2019, meaning there is no variation in treatment timing. These descriptive results highlight the need to control for demographic characteristics that could vary over time, such as the presence of partners or younger children, as well as unobserved differences between families.

Table 2-2 presents the unweighted summary statistics of the key outcome variables for the 3K treatment and comparison groups, based on the focal child's age and their (pre)school grade. Panel A shows that mothers' employment rates increased gradually as the focal child aged from 1 to 3 in both the treatment and comparison groups. Notably, the year-to-year increase between ages 2 and 3 was larger for the treatment group (9 percentage points, from 60% to 69%) compared to the comparison group (4 percentage points, from 61% to 65%). Both groups

[5] Most results are robust to restricting the sample to families in districts with priority in the 3K expansion plan. See Tables 2-A9 —2-A19 in the Appendix for robustness checks.

experienced a temporary dip in employment rates when their children turned four, likely due to the disruptive effects of the COVID-19 pandemic, as the majority (89%) of the sample had children born in 2016 who turned four in 2020. Employment rates rebounded for both groups when children turned five.

Panel B shows an increasing pattern in SPM income-to-needs ratio as children aged from 1 to 3, from 1.86 to 2.05 in the treatment group and from 1.99 to 2.22 in the comparison group. A more substantial increase occurred between ages three and four, from 2.05 to 2.50 in the treatment group and from 2.22 to 2.63 in the comparison group, possibly due to the expansion of social safety net policies in response to the pandemic (Parolin & Filauro, 2023).

In a similar vein, Panel C indicates that the percentage of families experiencing at least one form of material hardship remained relatively stable from ages 1 to 3. However, both groups experienced a significant decline in material hardship when the focal child turned four. The treatment group saw a 14 percentage point reduction (from 38% to 24%), while the comparison group showed a 9 percentage point decrease (from 40% to 31%).

2.6 Analytic Approach

A major challenge in identifying the causal effects of universal pre-K on mothers' employment is that when the program is universally available to all age-eligible children, differences in employment between mothers who enroll their children in the program and those who do not may reflect underlying family preferences or needs rather than the true effects of the program. To address this issue, prior studies have employed difference-in-difference (DiD) designs to estimate the causal effects of universal pre-K. Some studies have used the introduction of the program to create exogenous variation in availability across states (Cascio & Schanzenbach, 2013; Li, 2020), while others have exploited variation in program eligibility

based on children's birthdate cutoffs and differences in program availability across states (Fitzpatrick, 2010). A more recent study applied a randomized controlled trial approach, leveraging variation in universal pre-K enrollment through a lottery system (Humphries et al., 2024).

This study uses the DiD framework to identify the causal effects of 3K availability. The first difference captures how the outcomes change as children become eligible for the 3K at age 3. The second difference leverages the staggered rollout plan of the 3K program within New York City, which created a quasi-experiment providing families in some parts of the city more availability of 3K. The DiD identifies the changes for the treated group in outcomes associated with the changes in 3K age-eligibility status (children's age) relative to the changes for the comparison group. The identification assumption is that the availability of 3K is the only reason for the treatment group to show different patterns in outcomes as children turn age 3 from the comparison group. In other words, assuming that outcomes would have changed at the same rate as children become three years old in all school districts in the absence of the 3K rollout, I estimate the effects of 3K by the difference in the rate of changes in outcomes between treated and comparison groups.

I estimate an event-study model instead of aggregating the differences in pre-post eligibility periods between the treated and comparison groups into a single DiD estimate. The event-study model is informative to statistically test the parallel trend assumption during the pre-eligible period (focal child age 1-2), as well as to identify the dynamic effects during the 3K year (focal child age 3) and after children aged out of 3K eligibility (focal child age 4-7). My specification equation is,

$$Y_{idt} = \beta_0 + \tau_i + \theta_t + \beta_1 Age_{it} + \beta_2 3K_i \times Age_{it} + \beta_3' X_{it} + \beta_4' Z_{dt} + \epsilon_{idt}\,, \qquad (1)$$

where Y_{idt} is the outcome variable of individual *i,* living in district *d,* observed at a year *t.* Importantly, the model controls for the family fixed-effects (τ_i) (or unit fixed-effects, as the outcomes are reported at family level), following Ilin et al. (2022). Including family fixed-effects allows comparison within individual families between pre- and post-eligible periods for 3K, which is defined by their child's age. The family fixed-effects controls for all characteristics of a family that were consistent over time, including observed characteristics such as race and ethnicity and unobserved characteristics such as unchanged preference for child care arrangements. The year fixed-effects are also controlled, denoted as θ_t. It considers that families were eligible for 3K in different years, facing different circumstances at the time. Age_{it} is a vector of dummy variables for the focal child's age when the outcomes were measured in *t.* The coefficient β_1 reveals the children's age effects on outcomes. $3K_i$ is an identifier of treatment status (3K availability). It is a binary variable equal to one if the family had 3K program in their residential school district when their focal child was age 3 and equal to zero otherwise. The treatment status is interacted with Age_{it}. β_2 is the vector of DiD coefficients captured by the interaction term between 3K availability and a set of dummies indicating the focal child's age, which tests parallel trend assumption during the pre-eligibility period from age 1 to 2 and shows the immediate and lasting intent-to-treat (ITT) effects of 3K availability as children grow to age 3 and older. X_{it} is a vector of individual-level time-variant covariates, including the presence of a partner in the household and the number of children younger than three. Z_{dt} is a vector of school district-level time-variant covariates that is related to the local labor market characteristics, such as the unemployment rate and proportion of individuals commuting to work over 1 hour. These data are retrieved from the American Community Survey (ACS), which allows for yearly estimates at the Public Use Microdata Area (PUMA) level, and were then aggregated to the

school district level. The estimates for 2023 are imputed with the estimates from 2022, given the 2023 ACS is not yet available. Standard errors are clustered by family to account for potential correlation in repeated observations of the same family.

2.7 Results

2.7.1 First Stage

I first examine the effect of 3K availability on families' usage of publicly funded early education programs. Figure 2-2 presents the event-study DiD estimates, where the x-axis represents the children's age associated with (pre)school grades. For example, "age 3" refers to the 12-month period from July of the year in which a child turns three and becomes eligible for the 3K program, to June of the following year when the child turns four and becomes eligible for the pre-K program. The dashed vertical line marks the reference period, which is one year prior to 3K eligibility (i.e., when the child was two years old). Dots and vertical lines in the figure indicate DiD event-study point estimates and 95% confidence intervals. In the Appendix, Table 2-A4 presents the estimates corresponding to Figure 2-2.

The results confirm that 3K availability increased enrollment in the 3K program by 21.8 percentage points (ppt). However, I do not find evidence that the increased 3K enrollment led to higher enrollment rates in pre-K, kindergarten, or primary school. This suggests that the comparison group enrolled their 4-year-olds in pre-K programs at rates comparable to those of the treatment group.

2.7.2 Effects on mothers' employment with the full sample

Figure 2-3 and Table 2-A4 present the event-study DiD estimates illustrating the effects of 3K availability on mothers' employment. The plot shows little evidence to reject the parallel trend assumption for mothers' employment during the pre-eligibility period when children were ages one and two. Upon children's eligibility for 3K, the positive estimate for mothers' employment in the full sample was not statistically different from zero. Additionally, the event-study coefficients for subsequent years suggest no delayed effects of 3K availability on mothers' employment after children aged out of the program.

Figure 2-A1 in the appendix provides results for other labor supply outcomes, including mothers' labor force participation, full-time employment, part-time employment, and months worked in the past 12 months. This figure shows a significant 5 percentage point increase in the likelihood of part-time employment ($p < .05$) and a marginally significant increase of 0.9 months in the number of months worked over the past year ($p < .10$).

2.7.3 Effects on families' economic well-being with the full sample

Figures 2-4 and 2-5 display the effects of 3K availability on families' income-to-needs ratio and experiences of material hardship over the past 12 months, respectively. The estimates presented in these event-study plots are provided in Table 2-A4. Using the full sample, I find no evidence that 3K availability raised families' income-to-needs ratio, either during or after the year of 3K eligibility. In Figure 2-5, however, the coefficients suggest that 3K availability reduced a family's likelihood of experiencing material hardship by approximately 8 percentage points, though this estimate was only marginally significant ($p < .10$). The supplement analyses on five individual hardship indicators of food, housing, bill, finance, and medical needs do not

find evidence that this result was driven by a reduction in specific types of hardship (Table 2-A8 in the Appendix).

2.7.4 Heterogeneous effects by subgroups

I stratified the analytic sample by family structure, presence of younger children, family income, and parental immigrant status to assess heterogeneous policy effects. Figures 2-6, 2-7, and 2-8 present the event-study DiD plots for each subgroup for maternal employment, income-to-needs ratio, and material hardship, respectively. The estimates in these plots are provided in Tables 2-A5, 2-A6, and 2-A7.

Family Structure

The first row in Figure 2-6 shows that mothers living with a partner (spouse or domestic partner) experienced a significant increase in employment following their child's 3K eligibility ($p < .05$), by approximately 6.6 percentage points (10% increase from the comparison group's employment rate of 63%). In contrast, single mothers did not show a similar increase during their child's 3K eligibility period but did exhibit a significant increase in employment one year after by 13 percentage points ($p < .05$)(19% increase from the comparison group's employment rate of 70%).

As indicated in Figure 2-8, two-parent families experienced a marginally significant decrease in material hardship when their focal child was age three by 8.9 percentage points ($p < .10$)(29% decline from the comparison group's material hardship rate of 31%).

Presence of Younger Children

The second row of Figure 2-6 reveals a marginally significant increase in employment among mothers who had younger children when their focal child became eligible for 3K ($p < .10$). In Figure 2-8, the families with younger children also showed a significant reduction in

material hardship when their focal child was ages three, by 18.9 percentage points ($p < .05$)(54% decline from the comparison group's material hardship rate of 35%), which extended through age 6.

Family Income Level

The third row of Figure 2-6 indicate no significant employment increase for either low-income families (at or below 200% of the poverty line) or higher-income families (above 200% of the poverty line) during the 3K eligibility period. However, mothers from low-income families in districts with 3K access showed a lagged, marginally significant increase in employment in the following year by 7% (12% increase from the comparison group employment rate of 59%), when their children became eligible for pre-K ($p < .10$). Although the coefficients are only marginally significant ($p < .10$), Figure 2-7 shows suggestive evidence that 3K availability increased families' income-to-needs ratio for low-income families by 0.14 standard deviation, while it lowered for higher-income families by 0.55 standard deviation. Also, in Figure 2-8, a significant reduction in material hardship was observed for low-income households when their focal child was ages three and four ($p < .05$), by 12 percentage points (28% decline from the comparison group material hardship rate of 43%).

Parental Immigrant Status

The fourth row of Figure 2-6 shows that both immigrant and U.S.-born mothers did not experience statistically significant changes in employment following 3K eligibility, as positive estimates for both groups remained insignificant. Despite this, families with U.S.-born parents showed a significant drop in the likelihood of experiencing material hardship by 11 percentage points ($p < .05$) when their focal child was age three (33% decline from the comparison group material hardship rate of 33%).

2.8 Robustness Checks

2.8.1 Alternative samples and specification

To ensure the robustness of the findings, additional analyses were conducted using alternative samples and model specifications. First, to check the sensitivity of my result by exclusion criteria, I added families with children who became eligible for the 3K program during COVID-19 into the analytic sample. Second, to examine whether the findings remain consistent when the comparison is made within the districts that had priority in the 3K program expansion, I restricted the sample to those who lived in the 16 school districts that rolled out 3K earlier than the other 16 districts. I also examined the robustness of the coefficients by comparing models with and without family- and district-level covariates. Results are presented in Tables 2-A9—2-A19 in the Appendix.

With full sample, the estimated effects of the 3K program on mothers' employment (Table 2-A9 in the Appendix) and families' income-to-needs ratio (Table 2-A10 in the Appendix) remained insignificant across different sample sets and model specifications. However, Table 2-A11 shows that including families eligible for 3K during the COVID-19 pandemic reduced the effect size, while restricting the sample to early rollout districts increased the effect size.

Findings of increased employment among partnered mothers, single mothers, and mothers from low-income families due to 3K availability proved robust across alternative samples and model selections (Tables 2-A12, 2-A13, and 2-A15 in the Appendix). Similarly, the observed reductions in material hardship for households with younger children (Table 2-A17 in the Appendix), low-income households (Table 2-A18 in the Appendix), and households with U.S.-born parents (Table 2-A19 in the Appendix) remained stable. However, the estimated effects of 3K availability on increasing maternal employment for mothers with younger children (Table 2-

A14 in the Appendix) and reducing material hardship for two-parent households (Table 2-A16 in the Appendix) were sensitive to the expanded sample including families eligible for 3K during the pandemic.

2.8.2 Placebo Tests

The identification strategy of this study assumes that no other shocks, aside from the 3K rollout, influenced differential employment responses between the treatment and comparison groups. To test the validity of this assumption, a placebo test was conducted with samples of families whose economic well-being were unlikely to be affected by the 3K rollout. The placebo test included two groups: families without preschool-age children and families with only school-age children (ages 6–18) and no preschool-age children. These samples were drawn from the Poverty Tracker (PT) survey data collected from 2017 to 2020. The same event-study DiD model was applied to test the null hypothesis that changes in employment were parallel between families residing in early- and late-3K-rollout school districts. Given that the majority (89%) of the analytic sample became eligible for the 3K program in 2019, 2018 was chosen as the reference year.

As shown in Table 2-A20 in the Appendix, there is no evidence to reject the null hypothesis, indicating that employment, income-to-needs ratio, and material hardship changes remained parallel between comparison groups from 2017 to 2020. These findings support the assumption that no other significant labor market shocks affected the early 3K rollout school districts during the program's expansion.

2.9 Discussion and Conclusion

This study investigated the effects of a universal pre-K program for three-year-old children on parental economic outcomes, leveraging the staggered rollout of New York City's

3K program from 2017 to 2021. Using a difference-in-difference framework with family fixed-effects within an event-study design, I compared within-family changes in outcomes based on children's ages between families with and without access to 3K in their residential school districts.

The full sample results suggest little evidence that 3K availability significantly increased mothers' employment during their child's eligibility year. The confidence interval ranged from -0.8 percentage points to 9 percentage points, aligning with prior studies reporting ranges from -3 to 4 percentage points (Fitzpatrick, 2010) and 0.6 to 11 percentage points (Humphries et al., 2024). A marginally significant reduction in material hardship (8 percentage points) was observed, but there was no significant increase in the income-to-needs ratio.

Subgroup analyses revealed significant employment increases among mothers in two-parent households, consistent with findings from Li (2020) in Georgia. Conversely, single mothers did not exhibit an immediate employment increase when their children became eligible for 3K; however, a significant increase was observed one year later. Several factors may explain this pattern: partnered mothers, who may be less likely to qualify for child care subsidies, could derive greater immediate benefits from the 3K program. Additionally, the school-day schedule of 3-K may not align well with standard work hours or accommodate nonstandard or variable work schedules. This misalignment can complicate child care arrangements, particularly for single mothers without a partner to address the child care gap after 3 PM, potentially delaying the policy's intended effects. Moreover, welfare reforms following 1996 may have already increased single mothers' labor force participation by the time their children reached age two (Byker, 2016), making them less likely to respond immediately to 3K availability. Overall, for both

partnered mothers and single mothers, the employment gains did not persist over multiple years as the comparison group caught up in their employment in subsequent years.

This study did not find evidence that maternal employment gains were concentrated among mothers without younger children. This result aligns with earlier studies on universal pre-K programs that did not find subgroup-specific effect by the presence of younger children (Fitzpatrick, 2010; Li, 2020), but it diverges from evidence that kindergarten programs for 5-year-olds often increase mothers' labor supply, particularly for those without younger children (Gibbs et al., 2024). One potential explanation for this discrepancy is three-year-olds are closer in age to younger children and can be accommodated in the same early education program. Thus, mothers' labor supply responses to free early education programs for preschoolers might be less dependent on whether they have younger children than programs for older children.

Further subgroup analyses on economic well-being revealed a significant reduction in material hardship among families with younger children, low-income families, and families with U.S.-born parents. Notably, low-income families exhibited marginally significant increase in maternal employment and income-to-needs-ratio, along with significant reduction in material hardship, indicating the downstream effects of universal pre-K on mothers' employment and on families' economic well-being. In contrast, families with younger children showed marginally significant increase in maternal employment without significant changes in income-to-needs ratio, and families with US-born families did not exhibit a significant increase in both outcomes following 3-K availability. These findings suggest that the role of universal pre-K programs in improving families' consumption-based economic well-being may operate through multiple channels, not solely by increasing maternal employment or increasing income. These results highlight the need for further research on the mechanisms linking universal pre-K to reductions

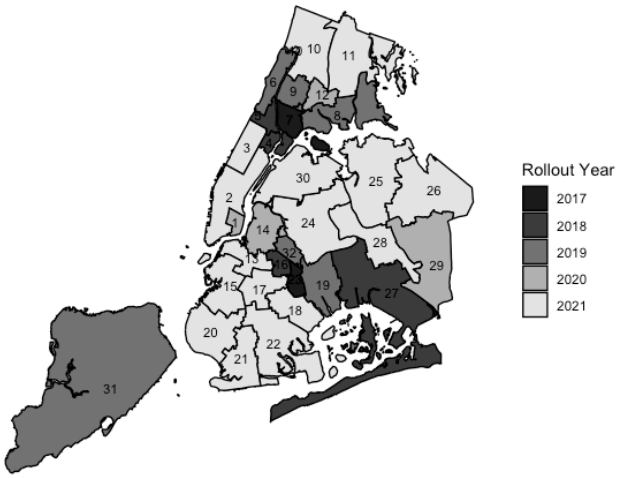
in material hardship, including parental earnings, savings on childcare expenses, and in-kind benefits associated with pre-K programs (e.g., school meals).

This study has several limitations. The relatively small sample size may have limited the detection of true overall employment effects for full sample of mothers. Additionally, the identification strategy assumes that, absent the 3K program, outcomes would have evolved similarly for both treatment and comparison groups as children aged from one to seven. While family fixed-effects control for all time-invariant differences across individuals, time-variant factors (e.g., differential COVID-19 impacts) cannot be fully ruled out.

Despite these limitations, this study makes several contributions to the literature on pre-K and early childhood education. First, it provides new quasi-experimental evidence on the causal effects of universal pre-K on mothers' employment, with a specific focus on New York City's 3K program. The findings indicate a significant increase in employment during the 3K year among partnered mothers. Second, this study examines the longer-term effects of universal pre-K on maternal employment using longitudinal panel data within an event-study DiD design. The results suggest a delayed increase in maternal employment, significant for single mothers, though the short-term employment gains may not persist over extended periods. Finally, this study is the first to provide evidence that universal pre-K can reduce material hardship for low-income families and families with infants and toddlers, underscoring its potential as an economic support tool.

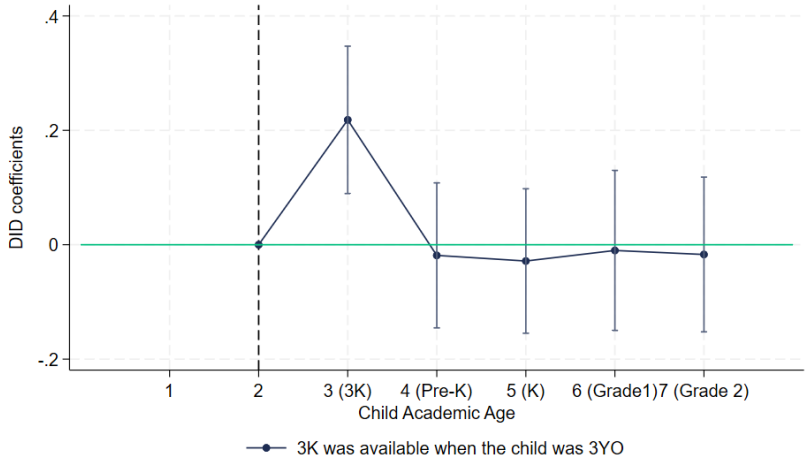
Figures

Figure 2-1. Variation in 3-K for All program rollout year across New York City school districts



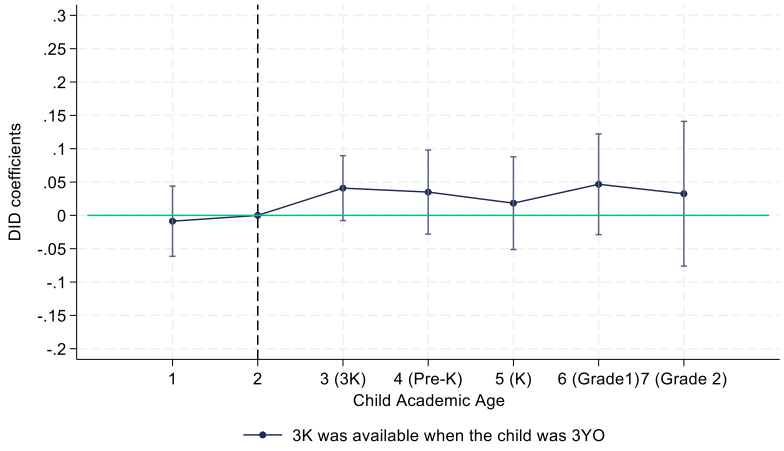
Note: Author's visualization based on data from the New York City Office of the Mayor (2018).

Figure 2-2. First-stage effect of availability of 3K on publicly funded early education and school enrollment



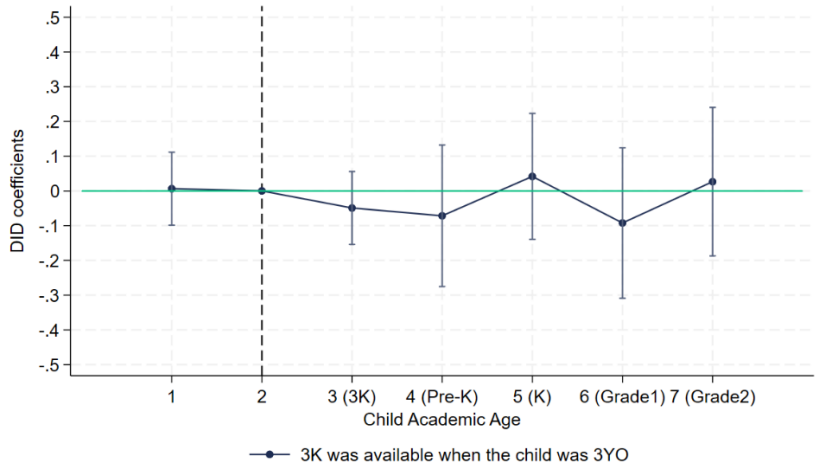
Source: Early Childhood Poverty Tracker (2017-2022). N=1,897. **Note**: The event-study difference-in-difference estimates and 95% confidence intervals are shown. Robust standard errors are clustered by household. The model controls for family fixed-effects, year fixed-effects, time-varying family characteristics (presence of a spouse or domestic partner and the number of children under age 3), and time-varying district-level labor market characteristics (unemployment rate and percentage of individuals commuting over 1 hour). The black dashed vertical line indicates the reference period—a year before the focal child's 3K eligibility begins.

Figure 2-3. The effect of availability of 3K on mothers' employment



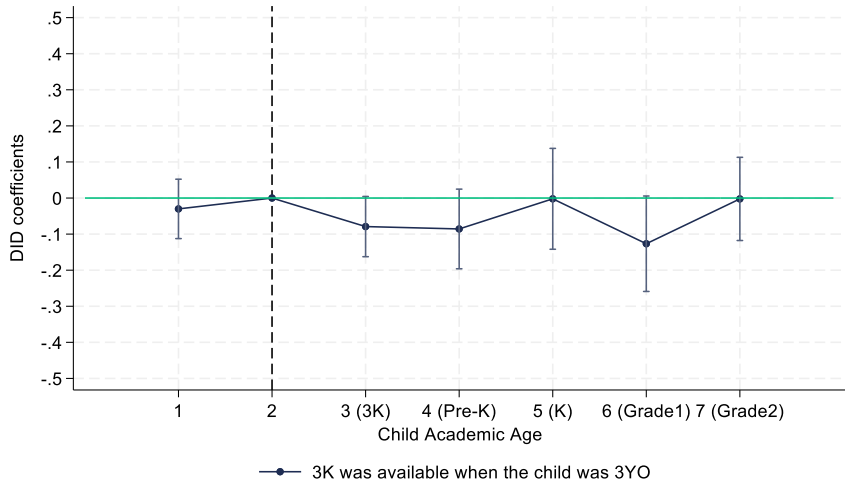
Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). N=8,055. **Note**: The event-study difference-in-difference estimates and 95% confidence intervals are shown. Robust standard errors are clustered by household. The model controls for family fixed-effects, year fixed-effects, time-varying family characteristics, and time-varying district-level labor market characteristics. The black dashed vertical line indicates the reference period—a year before the focal child's 3K eligibility begins.

Figure 2-4. The effect of availability of 3K on families' income-to-needs ratio



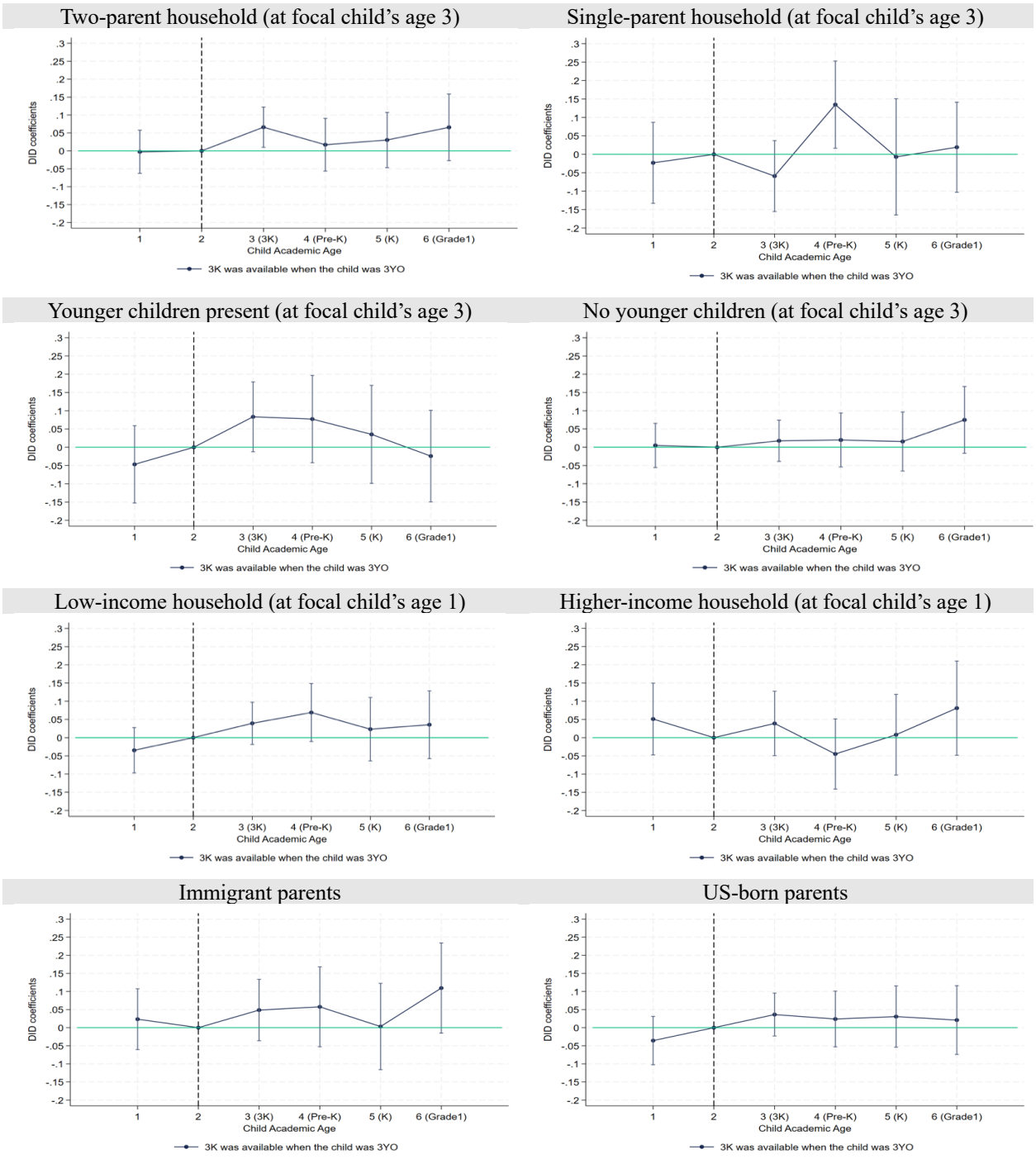
Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). N=2,874. **Note**: The event-study difference-in-difference estimates and 95% confidence intervals are shown. Robust standard errors are clustered by household. The income-to-needs ratio measures the household SPM resources as a proportion to the poverty line threshold and is standardized (mean=0, S.D.=1). The model controls for family fixed-effects, year fixed-effects, time-varying family characteristics, and time-varying district-level labor market characteristics. The black dashed vertical line indicates the reference period—a year before the focal child's 3K eligibility begins.

Figure 2-5. The effect of availability of 3K on families' material hardship



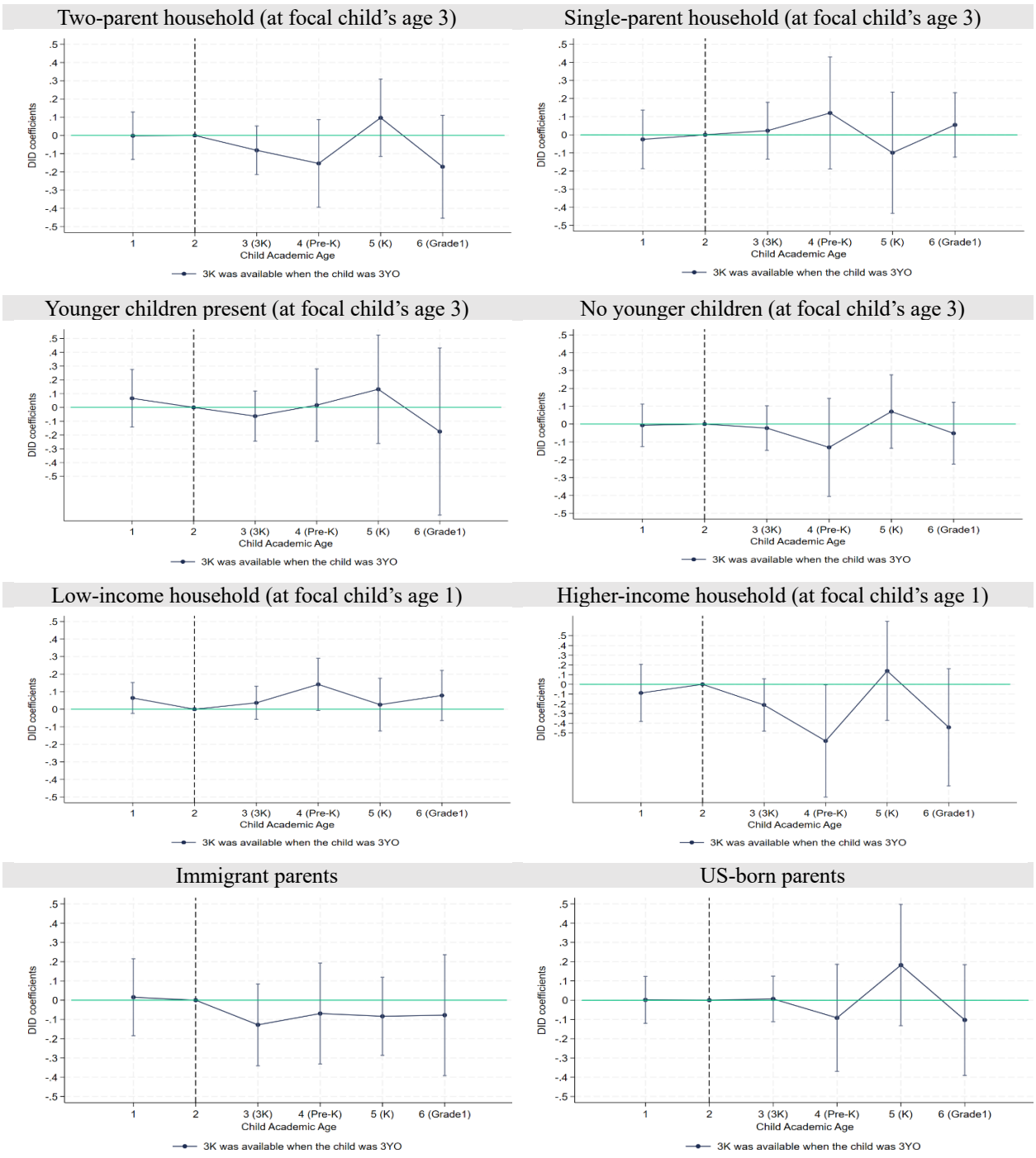
Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). N=2,874. **Note**: The event-study difference-in-difference estimates and 95% confidence intervals are shown. Robust standard errors are clustered by household. Material hardship is defined as experiencing at least one type of hardship, including food insufficiency, inability to pay rent, running out of money between paychecks, inability pay for utility bills, unmet medical needs due to costs. The model controls for family fixed-effects, year fixed-effects, time-varying family characteristics, and time-varying district-level labor market characteristics. The black dashed vertical line indicates the reference period—a year before the focal child's 3K eligibility begins.

Figure 2-6. The effect of availability of 3K on mothers' employment, by subgroups



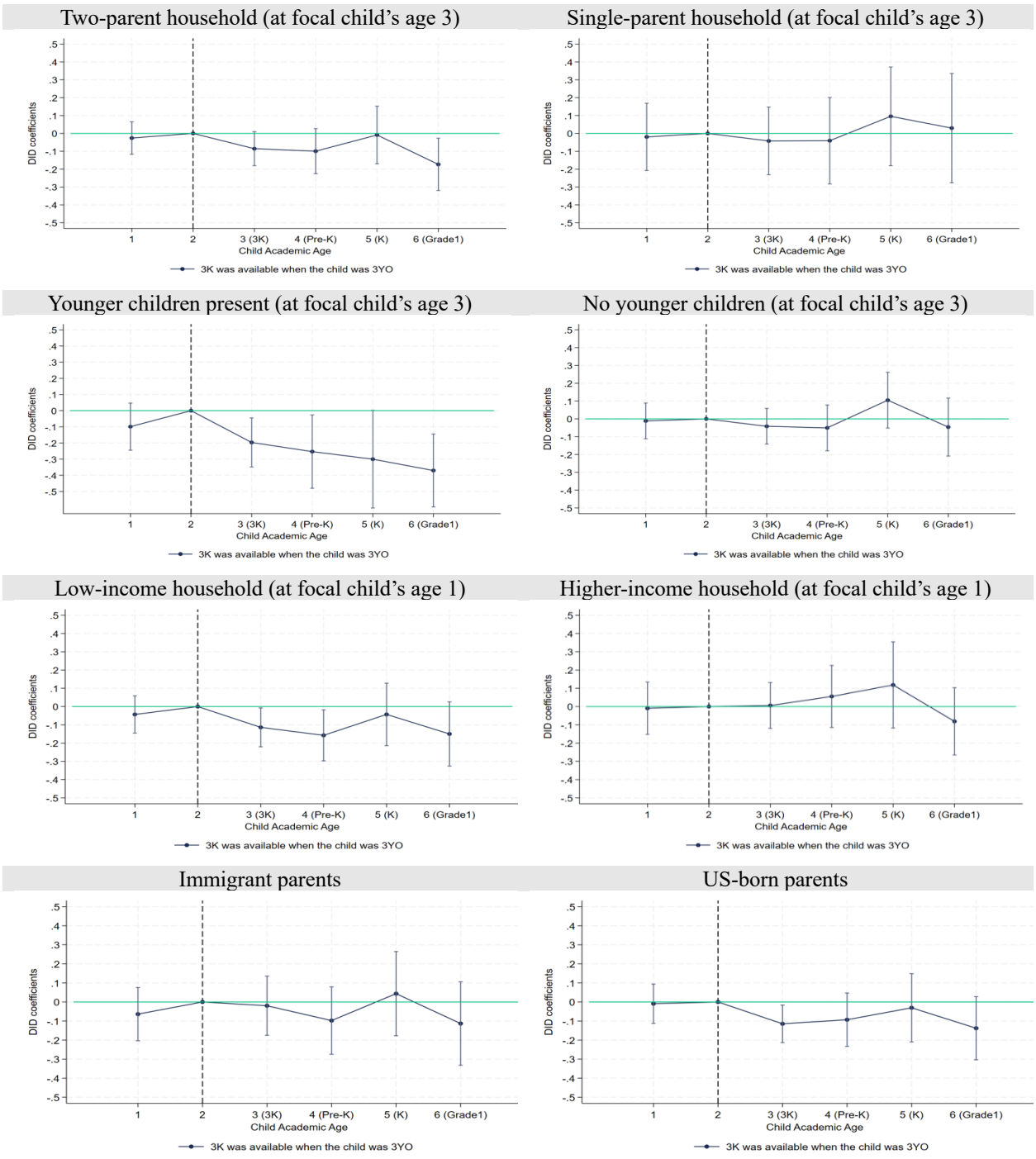
Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: Two-parent households N=6,229; Single-parent households N=1,826; Households with younger children N=2,396; Households without younger children N=5,659; Low-income households N=5,664; Higher-income households N=2,388; Immigrant parent households N=3,085; US-born parent households N=4,970. The event-study difference-in-difference estimates and 95% confidence intervals are shown. Robust standard errors are clustered by household.

Figure 2-7. The effect of availability of 3K on families' income-to-needs ratio, by subgroups



Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: Two-parent households N=2,231; Single-parent households N=643; Households with younger children N=955; Households without younger children N=1,919; Low-income households N=2,001; Higher-income households N=870; Immigrant parent households N=1,110; US-born parent households N=1,764. The event-study difference-in-difference estimates and 95% confidence intervals are shown. Robust standard errors are clustered by household. The income-to-needs ratio measures the household SPM resources as a proportion to the poverty line threshold and is standardized (mean=0, S.D.=1).

Figure 2-8. The effect of availability of 3K on families' material hardship, by subgroups



Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: Two-parent households N=2,231; Single-parent households N=643; Households with younger children N=955; Households without younger children N=1,919; Low-income households N=2,001; Higher-income households N=870; Immigrant parent households N=1,110; US-born parent households N=1,764. The event-study difference-in-difference estimates and 95% confidence intervals are shown. Robust standard errors are clustered by household. Material hardship is defined as experiencing at least one type of hardship in meeting food, housing, utility, financial, medical needs due to costs.

Tables

Table 2-1. Summary statistics of the analytic sample, by 3K treatment status

	Treatment group (3K was *available* at 3)	Comparison group (3K was *unavailable* at 3)	Difference
	Mean (SD)/ Proportion	Mean (SD)/ Proportion	
Parent age	32.6 (5.4)	32.2 (6.9)	0.33
Single (unpartnered when focal child was age 3)	0.27	0.20	0.07*
Birth year of focal child			
2014	0	0.10	-0.10***
2015	0	0.05	-0.05***
2016	1	0.85	0.15
Has a younger child (when focal child was age 3)	0.26	0.36	-0.10**
Immigrant	0.37	0.40	-0.03
Respondent parent education			
Less than HS	0.14	0.14	0.00
HS graduate or GED	0.12	0.21	-0.09**
Some college or associate's degree	0.31	0.27	0.04
Bachelor's degree or more	0.42	0.38	0.05
Household income below 200% SPM (when focal child was age 1)	0.70	0.69	0.00
Parent race and ethnicity			
Non-Hispanic White	0.22	0.34	-0.12***
Non-Hispanic Black	0.25	0.17	0.08*
Non-Hispanic Asian	0.03	0.05	-0.02
Other	0.05	0.05	0.00
Hispanic	0.45	0.39	0.06
Child female	0.51	0.53	-0.02
N of families	233	404	Total=637
N of wave-family observations (employment)	3,143	4,912	Total=8,055
N of wave-family observations (economic well-being)	1,042	1,836	Total=2,874

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The unweighted summary statistics of the main analytic sample is shown. The treatment group is defined as families who had a 3K program in their residential school districts, and the comparison group is those who did not have 3K in their school districts. Mothers' employment status was observed in 15 survey waves (5 annual and 10 interim surveys) and economic well-being indicators were observed in 5 annual surveys. The asterisks in the third column represent the statistical significance of two-tailed t-test of the differences in means between the treatment and comparison groups. + $p < .10$ *$p<.05$ **$p < .01$ ***$p < .001$.

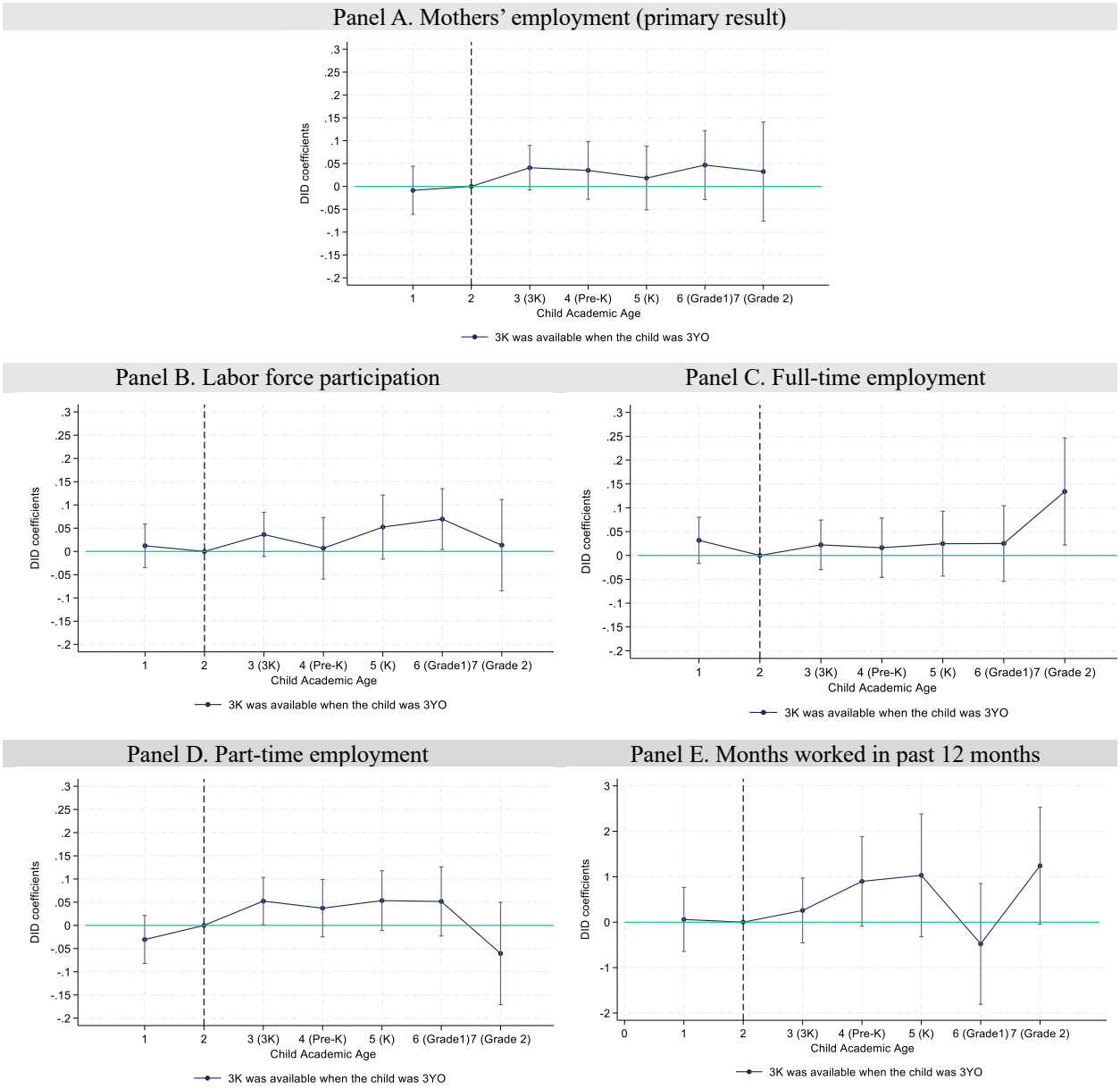
Table 2-2. Summary statistics of outcome variables by focal child's age

Focal child's age related to (pre)school grade	Panel A Mothers' employment rate (%)		Panel B SPM income-to-needs ratio (Mean)		Panel C Material hardship rate (%)	
	3K	No 3K	3K	No 3K	3K	No 3K
1	56	59	1.86	1.99	39	39
2	60	61	1.97	2.09	42	36
3 (3K)	69	65	2.05	2.22	38	40
4 (Pre-K)	64	61	2.50	2.63	24	31
5 (K)	71	68	2.56	2.40	35	36
6 (Grade 1)	75	72	1.72	2.02	34	39
7 (Grade 2)	73	72	2.28	2.29	36	31
Total	64	63	2.07	2.20	36	37
N of families	233	404	233	404	233	404
N of wave-family observations	3,143	4,912	1,042	1,832	1,042	1,832

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: "3K" refers to the treatment group—families who had a 3K program in their residential school districts, and "No 3K" refers to the comparison group who did not have 3K in their school districts. Sample descriptive statistics are unweighted.

Appendix

Figure 2-A1. The effect of availability of 3K on mothers' labor supply outcomes



Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). Employment N=8,055; Labor force participation, full-time employment, part-time employment N=6,799; Mothers' months worked in past 12 months N=2,868. **Note**: The event-study difference-in-difference estimates and 95% confidence intervals are shown for alternative labor supply outcomes. Robust standard errors are clustered by household. The model controls for family fixed-effects, year fixed-effects, time-varying family characteristics such as the presence of a spouse or domestic partner and the number of children under age 3, and time-varying district-level labor market characteristics such as unemployment rate and percentage of individuals commuting over 1 hour. The black dashed vertical line indicates the reference period—a year before the focal child's 3K eligibility begins.

Table 2-A1. Summary statistics of the supplemental analytic sample, by 3K treatment status

	Treated group (3K was *available* at 3)	Comparison group (3K was *unavailable* at 3)	Difference
	Mean (SD)/ Proportion	Mean (SD)/ Proportion	
Parent age	32.6 (5.9)	32.3 (6.7)	0.28
Presence of spouse or domestic partner when focal child was age 3			
Single (unpartnered)	0.26	0.18	0.08*
Birth year of focal child			
2014	0	0.08	-0.08***
2015	0	0.04	-0.04***
2016	0.75	0.70	0.06
2017	0.25	0.18	0.07*
Presence of younger child when focal child was age 3			
Has a younger child	0.27	0.36	-0.09**
Foreign born status			
Immigrant	0.34	0.42	-0.08
Respondent parent education			
Less than HS	0.14	0.13	0.00
HS graduate or GED	0.15	0.21	-0.07**
Some college or associate's degree	0.29	0.25	0.04
Bachelor's degree or more	0.42	0.40	0.02
Household Income when focal child was age 1			
Below 200% SPM	0.69	0.67	0.02
Parent race and ethnicity			
Non-Hispanic White	0.25	0.36	-0.12***
Non-Hispanic Black	0.23	0.15	0.07*
Non-Hispanic Asian	0.04	0.06	-0.03
Other	0.05	0.04	0.00
Hispanic	0.45	0.38	0.07
Child gender			
female	0.46	0.52	-0.05
N of families	310	492	Total=802
N of wave-family observations (employment)	4,156	6,117	Total=10,273
N of wave-family observations (economic well-being)	1,393	2,246	Total=3,639

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The unweighted summary statistics of the supplemental analytic sample is shown. The treatment group is defined as families who had a 3K program in their residential school districts, and the comparison group is those who did not have 3K in their school districts. The asterisks represent the statistical significance of t-test of the differences in means between the treatment and comparison groups. + $p < .10$ *$p<.05$ **$p < .01$ ***$p < .001$.

Table 2-A2. Changes in the analytic sample by exclusion criteria

Exclusion criteria	Change in N	Total N
ECPT families with children in ages 0-3 in 2017		1,516
PT families with children in ages 0-1 in 2015	+105	1,621
Excluded families where mothers' employment information is unavailable when the focal child was age 3	-296	1,325
Excluded families where mothers' employment information is unavailable when the focal child was age 1	-521	804
Excluded families with children who were eligible for the 3K program during the pandemic (For the main analytic sample)	-167	637

Table 2-A3. Question wording and definition of material hardship

Definition	Questions
Food hardship	
Often running out of food or often worrying food run out	In the past 12 months, we worried whether our food would run out before we got money to buy more. 1) Often; 2) Sometimes 3) Never In the past 12 months, the food we bought just didn't last and we didn't have money to get more 1) Often 2) Sometimes 3) Never
Housing hardship	
Having to stay in a shelter or other place not meant for regular housing, or having to move in with others due to costs	In the past 12 months, did you stay at a shelter, in an abandoned building, an automobile, or any other place not meant for regular housing, even for one night? 1) Yes 2) No In the past 12 months, did you move in with other people even for a little while because of financial problems? 1) Yes 2) No
Bill hardship	
Having utility cut off due to insufficient money	In the past 12 months, was your phone, gas or electricity service ever cut off because there wasn't enough money to pay the bills? 1) Yes 2) No
Financial hardship	
Often run out of money between the paychecks	During that past 12 months, how often did you run out of money between paychecks or before the end of the month? Would you say that happened 1) Often 2) Sometimes 3) Never
Medical hardship	
Not being able to see a doctor due to cost	In the past 12 months, was there a time when you or anyone else in your household needed to see a doctor, a dentist or go to the hospital but couldn't go because of the cost? 1) Yes 2) No

Table 2-A4. The effect of availability of 3K on publicly funded early education and school enrollment, mothers' employment, families' income-to-needs ratio, and material hardship (full sample)

Focal child's age related to (pre)school grade	Publicly funded early education and school enrollment	Mothers' employment	Income-to-needs ratio	Material hardship
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	n/a	-0.009	0.006	-0.030
	n/a	(0.027)	(0.054)	(0.042)
Age 3 (3K)	**0.218*****	0.041	-0.049	**-0.079+**
	(0.066)	(0.025)	(0.054)	(0.043)
Age 4 (Pre-K)	-0.019	0.035	-0.072	-0.086
	(0.065)	(0.032)	(0.104)	(0.056)
Age 5 (K)	-0.028	0.018	0.042	-0.002
	(0.064)	(0.035)	(0.092)	(0.071)
Age 6 (Grade 1)	-0.010	0.047	-0.092	**-0.127+**
	(0.071)	(0.039)	(0.110)	(0.067)
Age 7 (Grade 2)	-0.017	0.033	0.027	-0.002
	(0.069)	(0.055)	(0.109)	(0.059)
Family FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Family-level covariates	Yes	Yes	Yes	Yes
District-level covariates	Yes	Yes	Yes	Yes
N	1,897	8,055	2,874	2,874

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).

Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Family-level covariates include presence of a spouse or domestic partner and the number of children under age, and district-level covariates include unemployment rate and percentage of individuals commuting over 1 hour. ** p<.01, * p<.05, + p<.1

Table 2-A5. The effect of availability of 3K on mothers' employment, by subgroups

Focal child's age related to (pre)school grade	Two parents	Single parent	Younger children present	No younger children	Low-income	Higher-income	Immi-grant	US-born
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.002	-0.026	-0.046	0.006	-0.034	0.052	0.024	-0.035
	(0.031)	(0.056)	(0.054)	(0.031)	(0.032)	(0.050)	(0.043)	(0.034)
Age 3 (3K)	**0.066***	-0.057	**0.085+**	0.018	0.040	0.038	0.048	0.037
	(0.029)	(0.049)	(0.049)	(0.029)	(0.030)	(0.045)	(0.043)	(0.030)
Age 4 (Pre-K)	0.017	**0.134***	0.076	0.020	**0.068+**	-0.044	0.060	0.022
	(0.037)	(0.060)	(0.061)	(0.038)	(0.041)	(0.049)	(0.056)	(0.039)
Age 5 (K)	0.030	-0.010	0.035	0.015	0.023	0.008	0.002	0.030
	(0.039)	(0.080)	(0.068)	(0.041)	(0.045)	(0.056)	(0.061)	(0.043)
Age 6 (Grade 1)	0.065	0.017	-0.024	0.073	0.033	0.083	**0.109+**	0.020
	(0.047)	(0.062)	(0.064)	(0.047)	(0.047)	(0.066)	(0.063)	(0.049)
Age 7 (Grade 2)	0.016	0.138	-0.054	0.057	-0.027	**0.168***	0.080	0.011
	(0.061)	(0.132)	(0.097)	(0.067)	(0.072)	(0.077)	(0.092)	(0.067)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District-level covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6,229	1,826	2,396	5,659	5,664	2,388	3,085	4,970

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).

Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Family-level covariates include presence of a spouse or domestic partner and the number of children under age, and district-level covariates include unemployment rate and percentage of individuals commuting over 1 hour. ** p<.01, * p<.05, + p<.1

Table 2-A6. The effect of availability of 3K on families' income-to-needs ratio, by subgroups

Focal child's age related to (pre)school grade	Two parents	Single parent	Younger children present	No younger children	Low-income	Higher-income	Immi-grant	US-born
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.005	-0.029	0.071	-0.015	0.063	-0.089	0.013	0.003
	(0.066)	(0.082)	(0.107)	(0.060)	(0.045)	(0.149)	(0.102)	(0.062)
Age 3 (3K)	-0.086	0.016	-0.058	-0.034	0.038	-0.225	-0.139	0.009
	(0.068)	(0.079)	(0.092)	(0.064)	(0.047)	(0.138)	(0.108)	(0.060)
Age 4 (Pre-K)	-0.147	0.116	0.023	-0.125	**0.140+**	**-0.554+**	-0.075	-0.080
	(0.122)	(0.156)	(0.135)	(0.137)	(0.076)	(0.291)	(0.132)	(0.141)
Age 5 (K)	0.077	-0.115	0.147	0.036	0.019	0.079	-0.085	0.144
	(0.107)	(0.169)	(0.193)	(0.104)	(0.075)	(0.256)	(0.102)	(0.158)
Age 6 (Grade 1)	-0.160	0.052	-0.165	-0.053	0.079	-0.432	-0.077	-0.096
	(0.144)	(0.090)	(0.310)	(0.089)	(0.073)	(0.307)	(0.160)	(0.146)
Age 7 (Grade 2)	0.005	0.084	0.005	0.044	**0.153***	-0.293	-0.033	0.057
	(0.136)	(0.078)	(0.117)	(0.145)	(0.069)	(0.335)	(0.105)	(0.174)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District-level covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,231	643	955	1,919	2,001	870	1,110	1,764

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).

Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Family-level covariates include presence of a spouse or domestic partner and the number of children under age, and district-level covariates include unemployment rate and percentage of individuals commuting over 1 hour. ** p<.01, * p<.05, + p<.1

Table 2-A7. The effect of availability of 3K on families' material hardship, by subgroups

Focal child's age related to (pre)school grade	Two parents	Single parent	Younger children present	No younger children	Low-income	Higher-income	Immi-grant	US-born
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.026	-0.022	-0.095	-0.015	-0.045	-0.009	-0.069	-0.009
	(0.046)	(0.096)	(0.073)	(0.051)	(0.052)	(0.072)	(0.071)	(0.053)
Age 3 (3K)	**-0.089+**	-0.040	**-0.189***	-0.043	**-0.115***	0.008	-0.028	**-0.109***
	(0.049)	(0.096)	(0.077)	(0.051)	(0.054)	(0.064)	(0.079)	(0.050)
Age 4 (Pre-K)	-0.095	-0.016	**-0.255***	-0.039	**-0.150***	0.064	-0.092	-0.082
	(0.064)	(0.123)	(0.116)	(0.065)	(0.071)	(0.084)	(0.090)	(0.071)
Age 5 (K)	-0.018	0.086	-0.296*	0.088	-0.045	0.092	0.037	-0.039
	(0.082)	(0.139)	(0.160)	(0.079)	(0.087)	(0.119)	(0.113)	(0.090)
Age 6 (Grade 1)	**-0.172***	0.026	**-0.365****	-0.045	-0.147	-0.080	-0.114	-0.133
	(0.075)	(0.155)	(0.116)	(0.083)	(0.090)	(0.094)	(0.112)	(0.085)
Age 7 (Grade 2)	0.003	0.047	0.025	-0.006	-0.076	**0.170+**	-0.015	0.001
	(0.069)	(0.135)	(0.118)	(0.067)	(0.073)	(0.094)	(0.108)	(0.069)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District-level covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,231	643	955	1,919	2,001	870	1,110	1,764

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).

Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Family-level covariates include presence of a spouse or domestic partner and the number of children under age, and district-level covariates include unemployment rate and percentage of individuals commuting over 1 hour. ** p<.01, * p<.05, + p<.1

Table 2-A8. The effect of availability of 3K on families' food, housing, bill, financial, medical hardship

Focal child's age related to (pre)school grade	Food hardship	Housing hardship	Bill hardship	Financial hardship	Medical hardship
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.027	0.029	-0.045	-0.063+	-0.002
	(0.027)	(0.029)	(0.033)	(0.033)	(0.034)
Age 3 (3K)	-0.031	0.004	-0.012	-0.052	-0.011
	(0.029)	(0.028)	(0.034)	(0.036)	(0.036)
Age 4 (Pre-K)	-0.010	0.030	-0.022	-0.053	-0.011
	(0.032)	(0.031)	(0.039)	(0.044)	(0.044)
Age 5 (K)	-0.026	0.046	0.043	-0.040	-0.027
	(0.046)	(0.044)	(0.051)	(0.061)	(0.061)
Age 6 (Grade 1)	-0.039	0.040	-0.046	-0.064	-0.010
	(0.036)	(0.039)	(0.047)	(0.054)	(0.059)
Age 7 (Grade 2)	-0.059+	0.049	0.002	-0.030	0.051
	(0.035)	(0.032)	(0.043)	(0.052)	(0.055)
Family FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Family-level covariates	Yes	Yes	Yes	Yes	Yes
District-level covariates	Yes	Yes	Yes	Yes	Yes
N	2,874	2,874	2,874	2,874	2,874

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).

Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Family-level covariates include presence of a spouse or domestic partner and the number of children under age, and district-level covariates include unemployment rate and percentage of individuals commuting over 1 hour. ** p<.01, * p<.05, + p<.1

Table 2-A9. Robustness test: The effect of availability of 3K on mothers' employment with different samples and specifications

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.009	-0.009	-0.010	-0.010	0.0288	0.0263
	(0.027)	(0.027)	(0.023)	(0.023)	(0.0356)	(0.0356)
Age 3 (3K)	**0.042**+	0.041	0.033	0.034	0.0438	0.0426
	(0.025)	(0.025)	(0.023)	(0.023)	(0.0363)	(0.0362)
Age 4 (Pre-K)	0.040	0.035	0.037	0.036	**0.0737**+	**0.0692**+
	(0.032)	(0.032)	(0.029)	(0.029)	(0.0386)	(0.0386)
Age 5 (K)	0.027	0.018	0.035	0.031	0.0641	0.0563
	(0.035)	(0.035)	(0.030)	(0.030)	(0.0487)	(0.0489)
Age 6 (Grade 1)	0.055	0.047	0.059	0.053	0.0808	0.0747
	(0.039)	(0.039)	(0.036)	(0.036)	(0.0493)	(0.0497)
Age 7 (Grade 2)	0.040	0.032	0.040	0.034	0.0829	0.0752
	(0.056)	(0.055)	(0.055)	(0.055)	(0.0846)	(0.0852)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	8,055	8,055	10,273	10,273	4,255	4,255

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).

Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A10. Robustness test: The effect of availability of 3K on families' income-to-needs ratio with different samples and specifications

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	0.0121	0.0064	0.0113	0.0096	-0.1097	-0.1068
	(0.0598)	(0.0600)	(0.0503)	(0.0503)	(0.0739)	(0.0739)
Age 3 (3K)	-0.0425	-0.0491	-0.0577	-0.0600	-0.0197	-0.0188
	(0.0599)	(0.0603)	(0.0550)	(0.0547)	(0.0688)	(0.0691)
Age 4 (Pre-K)	-0.0602	-0.0716	-0.0736	-0.0804	0.0488	0.0512
	(0.0938)	(0.0942)	(0.0832)	(0.0834)	(0.0941)	(0.0974)
Age 5 (K)	0.0516	0.0418	0.1573	0.1514	0.0328	0.0330
	(0.0915)	(0.0918)	(0.1083)	(0.1094)	(0.1142)	(0.1157)
Age 6 (Grade 1)	-0.0827	-0.0923	-0.0493	-0.0547	-0.0684	-0.0597
	(0.1051)	(0.1062)	(0.0841)	(0.0845)	(0.0932)	(0.0949)
Age 7 (Grade 2)	0.0393	0.0266	0.0402	0.0290	0.1128	0.1093
	(0.1008)	(0.1017)	(0.0992)	(0.0997)	(0.0914)	(0.0917)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	2,874	2,874	3,634	3,634	1,523	1,523

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A11. Robustness test: The effect of availability of 3K on families' material hardship with different samples and specifications

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.030	-0.030	0.017	0.018	-0.0869	-0.0915
	(0.042)	(0.042)	(0.035)	(0.036)	(0.0635)	(0.0641)
Age 3 (3K)	**-0.080+**	**-0.079+**	-0.048	-0.047	**-0.1422***	**-0.1472***
	(0.042)	(0.043)	(0.038)	(0.038)	(0.0659)	(0.0661)
Age 4 (Pre-K)	-0.086	-0.086	-0.074	-0.073	-0.0727	-0.0853
	(0.056)	(0.056)	(0.051)	(0.051)	(0.0796)	(0.0814)
Age 5 (K)	-0.003	-0.002	-0.012	-0.011	-0.0696	-0.0857
	(0.071)	(0.071)	(0.059)	(0.059)	(0.0963)	(0.0969)
Age 6 (Grade 1)	**-0.125+**	**-0.127+**	-0.048	-0.047	**-0.2358***	**-0.2439***
	(0.067)	(0.067)	(0.060)	(0.060)	(0.1107)	(0.1104)
Age 7 (Grade 2)	-0.005	-0.002	0.018	0.020	-0.0751	-0.0873
	(0.059)	(0.059)	(0.058)	(0.058)	(0.1014)	(0.1025)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	2,874	2,874	3,634	3,634	1,523	1,523

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A12. Robustness test: The effect of availability of 3K on mothers' employment with different samples and specifications: Two-parent households

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.004	-0.002	-0.006	-0.006	0.0342	0.0347
	(0.031)	(0.031)	(0.026)	(0.026)	(0.0414)	(0.0414)
Age 3 (3K)	**0.068***	**0.066***	**0.053***	**0.055***	0.0720	0.0709
	(0.029)	(0.029)	(0.026)	(0.026)	(0.0438)	(0.0437)
Age 4 (Pre-K)	0.020	0.017	0.023	0.024	0.0386	0.0367
	(0.038)	(0.037)	(0.034)	(0.034)	(0.0475)	(0.0477)
Age 5 (K)	0.038	0.030	0.037	0.033	0.0453	0.0376
	(0.040)	(0.039)	(0.034)	(0.034)	(0.0562)	(0.0564)
Age 6 (Grade 1)	0.074	0.065	0.068	0.060	0.0548	0.0458
	(0.047)	(0.047)	(0.043)	(0.043)	(0.0623)	(0.0634)
Age 7 (Grade 2)	0.023	0.015	0.019	0.014	0.0705	0.0699
	(0.061)	(0.061)	(0.060)	(0.060)	(0.0922)	(0.0944)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	6,229	6,229	8,099	8,099	3,018	3,018

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A13. Robustness test: The effect of availability of 3K on mothers' employment with different samples and specifications: Single-parent households

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.020	-0.026	-0.013	-0.020	0.0238	0.0220
	(0.056)	(0.056)	(0.052)	(0.052)	(0.0690)	(0.0693)
Age 3 (3K)	-0.055	-0.057	-0.056	-0.056	-0.0260	-0.0288
	(0.049)	(0.049)	(0.046)	(0.046)	(0.0624)	(0.0628)
Age 4 (Pre-K)	**0.143***	**0.134***	**0.124***	**0.116***	**0.1378***	**0.1328***
	(0.061)	(0.060)	(0.058)	(0.057)	(0.0664)	(0.0662)
Age 5 (K)	0.003	-0.010	0.036	0.031	0.1156	0.1070
	(0.080)	(0.080)	(0.070)	(0.070)	(0.0930)	(0.0936)
Age 6 (Grade 1)	0.030	0.017	0.063	0.057	0.0976	0.0914
	(0.064)	(0.062)	(0.062)	(0.061)	(0.0799)	(0.0809)
Age 7 (Grade 2)	0.145	0.138	0.147	0.141	0.1074	0.1002
	(0.136)	(0.132)	(0.135)	(0.131)	(0.1991)	(0.1965)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	1,826	1,826	2,174	2,174	1,237	1,237

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A14. Robustness test: The effect of availability of 3K on mothers' employment with different samples and specifications: Households with younger children

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.046	-0.046	-0.045	-0.048	0.0891	0.0841
	(0.054)	(0.054)	(0.042)	(0.042)	(0.0784)	(0.0778)
Age 3 (3K)	**0.086+**	**0.085+**	0.039	0.040	0.0740	0.0589
	(0.049)	(0.049)	(0.044)	(0.044)	(0.0729)	(0.0727)
Age 4 (Pre-K)	0.085	0.076	0.056	0.051	**0.1650+**	0.1340
	(0.062)	(0.061)	(0.055)	(0.054)	(0.0848)	(0.0873)
Age 5 (K)	0.047	0.035	0.009	0.002	0.0290	-0.0050
	(0.068)	(0.068)	(0.056)	(0.056)	(0.1028)	(0.1043)
Age 6 (Grade 1)	-0.017	-0.024	-0.041	-0.046	-0.0154	-0.0244
	(0.063)	(0.064)	(0.058)	(0.058)	(0.1063)	(0.1079)
Age 7 (Grade 2)	-0.042	-0.054	-0.061	-0.068	-0.0173	-0.0359
	(0.098)	(0.097)	(0.098)	(0.097)	(0.1701)	(0.1792)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	2,396	2,396	3,130	3,130	1,165	1,165

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).

Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A15. Robustness test: The effect of availability of 3K on mothers' employment with different samples and specifications: Low-income households

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.033	-0.034	-0.028	-0.028	0.0181	0.0166
	(0.032)	(0.032)	(0.028)	(0.028)	(0.0403)	(0.0403)
Age 3 (3K)	0.041	0.040	0.029	0.030	0.0346	0.0357
	(0.030)	(0.030)	(0.028)	(0.028)	(0.0411)	(0.0410)
Age 4 (Pre-K)	**0.074+**	**0.068+**	**0.066+**	**0.062+**	**0.0824+**	**0.0808+**
	(0.041)	(0.041)	(0.038)	(0.038)	(0.0429)	(0.0429)
Age 5 (K)	0.030	0.023	0.045	0.039	0.0800	0.0771
	(0.045)	(0.045)	(0.039)	(0.039)	(0.0557)	(0.0559)
Age 6 (Grade 1)	0.042	0.033	0.051	0.044	**0.1019+**	**0.0995+**
	(0.048)	(0.047)	(0.045)	(0.045)	(0.0564)	(0.0571)
Age 7 (Grade 2)	-0.018	-0.027	-0.016	-0.024	0.0393	0.0324
	(0.072)	(0.072)	(0.072)	(0.071)	(0.0980)	(0.0989)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	5,664	5,664	7,013	7,013	3,164	3,164

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).

Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A16. Robustness test: The effect of availability of 3K on families' material hardship with different samples and specifications: Two-parent households

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.025	-0.025	0.021	0.023	-0.0760	-0.0799
	(0.046)	(0.046)	(0.038)	(0.038)	(0.0788)	(0.0793)
Age 3 (3K)	**-0.090+**	**-0.089+**	-0.055	-0.053	**-0.2186****	**-0.2218****
	(0.048)	(0.049)	(0.042)	(0.042)	(0.0762)	(0.0765)
Age 4 (Pre-K)	-0.096	-0.095	-0.082	-0.082	-0.1152	-0.1308
	(0.063)	(0.064)	(0.056)	(0.057)	(0.0994)	(0.1023)
Age 5 (K)	-0.019	-0.018	-0.027	-0.026	-0.0484	-0.0611
	(0.082)	(0.082)	(0.067)	(0.067)	(0.1121)	(0.1125)
Age 6 (Grade 1)	**-0.171***	**-0.172***	-0.098	-0.096	**-0.2647+**	**-0.2802+**
	(0.075)	(0.075)	(0.066)	(0.066)	(0.1567)	(0.1579)
Age 7 (Grade 2)	-0.001	0.003	0.022	0.025	-0.0759	-0.0793
	(0.069)	(0.069)	(0.067)	(0.067)	(0.1123)	(0.1131)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	2,231	2,231	2,875	2,875	1,090	1,090

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A17. Robustness test: The effect of availability of 3K on families' material hardship with different samples and specifications: Households with younger children

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.090	-0.095	-0.016	-0.019	-0.1587	-0.1815
	(0.074)	(0.074)	(0.063)	(0.063)	(0.1138)	(0.1170)
Age 3 (3K)	**-0.189***	**-0.188***	**-0.135***	**-0.133+**	**-0.2265***	**-0.2547***
	(0.076)	(0.077)	(0.068)	(0.069)	(0.1128)	(0.1140)
Age 4 (Pre-K)	**-0.243***	**-0.255***	**-0.233***	**-0.242***	**-0.2419+**	**-0.2955***
	(0.115)	(0.116)	(0.101)	(0.104)	(0.1428)	(0.1482)
Age 5 (K)	**-0.301+**	**-0.295+**	**-0.250***	**-0.256***	**-0.4211***	**-0.4618***
	(0.159)	(0.160)	(0.122)	(0.123)	(0.1764)	(0.1793)
Age 6 (Grade 1)	**-0.350****	**-0.365****	**-0.233***	**-0.227***	**-0.3495+**	**-0.3489+**
	(0.112)	(0.116)	(0.092)	(0.093)	(0.1800)	(0.1841)
Age 7 (Grade 2)	0.014	0.024	0.048	0.042	0.1069	0.0584
	(0.119)	(0.118)	(0.118)	(0.116)	(0.2033)	(0.2011)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	955	955	1,211	1,211	489	489

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020).
Note: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A18. Robustness test: The effect of availability of 3K on families' material hardship with different samples and specifications: Low-income households

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.047	-0.045	-0.002	-0.001	-0.0762	-0.0832
	(0.052)	(0.052)	(0.045)	(0.045)	(0.0706)	(0.0713)
Age 3 (3K)	**-0.118***	**-0.115***	-0.072	-0.070	**-0.1613***	**-0.1678***
	(0.054)	(0.054)	(0.049)	(0.050)	(0.0750)	(0.0751)
Age 4 (Pre-K)	**-0.155***	**-0.150***	**-0.142***	**-0.138***	-0.1390	**-0.1562+**
	(0.071)	(0.071)	(0.065)	(0.065)	(0.0897)	(0.0920)
Age 5 (K)	-0.048	-0.045	-0.054	-0.050	-0.1207	-0.1382
	(0.087)	(0.087)	(0.077)	(0.077)	(0.1043)	(0.1048)
Age 6 (Grade 1)	**-0.149+**	-0.146	-0.071	-0.067	**-0.2790***	**-0.2939***
	(0.089)	(0.090)	(0.080)	(0.080)	(0.1234)	(0.1230)
Age 7 (Grade 2)	-0.081	-0.076	-0.054	-0.049	**-0.1770+**	**-0.1875+**
	(0.073)	(0.073)	(0.071)	(0.071)	(0.1036)	(0.1040)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	Yes
N	2,001	2,001	2,459	2,459	1,127	1,127

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A19. Robustness test: The effect of availability of 3K on families' material hardship with different samples and specifications: Households of US-born parents

Focal child's age related to (pre)school grade	Main sample (2014-2016 birth cohort)	Main sample (2014-2016 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 1 (Added 2017 birth cohort)	Supplemental sample 2 (Limited to early 3K rollout districts)	Supplemental sample 2 (Limited to early 3K rollout districts)
	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
Age 1	-0.009	-0.009	0.033	0.037	-0.1006	-0.1039
	(0.052)	(0.053)	(0.043)	(0.043)	(0.0793)	(0.0798)
Age 3 (3K)	**-0.114***	**-0.110***	**-0.100***	**-0.096***	**-0.1807***	**-0.1808***
	(0.050)	(0.050)	(0.044)	(0.044)	(0.0801)	(0.0805)
Age 4 (Pre-K)	-0.091	-0.083	-0.073	-0.068	-0.0577	-0.0677
	(0.070)	(0.071)	(0.064)	(0.064)	(0.0973)	(0.1003)
Age 5 (K)	-0.048	-0.039	-0.069	-0.064	-0.1028	-0.1157
	(0.089)	(0.090)	(0.078)	(0.078)	(0.1210)	(0.1243)
Age 6 (Grade 1)	-0.134	-0.133	-0.026	-0.024	**-0.3130***	**-0.3291****
	(0.084)	(0.085)	(0.075)	(0.075)	(0.1242)	(0.1232)
Age 7 (Grade 2)	-0.010	0.001	0.006	0.013	-0.1671	-0.1744
	(0.068)	(0.069)	(0.067)	(0.067)	(0.1362)	(0.1403)
Family FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Family-level covariates	No	Yes	No	Yes	No	Yes
District-level covariates	No	Yes	No	Yes	No	No
N	1,764	1,764	2,236	2,236	967	967

Source: Early Childhood Poverty Tracker (2017-2023) and Poverty Tracker 2nd cohort (2015-2020). **Note**: The event-study difference-in-difference estimates and robust standard errors that are clustered by household are shown. Main sample includes only mothers with children eligible for 3K prior to the COVID-19 pandemic (born in 2014, 2015, and 2016). The supplemental sample includes mothers with children eligible for 3K during the pandemic (born in 2017). ** p<.01, * p<.05, + p<.1

Table 2-A20. Placebo test: The effect of availability of 3K on mothers' employment and material hardship among families without preschool-age children

Panel A: Full sample	Employment (Families without preschool-age children)	Employment (Families with children in ages 6-18)	Income-to-needs ratio (Families without preschool-age children)	Income-to-needs ratio (Families with children in ages 6-18)	Material Hardship (Families without preschool-age children)	Material Hardship (Families with children in ages 6-18)
Year (reference year=2018)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)	Coef (S.E.)
2017	-0.016	0.002	0.028	-0.012	0.019	-0.024
	(0.019)	(0.042)	(0.048)	(0.109)	(0.023)	(0.050)
2019	0.003	-0.008	0.042	0.147	0.024	-0.011
	(0.021)	(0.047)	(0.049)	(0.114)	(0.025)	(0.054)
2020	-0.012	-0.053	0.056	0.021	-0.006	-0.108
	(0.029)	(0.063)	(0.060)	(0.096)	(0.034)	(0.067)
N	9,735	2,240	9,735	2,240	9,735	2,240

Source: Poverty Tracker 2nd cohort (2017-2020). **Note**: The event-study difference-in-difference estimates and robust standard errors clustered by household are shown. Results presented in Panel A use the sample restricted to families with a female adult without any child under age 6. Results in Panel B use the sample further restricted to those families with a female adult living with children aged 6-18 without children under age 6. The placebo treatment group is defined as families who lived in school districts where had 3K by 2019, and the placebo comparison group is families who lived in districts where did not have 3K until 2019. ** p<.01, * p<.05, + p<.1

Paper 3: Pre-kindergarten Attendance and Children's Cognitive Development in the Short, Middle, and Long Term

3.1 Abstract

Publicly funded pre-kindergarten (pre-K) has become a cornerstone policy for expanding and equalizing access to high-quality early education, particularly for lower-income families. Evaluations of local pre-K programs have documented short-term cognitive benefits for children, but evidence on longer-term effects and the mechanisms remains limited and inconclusive. Using data from the Future of Families and Child Wellbeing Study—a longitudinal study tracking urban-born children from birth to young adulthood—this study examines whether pre-K attendance predicts better early cognitive outcomes and whether these short-term benefits extend into middle childhood, adolescence, and adulthood. The findings show that pre-K attendance is strongly associated with improved early cognitive skills, particularly in language, literacy, and attention at age 5. These associations persist into middle childhood, with modest and muted association with higher vocabulary, reading, and math test scores and strong association with a reduced likelihood of grade repetition in earlier grades. Associations weaken in adolescence, particularly for self-reported GPA and grade retention in higher grades, but long-term follow-up reveals that pre-K attendance predicts better educational outcomes at age 22, including a higher probability of high school graduation on time. Notably, early and middle childhood cognitive gains were most pronounced among children of mothers with a high school education or less and among Black and Hispanic families. The long-term association with junior college or college

completion at age 22 was larger for Black children than for white children. Implications on the skill-building model and institutional gateway model are discussed.

3.2 Introduction

Over the past decades, many states have expanded prekindergarten (pre-K) programs to make high-quality early education accessible to low- and moderate-income families. Pre-K curricula, eligibility rules, and program schedules vary significantly across states, but the shared goal is to reduce disparities in school readiness linked to socioeconomic status, laying a foundation for equitable development throughout childhood and beyond (Duncan & Magnuson, 2011). Unlike Head Start—a federally funded early childhood education program targeting families below the federal poverty line and providing comprehensive developmental support—state pre-K programs often emphasize academic readiness with broader or no income eligibility criteria.

Despite variations across states, studies consistently report that pre-K attendance is associated with short-term gains in literacy and numeracy at kindergarten entry (Cascio, 2023; Gormley et al., 2005; Lipsey et al., 2018; Weiland & Yoshikawa, 2013). However, the evidence on middle- and long-term benefits is mixed. Some research suggests that cognitive advantages quickly diminish as children progress through school (Bassok et al., 2019; Lipsey et al., 2018; Magnuson et al., 2007), whereas other studies document higher school achievement in middle childhood and adolescence associated with pre-K exposure or participation (Bai et al., 2020; Fitzpatrick, 2008; Gormley et al., 2018; Watts et al., 2023). Recent evaluations of universal pre-K programs in Tulsa and Boston identify long-term benefits, including higher rates of high school completion and college enrollment (Gormley et al., 2023; Gray-Lobe et al., 2023). However, there is evidence suggesting that children from low-income families, at least in the

short run, benefit less from means-tested programs compared to universal programs (Cascio, 2023). Thus, it remains unclear whether the long-term benefits found from two universal pre-K programs can also be observed with various forms of state pre-K programs.

This study addresses these gaps by examining the link between pre-K attendance and cognitive development outcomes across multiple developmental stages—early childhood, middle childhood, adolescence, and young adulthood. Using longitudinal data from the Future of Families and Child Wellbeing Study (FFCWS), which tracks urban-born children from birth to adulthood, the analysis compares children who attended pre-K the year before kindergarten with those in home-based care, controlling for a range of family and child characteristics measured before pre-K enrollment.

This study seeks to answer three key questions:

1. Does pre-K attendance predict better cognitive outcomes in early childhood?
2. Do short-term cognitive gains persist into middle childhood and adolescence, ultimately influencing educational outcomes in adulthood?
3. Do children from disadvantaged families benefit more from attending pre-K?

Findings suggest that pre-K attendance is associated with better early cognitive skills—particularly in language, literacy, and attention—compared to home-based care. These benefits persist into middle childhood, with a lower likelihood of grade repetition by around age 9 and modestly higher vocabulary, reading, and math skills. But the associations fade by adolescence, as indicated by the lack of association with self-reported GPA at age 15. Nevertheless, pre-K attendance predicts a higher probability of high school graduation on time.

Subgroup analyses reveal that cognitive gains in early and middle childhood are most pronounced among children of mothers with a high school degree or less and among Black and

Hispanic families. The associations between pre-K attendance and postsecondary outcomes in young adulthood were particularly salient for Black individuals. Boys and girls tend to show comparable benefits throughout.

The paper is structured as follows: Section 3.3 and 3.4 review the conceptual framework for the long-term benefits of pre-K attendance—the skill-building model and institutional gateway model—and prior evidence on the short-term and sustained effects of pre-K on cognitive development. Sections 3.5 and 3.6 outline the data and analytical approach. Sections 3.7 and 3.8 present results from the main and supplemental analyses, respectively, and the paper concludes in Section 3.9 with a discussion of findings and policy implications.

3.3 Theoretical Framework

Skill-building model and institutional gateway model

Early childhood education program is theorized to yield long-term benefits through multiple pathways. Cunha and Heckman (2007) formulate a framework of viewing the early educational investments to produce multiplier effects that "skills beget skills." They describe two mechanisms that make early childhood investment efficient. First, learning is "self-productive"—early simpler skill facilitates acquiring later advanced skills. Second, early skill investments make subsequent investment more productive. This process is called "dynamic complementarity," where early skills create synergistic gains in later learning. For example, a child with better letter decoding skills can benefit more from a first-grade reading class than a child who is not equipped with decoding skills. In this scenario, the child with better decoding skills will continue to excel beyond the other child in more complex reading comprehension skills as they advance through grades. Therefore, the dynamic complementarity skill-building model posits the persistent effects of early education programs.

However, this scenario may not hold if later skill-building is more efficient for children with poorer foundational skills. This is characterized as "dynamic substitutability," which can occur when the early education programs target skills that children will eventually be learned through subsequent schooling (Bailey et al., 2020; Duncan et al., 2023). For example, if a child who began kindergarten with poorer decoding skills readily catches up to their high-performing peers through first-grade instruction, then the difference in decoding skills between the two children would converge, and the two children would later demonstrate comparable reading performance. If this is the case, the educational advantage derived from early education programs would not last long.

The institutional gateway—or foot-in-the-door—perspective provides another theoretical pathway through which a well-timed education program may yield lasting benefits (Bailey et al., 2017; Bailey et al., 2020). According to this perspective, early education programs can prepare children to successfully transition into formal schooling on time, which may create cumulative advantages across multiple domains over time. As Elder and Shanahan (2006) underscore, the potential long-term developmental significance of early transitions is that "the quality of transition experiences early in life may foretell the likelihood of successful and unsuccessful adaptation to later transitions across the life course" (p. 685).

Bailey et al. (2020) illustrate the theoretical mechanism of the institutional gateway model through a two-stage process. The primary effect is children's skill development through early education programs, which equip children with fundamental skills to stay on track during school entry and early schooling years. The secondary effect follows: compared to children who were institutionally disqualified from an on-time transition to schooling, those who transition at

the institutionally expected age may develop more positive belief systems about their educational capabilities. This shift can be observed among parents, teachers, and the children themselves. The institutional transition model emphasizes the secondary effect as the key driver generating the long-term benefits of early education programs. That is, even if the skills acquired through early education programs could eventually be learned later in schooling, this model posits that the timing of the program matters for life-course outcomes by supporting a successful first institutional transition.

3.4 Literature Review

Evidence on Pre-K's short, middle, and long-term effects on cognitive development

Studies on pre-K's short-, middle-, and long-term developmental effects build on literature from model early intervention programs, such as the Perry Preschool Program and the Abecedarian Project, that target high-risk young children. In randomized controlled trial (RCT) evaluations, the treated group showed higher test scores in early grades, a lower probability of grade retention, and a lower assignment to special education compared to the control group (Ramey & Campbell, 1991). The treated group also exhibited lifelong benefits, including a higher probability of graduating from high school and college, as well as increased earnings (Campbell et al., 2014; García, Heckman, Leaf, & Prados, 2020).

This promising evidence on the short- and long-term impacts of model intervention programs has also been documented in evaluations of Head Start programs, which target children in poverty. Numerous observational and quasi-experimental studies have shown that Head Start participation is associated with higher test scores in short-term (Deming, 2009; Zhai et al., 2011) and long-term (Bailey et al., 2021; Carneiro & Ginja, 2014; Currie & Thomas, 1995; Deming, 2009; Garces et al., 2002; Ludwig & Miller, 2007). In contrast, the large-scale Head Start RCT

evaluation that followed children from kindergarten to third grade—Head Start Impact Study (HSIS)—yielded less positive results than other studies, documenting small and short-lived impacts of Head Start on test scores. However, research that revisited the HSIS found that Head Start participants outperformed the comparison group, particularly when compared with children in informal care settings as opposed to those in preschool programs comparable to Head Start, such as state pre-K (Kline & Walters, 2016; Zhai et al., 2014).

Although Head Start and Pre-K programs serve as close substitutes for low-income families, the evidence from studies of Head Start's short- and long-term effects may not necessarily apply to pre-K programs because of differences in the target population and the scope of services provided to children and families. Pre-K programs operate on a larger scale and serve children from families across a broader income spectrum. Additionally, they primarily provide early education in an academic setting, rather than the comprehensive social services (health, nutrition, and parenting education) offered by Head Start. Therefore, whether participating in state pre-K programs yields short- and long-term developmental benefits for children and whether the benefits are comparable to Head Start are important policy questions relevant to child development.

Studies consistently find that state pre-K programs help children develop key cognitive skills—including language, literacy, numeracy, and executive functioning—at kindergarten entry (Ansari et al., 2019; Barnett et al., 2018; Gormley et al., 2005; Lipsey et al., 2018; Phillip et al., 2017; Weiland & Yoshikawa, 2013; Wong et al., 2008), although the effect sizes can vary depending on the variations in program designs across states (Cascio, 2023). For instance, quasi-experimental studies of universal pre-K programs in Tulsa and Boston report substantial gains in literacy and math, ranging from 0.45 to 0.62 standard deviations (Gormley et al., 2005; Weiland

& Yoshikawa, 2013). Similarly, an experimental study of Tennessee's state pre-K program shows moderate gains of 0.30 standard deviations in cognitive skills by the end of the pre-K year (Lipsey et al., 2018).

However, whether these early gains persist into the middle-term remains debated. Some studies report a rapid "fade-out" effect in test scores, where cognitive advantages diminish quickly as non-attendees "catch up" in skill levels through subsequent education (Bailey et al., 2020). For example, in the RCT evaluations, universal pre-K attendees in Boston did not outperform non-attendees in third-grade academic achievement (Gray-Lobe et al., 2023; Weiland et al., 2020), which supports the "dynamic substitutability" skill-building model. In another RCT evidence from Tennessee, pre-K participants even showed adverse outcomes in third- and sixth-grade achievement compared to non-pre-K participants (Durkin et al., 2022; Lipsey et al., 2018).

In contrast, other studies find that pre-K attendance has sustained positive effects, supporting the "dynamic complementarity" model. For instance, in Tulsa, Oklahoma, the benefits of universal pre-K extended to seventh-grade academic achievement (Gormley et al., 2018). Similar findings are documented in Georgia and North Carolina, where state pre-K programs were associated with lasting academic effects through middle childhood and adolescence (Bai et al., 2020; Fitzpatrick, 2008; Watts et al., 2023).

The evidence on the long-term impacts of pre-K attendance is promising yet limited in generalizability. Two studies have evaluated universal pre-K programs in Boston (Gray-Lobe et al., 2023) and Tulsa, Oklahoma (Gormley et al., 2023), both of which document a positive link between pre-K attendance and young adulthood educational outcomes. Specifically, using an RCT design, Gray-Lobe et al. (2023) found that pre-K attendance increased the likelihood of high school graduation by 6 percentage points, the likelihood of on-time college enrollment by

8.3 percentage points, and college enrollment at any time by 5.4 percentage points. Notably, Gray-Lobe et al. (2023) did not observe academic advantages from third to twelfth grade, which challenges the skill complementarity model's prediction that early skill gains will amplify over time. However, the significant long-term effects suggest that the relationship between pre-K attendance and young adult outcomes may operate through channels beyond school achievement.

Similarly, using propensity score weighting, Gormley et al. (2023) found that pre-K attendees were 12.1 percentage points more likely to enroll in any college or university than children who did not attend either Tulsa pre-K or Head Start. Since these two studies focus on local universal pre-K programs, questions remain regarding the generalizability of pre-K's long-term benefits.

Evidence on subgroup differences in pre-K's short, middle, and long-term effects

Prior studies have investigated the heterogeneous effects of pre-K programs to examine whether the program generates greater benefits for specific groups of children. Whether children from disadvantaged family backgrounds benefit more than their relatively advantaged peers has been a particular question of interest. Watts et al. (2023) present three hypothetical patterns of interaction between children's environment and pre-K exposure: (1) "Complementary effects" – Pre-K effects are larger for children in advantaged environments, (2) "Compensatory effects" – Pre-K effects are larger for children in disadvantaged environments, and (3) "Additive effects" – Pre-K effects are comparable for children from different environments.

The sex difference in pre-K effects has also gained scholarly attention, considering that developmental sensitivity in early childhood may differ by sex (Chetty et al., 2016; Schore, 2017). In this section, I review studies that examined subgroup differences by parental socioeconomic status (SES), parental race and ethnic identity, and children's sex across short-,

middle-, and long-term periods. Following Watts et al. (2023), I refer to significantly larger effects for children from lower SES backgrounds or Black and Hispanic children as "compensatory" effects and insignificant subgroup differences as "additive" pre-K effects.

Parent socioeconomic status

Research often finds compensatory effects of state pre-K based on parent SES, but there is also evidence supporting additive effects. At the end of the pre-K year, Weiland and Yoshikawa (2013) found greater test score gains among students from lower-income families who attended Boston's universal pre-K. In Tulsa, Oklahoma, however, Gormley et al. (2005) documented that children from diverse income groups all benefited from attending universal pre-K, including children eligible for free lunch and those who were not eligible.

Numerous studies on pre-K's extended-term effects during middle childhood or adolescence align with the compensatory model, reporting greater effects for children from lower-SES families (proxied by eligibility for the school lunch program or mother's education) in North Carolina (Bai et al., 2020; Ladd et al., 2014; Watts et al., 2022) and in Oklahoma and Georgia (Cascio & Schanzenbach, 2013). However, Gormley et al. (2018) found that both free-lunch-eligible and ineligible students showed a persistent association between pre-K attendance and middle school performance in Tulsa, Oklahoma.

In two studies that found a significant long-term link between pre-K attendance and postsecondary education, neither found significant subgroup differences based on children's eligibility for free or reduced-price lunch (Gormley et al., 2023; Gray-Lobe et al., 2023), suggesting additive effects of pre-K attendance in the long run.

Race and ethnicity

Studies examining differential effects by race and ethnicity frequently find greater benefits among Hispanic and Black children compared to their white peers. For early childhood cognitive skills, Weiland and Yoshikawa (2013) found a larger boost in cognitive test scores among Hispanic students compared to white students in Boston. In contrast, findings from Tulsa highlight that white children showed significant increases in cognitive test scores, similar to Black and Hispanic children at the end of the pre-K year (Gormley et al., 2005).

In an exploration of heterogeneous sustained effects, multiple studies document larger lasting effects for Black or Hispanic children in North Carolina (Bai et al., 2020; Watts et al., 2022) and for Black children in Georgia (Fitzpatrick, 2008). Again, the evidence from universal program of Tulsa points to additive effects, indicating that all racial and ethnic groups benefited from pre-K attendance over extended periods (Gormley et al., 2018).

In young adulthood, the differences by race and ethnic group in pre-K's long-term effects were not significant in Boston and Tulsa (Gormley et al., 2023; Gray-Lobe et al., 2023).

Child sex

Prior studies often find insignificant sex differences in pre-K's effects or evidence favoring boys. In early childhood cognitive skills, Weiland and Yoshikawa (2013) found that both boys and girls who attended Boston's universal pre-K showed significant skill gains. In middle childhood, Fitzpatrick (2008) did not find differential effects by child sex on fourth-grade academic performance in Georgia's universal pre-K. Similarly, Gormley (2018) did not find sex differences in the effects of Tulsa's universal pre-K on eighth-grade outcomes.

In contrast, in North Carolina, Muschkin et al. (2020) found larger pre-K exposure effects for boys than for girls on standardized test scores in grades three to five, but the effects on reducing special education placements did not differ by sex. In the long run, Gormley et al.

(2023) documented that both male and female pre-K attendees showed a higher likelihood of college enrollment to a comparable degree in Tulsa, Oklahoma. However, Gray-Lobe et al. (2023) highlighted that pre-K attendance increased the likelihood of high school graduation and college enrollment, particularly for male pre-K participants in Boston.

Current study

The first panel of Appendix Table 1 summarizes evidence on the short- and long-term effects of pre-K programs. The literature largely indicates that pre-K effectively boosts test scores at kindergarten entry. However, the evidence on extended effects during middle childhood and adolescence remains inconclusive. Promising findings from Tulsa and Boston suggest long-lasting benefits in young adulthood.

The second panel of Table 3-A1 in the Appendix summarizes prior studies on the heterogeneous effects of pre-K based on parental SES, race and ethnicity, and child sex across short-, middle-, and long-term periods. In the short- and middle-term, studies often support the compensatory model, finding larger increases in test scores or academic performance among students from lower-SES backgrounds or those who identify as Black or Hispanic. Studies often do not find heterogeneous effects by child sex, but when they do, boys tend to show greater gains in educational achievements.

A major limitation in the literature is that long-term evidence regarding outcomes in young adulthood comes from only a small subset of cities that implemented universal pre-K (i.e., Boston, Tulsa). As a result, the generalizability of documented long-term benefits across various state pre-K programs remains unclear. Additionally, few studies on long-term effects have examined early childhood outcomes, limiting our understanding of the mechanisms underlying the persistent link between pre-K attendance and young adult educational achievements.

This study addresses these gaps by examining the association between pre-K attendance and cognitive outcomes across early childhood, middle childhood, adolescence, and young adulthood. Using longitudinal data from children born in 18 U.S. cities across 15 states, this study explores the patterns of effects of pre-K attendance across developmental stages, as well as the patterns of the subgroup differences in effect across life cycle.

3.5 Data

This study uses the Future of Families and Child Wellbeing Study (FFCWS) to examine the link between pre-K attendance and children's cognitive development. The FFCWS is a longitudinal birth cohort study of 5,000 children born between 1998 and 2000 in 20 U.S. cities across 15 states (Reichman et al., 2001). The study oversampled children born to unmarried parents, resulting in a higher representation of Black, Hispanic, and low-income families than the national average. Families were surveyed shortly after the focal child's birth, with follow-ups at ages 1, 3, 5, 9, 15, and 22.

The cohort of FFCWS children were eligible for pre-K programs between the 2002–2003 and 2004–2005 academic years, and 13 of the 15 FFCWS birth states had pre-K programs at that time. These programs primarily targeted low-income families or children at risk of lower academic achievement, with pre-K enrollment rates among 4-year-olds ranging from 2% (Tennessee) to 38% (Texas). Table 3-A2 in the Appendix provides details on these programs.

The analytic sample excluded 932 children for whom childcare arrangement data were unavailable, reducing the sample from 4,898 to 3,966. To focus on the target population for pre-K programs, the sample was further restricted to 3,225 children in households with incomes below 300% of the federal poverty line, measured during the age 3 survey.

As only 1,074 children provided full information for all child outcomes of interest, I used all available observations for each outcome rather than restricting the analytic sample to only those providing complete data across all outcomes. Additionally, about 85% of the analytic sample had data for all covariates. The 15% of cases with missing covariates were included in the analysis, with controls indicating missing values for each covariate.

Pre-K attendance

Pre-K attendance was identified through parental reports on childcare arrangements during the year before kindergarten. Mothers' responses were primarily used, supplemented by fathers' reports when mothers' reports were unavailable. In the age 5 follow-up survey, parents of children not yet in kindergarten were asked about current care arrangements, while parents of children already in kindergarten were asked about past care arrangements. The survey first inquired whether the child was cared for in a center- or school-based setting. For those who answered yes, it then asked about the specific type of school or center-based care, including (1) daycare, (2) nursery school, (3) preschool, (4) Head Start, (5) pre-kindergarten, and (6) junior kindergarten. If the child attended more than one category, respondents were instructed to select the category with the highest number, prioritizing publicly funded or operated early education programs. For example, a child enrolled in both (2) daycare and (5) pre-kindergarten would be classified as attending pre-kindergarten in the FFCWS.

In this study, children reported to be in pre-kindergarten or junior kindergarten were categorized as "pre-K." Children who were reported to be in Head Start are grouped into "Head Start", and the remaining children in other center-based care (i.e., daycare, nursery school, preschool) were grouped into "other center care." Children in family daycare, relative care, non-relative individual care, or parental care were classified as "home-based care."

Covariates

Families' demographic and socioeconomic status can influence childcare selection (Chaudry et al., 2010; Joshi et al., 2025) and affect children's short- and long-term outcomes. This study accounted for several family and child characteristics that could confound the association between pre-K attendance and child outcomes.

The covariates included mothers' race and ethnicity, marital and cohabiting status, and highest education level attained at the child's birth (less than high school, high school degree, some college, or college degree and higher). They also included mothers' employment history at child age 1, which was classified as non-employment, part-time work, or full-time work. Household income-to-needs ratio and child care arrangement at child age 3 (parental care, non-parental informal care, family daycare, or center-based care) were also included. Mothers' cognitive test scores measured with the sum of correct items in the Similarities subtest of the Wechsler Adult Intelligence Scale (WAIS-R) at child age 3 was controlled, which provides a rough estimate of cognitive ability, assessing verbal concept formation and reasoning abilities. Additionally, child's sex and low birth weight were accounted for. Since child outcomes were examined at different ages, child's age at assessment was also controlled in the analysis.

Sample characteristics by childcare arrangement

Table 3-1 describes the sample characteristics by childcare arrangement, showing demographic and socioeconomic differences among children who attended pre-K, other center-based care, Head Start, and home-based care. Compared to children in other center-based care, pre-K attendees were less likely to have white or Black mothers and more likely to have Hispanic mothers, possibly reflecting that states offering relatively more pre-K slots in the FFCWS also had a high share of Hispanic populations (e.g., Texas, New York). Mothers of pre-K attendees

were more likely to cohabit with the child's biological father and less likely to be single at the time of the child's birth.

Compared to children in home-based care, pre-K attendees were less likely to have white mothers and more likely to have Black mothers. Their mothers were less likely to cohabit with the biological father, less likely to have dropped out of high school, and more likely to have some college education. Pre-K attendees were more likely to have full-time working mothers instead of having non-working mothers at age 1, less likely to experience poverty at age 3, and more likely to be placed in center-based care rather than solely cared for by parents at age 3. The difference in mothers' cognitive scores measured with WAIS-S at the child's age of 3 was minimal.

Children's baseline characteristics were largely comparable across early care arrangement. No significant differences were observed in the proportion of male children and pre-treatment developmental outcomes, such as low birth weight and PPVT scores at age 3.

The results in Table 3-1 indicate that there are some characteristics where children who attended pre-K differ from their peers. As discussed below, these characteristics and all the others discussed above are included as controls in all the regression models.

Child outcomes

Cognitive development and educational transition outcomes were assessed at each developmental stage. Early childhood cognitive development was measured with standardized tests measuring language, literacy, and attention skills around age 5. All tests took place at the child's home for a subset of FFCWS participants whose parents had consented to participate in the In-Home Study (for about 2,600 children). Children's receptive vocabulary skill was measured with the Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1981),

measuring the ability to comprehend spoken words using visual cues. The examiner showed four pictures on a card and said a word, and children were asked to point to the picture that best matched the word. The Woodcock-Johnson Letter-Word Identification Test (WJ- Test 22; Woodcock et al., 2001) measured basic decoding ability, assessing a child's capacity to name individual letters and read words aloud. Children's sustained attention skills were measured using the Leiter International Performance Scale-Revised (Leiter-R; Roid & Miller, 1997), which assesses sustained attention and has been shown to predict children's learning approaches in middle childhood (Razza et al., 2010). Children were presented with a page containing various scattered pictures and a target object at the top. They were instructed to cross out as many target pictures as possible without mistakenly marking a non-target object within a limited time. The number of correct cross-outs measured focused attention, while the number of incorrect cross-outs (reverse-coded) indicated impulsivity. The combined scores reflected children's ability to sustain attention. These three tests were designed to be appropriate for children of varying ages, and scores were reported as standardized scores, indicating a child's skill level relative to the national normal distribution of skills among children of the same age.

To explore whether foundational cognitive skills in early childhood transferred to more advanced abilities in middle childhood, standardized test scores in vocabulary, reading, and math around age 9 were analyzed. Again, the PPVT-III (Dunn & Dunn, 1981) assessed receptive vocabulary skills. The Woodcock-Johnson Passage Comprehension scale (WJ Subtest 9; Woodcock et al., 2001) evaluated a child's ability to understand the context of written text. In this task, children were asked to identify the missing word that best fit in a short passage. The Woodcock-Johnson Applied Problems scale (WJ Subtest 10; Woodcock et al., 2001) measured mathematical reasoning and knowledge, requiring children to interpret and solve math problems

that involved multi-step calculations related to real-world scenarios. In addition, a binary measure of grade retention was included as an indicator of early institutional transitions, coded as 1 if the child had ever repeated a grade from kindergarten and age 9 survey and 0 otherwise.

Adolescents' self-reported GPA was analyzed to assess whether early skills developed in pre-K extended to predict later school achievements. In the age 15 follow-up survey, adolescents were asked to report their most recent GPA in English, math, science, and social studies, which was coded on a 4-point scale (A = 4, B = 3, C = 2, D or lower = 1). It should be noted that adolescents' academic achievements were measured based on self-reported grades rather than objective school records or standardized test scores, which may raise concerns about reporting errors. Grade retention since the age 9 survey was used as an additional indicator of academic progress throughout upper elementary and middle school, coded as 1 if the child repeated any grade since the age 9 follow-up survey and 0 otherwise.

Young adulthood educational transition outcomes were examined to explore the long-term benefits of pre-K attendance, measured by high school graduation, on-time high school graduation, junior college or college completion, and bachelor's degree attainment. These four outcomes were treated as binary variables. In the age 22 follow-up survey, young adults were asked about their highest completed grade or educational degree. High school graduation was coded as 1 if the adult obtained a high school diploma, GED, or higher education and 0 if the highest grade completed was 12th grade or lower. Among high school graduates, on-time high school graduation was determined based on whether young adults graduated in the expected year without any grade retention. For example, individuals born in 1998 who graduated by 2016 or earlier were coded as 1 for "on-time high school graduation", while those who graduated in 2017 or later were coded as 0. Junior college or college completion was coded as 1 if the adult

completed an associate's degree, junior college, bachelor's degree, or advanced education degree (including Master's, Doctoral, or professional degrees) and 0 otherwise. Bachelor's degree attainment was limited to those who completed at least a bachelor's degree, coded as 1 for completion and 0 otherwise.

Table 3-2 presents the unadjusted summary of child outcomes. The four columns show the mean values of the outcomes separately by type of early education and care used before kindergarten in the analytic sample, while the rightmost column presents the total number of observations for each outcome. Few significant differences were observed between pre-K attendees and children in other center-based care, though pre-K attendees scored higher on the Leiter test around age 5 and had a slightly higher probability of repeating grades during early adolescence. In contrast, pre-K attendees consistently outperformed children in home-based care across multiple developmental stages. They demonstrated higher scores on the PPVT, WJ, and Leiter tests at age 5, higher WJ-Math scores by age 9, and a lower likelihood of grade repetition by age 9. By age 15, pre-K attendees reported higher science grades, and by young adulthood, they exhibited a greater likelihood of high school graduation, on-time graduation, college completion, and attainment of a bachelor's degree.

These descriptive results are suggestive of some positive associations between pre-K and cognitive outcomes, but do not control for other characteristics that might differ between children who attended pre-K and their peers. For this reason, we now turn to the multivariate analysis.

3.6 Analytic Approach

This study estimated the association between pre-K attendance in the year before kindergarten and children's cognitive and academic outcomes around ages 5, 9, 15, and 22 using

ordinary least square (OLS) regression models. These models account for family sociodemographic and child characteristics before the treatment, and state fixed effects. The primary OLS regression equation is:

$$Y_{ist} = \beta_0 + \beta_1 PreK_{ist=5} + \beta_2 Center_{ist=5} + \beta_3 HS_{ist=5} + \beta_4 X_{ist<5} + \gamma_{st} + \epsilon_{ist}, \quad (1)$$

where Y_{ist} represents the developmental outcome for child *i* in state *s* measured at age *t*. Continuous outcomes were normalized to have a mean of 0 and a standard deviation (SD) of 1, enabling interpretation of coefficients as effect sizes in SD units. For binary outcomes, coefficients were not standardized and represent effect sizes in percentage points.

The variable $PreK_{ist=5}$ is a binary indicator for pre-K attendance and is coded as 1 if the child is reported to attend "pre-kindergarten" or "junior kindergarten" by their parents. Instead of comparing pre-K attendees to all non-attendees, the model controls for alternative care types by adding two dummy variables, $Center_{ist=5}$ and $HS_{ist=5}$, representing other center-based care (e.g., daycare, nursery school, preschool) and Head Start, respectively. Children who did not attend pre-K, other center care, or Head Start and were only cared for in a home-based care setting, including parental care, family daycare, relative care, serve as the reference category. Therefore, coefficient β_1 estimates the difference in outcomes between pre-K attendees and children in home-based care, while β_2 and β_3 compare other childcare types to home-based care. This approach builds on the evidence that developmental benefits of early childhood education programs are found to be muted if the comparison is made with the close-substitute programs, while the program may still be effective compared to less formal care options (Duncan et al., 2023; Kline & Walters, 2016; Zhai et al., 2014). Also, this approach is conceptually more aligned with the policy goal of pre-K, which aims to expand access to formal early education for

low- and moderate-income families who would have not able to attend other center-based care arrangement due to the high price of care or income criteria of public early education options (e.g., Head Start).

As discussed earlier, the model included a vector of controls ($X_{ist<5}$) for family and child characteristics that can confound the association between pre-K attendance and child outcomes. They include mothers' race and ethnicity, marital and cohabiting status at child's birth, the highest education attained at child's birth, mothers' employment history at child age 1, household income-to-need levels at child age 3, mothers' cognitive test scores measured at child age 3, and child care arrangement at child age 3, child's sex, and child low birth weight. In addition, the age of child when the outcome was measured was also controlled.

Lastly, state fixed effects (γ_{st}) accounted for shared characteristics among children living within the same state, including other policies that might affect child outcomes. For all models, robust standard errors (ϵ_{ist}) were clustered at the state level to address geographical sampling design and state-level variation in pre-K availability.

Addressing selection bias

The OLS model within an observational study design can yield biased estimates if confounding variables are omitted from the model. To address this concern, two supplemental analyses were conducted. First, to explore whether children with better development selected into pre-K, I conducted placebo tests (Equation 2) examining the association between pre-K attendance before kindergarten and cognitive and behavioral development preceding the treatment measured at age 3 ($Y_{ist=3}$).[6]

[6] Children's pre-treatment cognitive development was measured through the PPVT standardized scores. For children's pre-treatment behavioral development, mothers' reports on Child Behavior Check List (CBCL) were used to measure internalizing and externalizing problems. CBCL subscales for Anxious/Depressed and Withdrawn were combined to capture internalizing problems and Aggressive subscale is used for externalizing problems.

$$Y_{ist=3} = \beta_0 + \beta_1 PreK_{ist=5} + \beta_2 Center_{ist=5} + \beta_3 HS_{ist=5} + \beta_4 X_{ist<5} + \gamma_{st=3} + \epsilon_{ist=3} \quad (2)$$

$$Y_{ist} = \beta_0 + \beta_1 PreK_{ist=5} + \beta_2 Center_{ist=5} + \beta_3 HS_{ist=5} + \beta_4 X_{ist<5} + \beta_5 PPVT_{ist=3} + \gamma_{st} + \epsilon_{ist} \quad (3)$$

A second set of supplemental analyses were based on lagged dependent variable (LDV) models, in which Equation 1 incorporated the child's vocabulary test score measured at age 3 ($PPVT_{ist=3}$), as a proxy for pre-treatment cognitive development. As expressed in Equation 3, this model controls for pre-existing developmental differences across children in different child care arrangement before kindergarten. The caveat of this model is that the LDV model significantly reduces the sample size by 25%-37%, differing depending on the outcomes, since PPVT test scores are available for only a subset of the analytic sample.

3.7 Results

Table 3-3 presents the main OLS regression results, estimating the differences in child cognitive development outcomes between pre-K attendees and children in home-based care, while controlling for family and child characteristics and state fixed effects. Figure 3-1 displays standardized effect sizes for cognitive development outcomes (solid bars) and non-standardized effect sizes for educational transition outcomes (striped bars), along with 95% confidence intervals, across four developmental stages: early childhood, middle childhood, adolescence, and young adulthood.

Panel A presents the results for early childhood outcomes. Compared to children in home-based care, pre-K attendees demonstrated significantly higher vocabulary skills (PPVT, +0.26 SD), word identification skills (WJ test, +0.46 SD), and sustained attention skills (Leiter, +0.21 SD) at age 5.

In Panel B, the results for middle childhood outcomes indicate that the immediate benefits persisted, though with smaller effect sizes compared to early childhood outcomes. Specifically, pre-K attendees had higher vocabulary scores (PPVT, +0.14 SD), reading scores (WJ-Reading, +0.12 SD), and math scores (WJ-Math, +0.17 SD) around age 9. Additionally, pre-K attendees were 6.7 percentage points less likely to repeat a grade by age 9, representing a 27% reduction from the comparison group's mean grade repetition rate of 25%.

However, in Panel C, there was little evidence of extended benefits in adolescent school academic achievements, as measured by self-reported GPA and the likelihood of grade repetition in upper elementary and middle school.

In young adulthood (Panel D), pre-K attendance was associated with significant gains in educational attainment. Pre-K attendees were 5.8 percentage points more likely to graduate from high school and 6.7 percentage points more likely to graduate high school on time, translating to a 7% higher probability of high school graduation and an 11% higher probability of on-time high school graduation compared to the comparison group (82% high school graduation rate, 59% on-time high school graduation rate). There was also suggestive evidence of increased bachelor's degree attainment (+3.1 percentage points), though this result was marginally significant ($p < .10$).

Notably, the effect sizes for pre-K attendance were comparable to those of other center-based care and Head Start attendance, which also showed positive associations relative to home-based care.

Subgroup analysis

Table 4 presents the differential link between pre-K attendance and developmental outcomes across subgroups. I stratified the sample by maternal education levels (mothers with a

high school degree or less vs. mothers with some college education or above), race/ethnicity (Non-Hispanic Black (hereafter referred to as Black), Hispanic, and Non-Hispanic white (hereafter referred to as white)), and child sex (girls and boys) and ran the OLS regression model separately for each subgroup. I calculated the differences in the coefficients representing the association between pre-K attendance and outcomes and tested the significance of the difference based on the z-statistic (calculated as the difference in coefficients divided by the standard error of the difference). In Table 3-4, the statistical significance of the z-statistics at a 90% confidence level is presented as a superscript of the first letter of the reference group above the coefficients. For example, the superscript 'w' above the coefficient for Black subgroups indicates that the coefficient among Black children differed significantly from that among white children. Results are presented for early childhood (Panel A), middle childhood (Panel B), adolescence (Panel C), and young adulthood (Panel D).

In early childhood (Panel A), pre-K attendance was associated with significantly higher cognitive test scores, particularly among children of mothers without a college education and children of Black or Hispanic mothers. However, the difference in coefficients was only significant for letter decoding skills measured with WJ Word Identification test between Black and white children ($p < .05$). Both boys and girls who attended pre-K exhibited significant improvements in early test scores compared to same-sex peers in home-based care, and the differences in effect sizes were not statistically significant.

In middle childhood (Panel B), cognitive test score gains continued to be concentrated among children of less-educated mothers and children of Black or Hispanic mothers. The subgroup difference by maternal education was marginally significant for PPVT test scores ($p < .10$), while the subgroup differences by race/ethnicity were statistically significant for multiple

assessments: PPVT vocabulary test scores ($p < .10$ for Black-white differences, $p < .001$ for Hispanic-white differences), WJ Reading test scores ($p < .10$ for Black-white and Hispanic-white differences), and WJ Math test scores ($p < .05$ for Black-white, $p < .01$ for Hispanic-white differences). For grade repetition, both children of mothers with some college education and those of mothers without showed significant reduction associated with pre-K attendance. Though the differences were not statistically significant across subgroups based on race and ethnicity, the effect size was larger for Black and Hispanic children than white counterparts. Additionally, for all middle childhood outcomes examined, the sex differences in associations were not statistically significant.

By adolescence (Panel C), there were no significant associations between pre-K attendance and academic outcomes, such as GPA or grade repetition, in either the full sample or within each subgroup.

In young adulthood (Panel D), pre-K attendance was overall associated with a higher likelihood of graduating from high school, graduating on time, and earning a bachelor's degree, but there was little evidence that these links differed significantly by maternal education, race/ethnicity, or child sex. While there was no significant association between pre-K attendance and junior college or college completion with the full sample, the subgroup analysis revealed that Black children showed a significant association, which was significantly larger than for white children ($p < .05$).

3.8 Placebo test and supplemental analyses

Pre-K attendance is an endogenous variable, and its association with child outcomes could be biased by families' self-selection based on unobserved characteristics, such as parental aspirations and expectations for their children's education. To address this, I performed a

placebo test to examine whether pre-K attendance was associated with earlier cognitive and behavioral development around age 3, which could reflect differences in home and childcare environments prior to pre-K enrollment. As shown in Table 3-A3, the results fail to reject the null hypothesis that pre-K attendance is not associated with higher PPVT scores or lower internalizing and externalizing behaviors at age 3, suggesting minimal selection bias due to unobserved pre-treatment factors.

Additionally, I conducted supplemental analyses using Lagged Dependent Variable (LDV) model. Appendix Table 3-A4 presents the LDV estimates, comparing them with estimates from the OLS model using both the full sample and the sample restricted to those with an available lagged dependent variable. For early childhood outcomes, LDV estimates confirm that the OLS estimates for vocabulary, decoding, and attention skills were robust to controlling for earlier vocabulary skills at age 3, yielding comparable effect sizes.

In middle childhood, the OLS estimates for standardized math scores and the probability of grade repetition remained robust in the LDV model. However, the effect sizes for vocabulary scores (PPVT) and reading scores (WJ-Reading) decreased and lost statistical significance under the LDV model. For young adult outcomes, the OLS estimates for on-time high school graduation and bachelor's degree attainment remained robust under the LDV model. However, the result for high school graduation was not robust to a smaller sample limited to those with an available PPVT score at age 3 and to the LDV model, suggesting that this outcome is sensitive to sample changes and model specification.

Overall, the placebo tests yielded null results, providing little evidence of systematic selection into pre-K based on children's early development. LDV models robustly showed positive associations between pre-K attendance and early childhood cognitive development

outcomes. Based on the LDV model, pre-K attendance consistently predicted a higher math score and a lower probability of grade repetition by age 9, a higher probability of graduating high school on time, and an increased likelihood of obtaining a bachelor's degree by age 22. However, effect sizes became smaller in the LDV model for vocabulary and reading scores at age 9 and for high school graduation at age 22. These findings suggest that OLS results for test scores at age 9 and the likelihood of high school graduation may be biased due to unobserved confounders, warranting cautious interpretation.

3.9 Discussion and Conclusion

State pre-K programs and short, middle, and long-term development

This study examined the role of state pre-K programs in supporting children's cognitive development in the short, middle, and long term. It builds on emerging research evaluating long-term effects of scaled-up pre-K programs, which have found positive links between universal pre-K attendance and postsecondary outcomes in Boston and Tulsa, Oklahoma (Gormley et al., 2023; Gray-Lobe et al., 2023). This study addresses the need for further exploration of whether similar long-term benefits are observed in other state pre-K programs.

Using longitudinal data on urban-born children across multiple states, this study found that pre-K attendance was significantly associated with improved cognitive skills in early childhood. Children who attended pre-K demonstrated better vocabulary, literacy, and attention skills at age 5 compared to their peers in home-based care. The effect sizes were moderate to medium, with improvements of 0.21 SD in attention skills, 0.26 SD in vocabulary skills, and 0.46 SD in literacy skills. To contextualize these findings, the effect size of 0.21 SD in attention skills corresponds to 56% of the income-based disparity between children in families with incomes below 100% and above 300% of the federal poverty line in the FFCWS data. The effect

size of 0.26 SD in vocabulary scores accounts for 28% of the disparity, and the effect size of 0.46 SD in literacy skills represents 65% of the disparity. This finding reinforces prior evidence confirming the effects of pre-K attendance on early childhood cognitive development, with comparable effect sizes (Ansari et al., 2020; Bassok et al., 2019; Lipsey et al., 2018; Magnuson et al., 2007; Weiland & Yoshikawa, 2013).

These short-term associations extended into middle childhood, as evidenced by higher vocabulary, reading, and math scores at age 9. However, the effect sizes for test scores were modest, ranging from 0.1 SD to 0.2 SD, and the main OLS estimates were not robust to alternative model specifications. The relatively muted and less robust results for middle childhood outcomes compared to early childhood align with the dynamic substitutability skill-building model, which predicts that short-term cognitive gains diminish over time, rather than the dynamic complementarity model, which suggests that early advantages would compound over time. Still, the association between pre-K attendance and a lower probability of grade repetition in middle childhood (-6.7 percentage points) was strong and robust, supporting the primary effect of the institutional gateway model. This aligns with prior evidence showing that state pre-K increases the likelihood of being on-grade for a child's age (Bai et al., 2020; Fitzpatrick, 2008).

In line with the diminishing pattern in test score gains, this study did not find significant associations between pre-K attendance and self-reported adolescent GPA. This finding aligns with earlier RCT findings from Boston, where pre-K attendance was not significantly linked to academic achievements from third to tenth grade (Gray-Lobe et al., 2023).

Nevertheless, significant links were found between pre-K attendance and young adulthood educational transitions. Specifically, pre-K attendance predicted a higher likelihood of

high school graduation (+5.8 percentage points, but this estimate was not robust to alternative specifications), on-time high school graduation (+6.7 percentage points), and bachelor's degree attainment (+3.1 percentage points, $p < .10$). These results are consistent with prior evidence from Boston's universal pre-K program, which found a 6 percentage-point increase in high school graduation and a 5.4 percentage-point increase in on-time graduation (Gray-Lobe et al., 2023). Although the effect of pre-K attendance on four-year college completion was not precisely estimated, the estimate in this study is close to that of Gray-Lobe et al. (2023), which reported a 3.5 percentage point increase. These effect sizes of pre-K attendance were comparable to the attendance in different types of early education, including other center-based care or Head Start.

Taken together, the results for middle childhood, adolescence, and adulthood suggest that while pre-K attendance was modestly associated with cognitive skills in middle childhood and did not predict higher academic achievement in high school, it still predicted long-term educational achievement in adulthood. Similar to the findings of Gray-Lobe et al. (2023), this study indicates that pre-K's long-term effects may not be carried through improved high school academic achievement. Instead, the findings support the "institutional gateway" model, which posits that early education facilitates the first institutional transition to schooling, leading to cumulative advantages in the long term—not necessarily through direct skill improvements, but rather by shaping belief systems (Bailey et al., 2020).

Compensatory role of state pre-K programs in short, middle, and long-term outcomes

In addition, this study examined the role of state pre-K programs in reducing disparities in developmental outcomes among children from different family backgrounds. Specifically, it investigated whether children of less-educated mothers and Black and Hispanic mothers

disproportionately benefited from pre-K attendance compared to their counterparts with more highly educated mothers and white mothers. It also explored the differences in effects by sex.

In early childhood, the positive association between pre-K attendance and cognitive test scores was consistently significant for children from families with less-educated mothers and Black or Hispanic mothers, though the difference in associations was statistically significant only for decoding skills between Black and white children.

In middle childhood, the subgroup differences in test score gains by mother's education and race and ethnicity became more pronounced. Children with less educated mothers consistently showed significant associations between pre-K attendance and higher test scores and a lower probability of grade retention. The association with vocabulary skill was significantly larger for children with less educated mothers. The racial heterogeneity in association was particularly prominent, with significant differences in effects across vocabulary, reading, and math scores.

In young adulthood, Black adults who attended pre-K had a higher likelihood of completing junior college or college than Black adults who received home-based care. This association was significantly larger than that of their white counterparts. However, the subgroup analyses did not find significant differences in associations by mother's education in young adulthood. Across all outcomes examined, boys and girls did not significantly differ in the association between pre-K attendance and short-, middle-, and long-term outcomes.

These subgroup analyses support the compensatory model, which predicts that pre-K attendance will have greater benefits for children whose alternative care may be less developmentally enriching (Ansari et al., 2021; Bassok, 2010; Cascio, 2021; Weiland & Yoshikawa, 2013). Consistent with earlier studies on heterogeneity in the extended effects of

pre-K (Bai et al., 2020; Watts et al., 2023), this study shows that the short-term compensatory effects persisted through middle childhood. Notably, this study did not find subgroup differences by families' socioeconomic status (proxied by mothers' education) in pre-K's long-term association with young adulthood educational outcomes, aligning with existing evidence (Gormley et al., 2023; Gray-Lobe et al., 2023). However, it presents new evidence of long-term compensatory effects of pre-K for Black individuals, who showed a significantly larger association between pre-K attendance and the probability of completing junior college or college compared to their white counterparts.

These results raise a question about why compensatory effects of pre-K in the long term were seen for racial groups but were only observed in early and middle childhood for differences based on family socioeconomic status. The institutional gateway model provides one possible explanation. While children of less educated mothers exhibited greater cognitive skill gains in early and middle childhood than children of more highly educated mothers, pre-K attendance in both groups was significantly associated with a lower likelihood of grade repetition. However, Black and Hispanic children not only demonstrated greater gains in cognitive test scores in early and middle childhood than their white counterparts, but they also exhibited a stronger association with a reduced probability of grade retention. The observed long-term compensatory effects by racial groups support the hypothesis that the long-term benefits of early education depend on its role in facilitating a successful early transition into schooling.

Strengths and Limitations

This study demonstrated the association between pre-K attendance and child outcomes in the short, middle, and long term. It illuminated association patterns over the life course using a birth cohort longitudinal study of urban-born children in multiple states. The evidence of long-

term associations corroborates the generalizability of recent findings on the long-term effects of universal pre-K programs in Boston and Tulsa. Also, the observed pattern—where early cognitive skill gains fade over time while long-term benefits in educational achievement emerge—supports the "institutional gateway" model: successful early transitions into schooling predict better later transitions (e.g., high school completion or advancement to postsecondary education), even if early cognitive gains diminish over time. In addition, this study contributes to the understanding of the compensatory effect of pre-K attendance across short-, middle-, and long-term outcomes.

Despite these strengths, several limitations should be acknowledged. First, this study examined associations rather than causal effects, as pre-K attendance is endogenous and subject to potential selection bias. Although the findings for early childhood outcomes, the probability of repeating grades, and on-time high school completion remained robust after controlling for child and family characteristics and pre-treatment cognitive development, omitted confounders may still bias the estimates.

Second, the reliance on parent-reported childcare arrangements introduces potential reporting errors. Misclassification of pre-K attendance could either overstate or understate its true effects on child outcomes. Future research should survey whether the pre-K program attended is subsidized by a local pre-K initiative, which would allow researchers to more precisely identify participation in publicly funded pre-K.

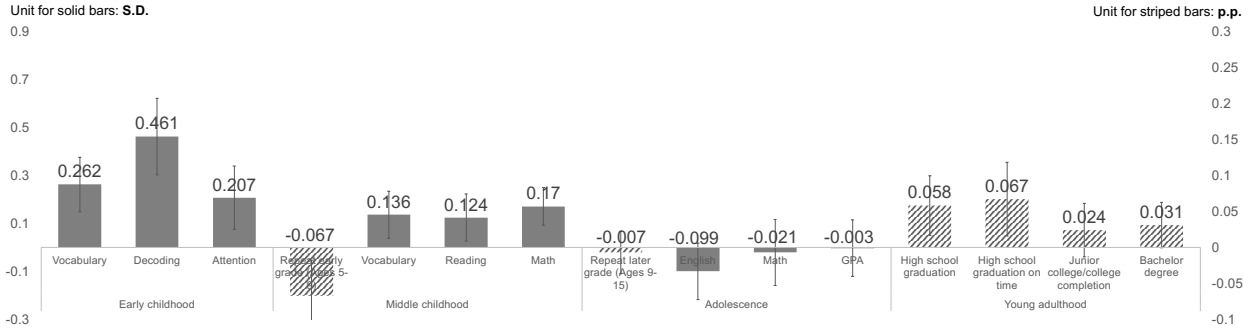
Third, adolescent academic achievement was based on self-reported grades, which may be prone to reporting error. This could partly explain the non-significant results observed in adolescence and suggests caution in interpreting these findings as evidence of a complete "fade-out" or "catch-up" effect.

Fourth, this study focused solely on children's cognitive and educational outcomes and therefore could not comprehensively test the mechanisms hypothesized by the "institutional gateway" model. While the interpretation of long-term educational gains alongside diminishing cognitive score gains lends support to the model, further investigation is needed to understand how early successful transitions into schooling affect lifelong outcomes. Future research examining the effects of pre-K attendance on children's socioemotional skills, self-perceptions, and subjective well-being across developmental stages can enrich our understanding of the "institutional gateway" through the lens of children's belief systems.

This study examined whether attending pre-K can set children up for future success. The link between pre-K attendance and later educational achievement suggests the lifelong value of policy efforts to expand high-quality pre-K access for low- and moderate-income families. Also, the concentration of benefits among children from disadvantaged families during early and middle childhood highlights the importance of investing in pre-K programs to help narrow socioeconomic and racial disparities in child development. Specifically, Black children later exhibited a larger association between pre-K attendance and the probability of completing an associate degree or college compared to their white peers. This suggests the potential of pre-K programs to reduce racial gaps in educational attainment—a key predictor of later labor market outcomes.

Figures

Figure 3-1. Associations between pre-K attendance and child cognitive skills and educational transition outcomes



Source: Data from the FFCWS age 5, 9, 15, and 22 follow-up surveys. **Note**: Figure shows standardized effect sizes for cognitive development outcomes (solid bars) and non-standardized effect sizes for educational transition outcomes (striped bars) with 95% confidence intervals.

Tables

Table 3-1. Sample characteristics, by child care arrangements in the year before kindergarten

	Pre-K	Other center care	Head Start	Home-based care
N	790	1,115	481	839
Family Characteristics	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Mother's race and ethnicity				
White	0.12[CH]	0.15	0.10	0.23
	(0.32)	(0.36)	(0.29)	(0.42)
Black	0.53[CH]	0.58	0.61	0.43
	(0.50)	(0.49)	(0.49)	(0.50)
Hispanic	0.33[C]	0.23	0.26	0.31
	(0.47)	(0.42)	(0.44)	(0.46)
Other	0.02	0.03	0.03	0.03
	(0.14)	(0.18)	(0.17)	(0.18)
Mother's age	24.43	24.69	23.64	24.58
	(5.70)	(5.99)	(5.12)	(5.80)
Mother's partnered status				
Married	0.18	0.18	0.10	0.17
	(0.38)	(0.39)	(0.30)	(0.38)
Cohabiting	0.39[CH]	0.34	0.40	0.45
	(0.49)	(0.47)	(0.49)	(0.50)
Single	0.43[C]	0.47	0.50	0.38
	(0.50)	(0.50)	(0.50)	(0.49)
Mother's education				
Less than High School	0.36[H]	0.34	0.43	0.46
	(0.48)	(0.47)	(0.49)	(0.50)
High School	0.34	0.34	0.35	0.33
	(0.47)	(0.47)	(0.48)	(0.47)
Some college	0.26[H]	0.26	0.21	0.18
	(0.44)	(0.44)	(0.41)	(0.38)
College or above	0.04[C]	0.06	0.01	0.03
	(0.19)	(0.24)	(0.12)	(0.17)
Mother's work status (age 1)				
Not employed	0.44[H]	0.48	0.51	0.58
	(0.50)	(0.50)	(0.50)	(0.49)
Part-time work	0.09	0.10	0.08	0.08
	(0.28)	(0.30)	(0.28)	(0.27)
Full-time work	0.47[CH]	0.42	0.40	0.34
	(0.50)	(0.49)	(0.49)	(0.47)
Family Income-to-needs (age 3)	1.63	1.77	1.29	1.43
	(1.43)	(1.58)	(1.26)	(1.40)

Family income status (age 3)				
Poverty (0-99% OPM)	0.48[H]	0.46	0.58	0.53
	(0.50)	(0.50)	(0.49)	(0.50)
Low-income (100-199% OPM)	0.34	0.33	0.32	0.32
	(0.47)	(0.47)	(0.47)	(0.47)
Moderate-income (200-299% OPM)	0.18	0.21	0.10	0.15
	(0.39)	(0.41)	(0.30)	(0.36)
Child care arrangement (age 3)				
Parental care only	0.38[H]	0.38	0.42	0.56
	(0.49)	(0.49)	(0.49)	(0.50)
Non-parent informal care	0.25[C]	0.20	0.24	0.23
	(0.43)	(0.40)	(0.43)	(0.42)
Family daycare	0.07	0.06	0.05	0.06
	(0.26)	(0.24)	(0.21)	(0.23)
Center-based care	0.30[CH]	0.36	0.29	0.15
	(0.46)	(0.48)	(0.46)	(0.36)
Mother's WAIS-R Test (age 3)	6.53	6.51	6.38	6.41
	(2.67)	(2.62)	(2.43)	(2.68)
Child is Boy	0.53	0.51	0.53	0.55
	(0.50)	(0.50)	(0.50)	(0.50)
Child was low birth weight	0.11	0.11	0.11	0.09
	(0.32)	(0.31)	(0.31)	(0.29)
Child PPVT score (age 3)	84.22	84.04	84.02	83.07
	(15.97)	(16.12)	(14.87)	(16.73)

Source: Data from the FFCWS baseline and age 1 and 3 follow-up surveys. **Note**: Child age is noted in parentheses when the characteristic was measured in a follow-up survey. Child's age is not noted for the variables measured in the baseline survey that was conducted around the child's birth. The sample is restricted to children for whom childcare arrangement data for the year before kindergarten was available and whose family income being below 300% of the federal poverty line when the child was age 3 (N = 3,225). The table shows unweighted sample means and standard deviations for the variables specified in the first column, categorized by childcare arrangement. Superscripts C and H denote statistically significant differences at the 95% confidence level: (1) C: Between children who used pre-K and those who used other center care; (2) H: Between pre-K attendees and children who used home-based care.

Table 3-2. Child cognitive and educational outcomes, by early education and care arrangement before kindergarten

	Pre-K	Other center care	Head Start	Home-based care	N
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	
Early childhood (age 5)					
PPVT	92.36[H]	92.30	91.13	87.69	1,881
	(14.85)	(15.35)	(14.18)	(16.96)	
WJ	100.94[H]	100.35	98.54	91.69	1,881
	(14.37)	(14.27)	(13.24)	(14.06)	
Leiter	12.73[CH]	12.31	12.11	11.71	1,712
	(3.23)	(3.35)	(3.42)	(3.52)	
Middle childhood (age 9)					
PPVT	91.05	91.48	89.50	89.77	2,451
	(14.02)	(13.87)	(13.24)	(13.92)	
WJ-Reading	91.16	92.49	90.66	89.86	2,445
	(14.69)	(14.23)	(13.24)	(15.26)	
WJ-Math	96.63[H]	97.34	95.91	94.43	2,452
	(15.82)	(16.08)	(15.67)	(17.19)	
Ever repeated grades	0.16[H]	0.14	0.17	0.25	2,603
	(0.37)	(0.34)	(0.38)	(0.43)	
Adolescence (age 15)					
Average GPA	2.83	2.78	2.76	2.78	2,427
	(0.63)	(0.67)	(0.66)	(0.68)	
English	2.86	2.82	2.81	2.89	2,347
	(0.86)	(0.87)	(0.86)	(0.86)	
Math	2.71	2.70	2.69	2.69	2,352
	(0.92)	(0.93)	(0.98)	(1.02)	
Social Science	2.93	2.83	2.79	2.85	2,201
	(0.92)	(0.90)	(0.92)	(0.94)	
Science	2.88[H]	2.79	2.78	2.75	2,311
	(0.92)	(0.92)	(0.91)	(0.93)	
Repeated grades since age 9	0.12[C]	0.09	0.12	0.11	2,587
	(0.32)	(0.28)	(0.33)	(0.32)	
Young adulthood (age 22)					
High school graduation	0.90[H]	0.89	0.87	0.82	2,099
	(0.30)	(0.31)	(0.34)	(0.38)	
High school graduation on time	0.68	0.67	0.65	0.59	2,078
	(0.47)	(0.47)	(0.48)	(0.49)	
Junior college or college completion	0.16[H]	0.18	0.14	0.12	2,099

	(0.37)	(0.39)	(0.34)	(0.32)	
Bachelor degree attainment	0.07[H]	0.09	0.07	0.04	2,099
	(0.26)	(0.29)	(0.25)	(0.18)	

Source*:* Data from FFCWS age 5, 9, 15, 22 follow-up surveys. **Note**: The sample is restricted to children for whom childcare arrangement data for the year before kindergarten was available and whose family income being below 300% of the federal poverty line when the child was age 3 (N = 3,225). The table shows unweighted sample means and standard deviations for the variables specified in the first column, categorized by childcare arrangement. Superscripts C and H denote statistically significant differences at the 95% confidence level: (1) C: Between children who used pre-K and those who used other center care; (2) H: Between pre-K attendees and children who used home-based care.

Table 3-3. Associations between pre-K attendance and child cognitive outcomes around ages 5, 9, 15, and 22 (full sample)

Panel A Early childhood (Age 5)	**PPVT**	**WJ**	**Leiter**	
Pre-K	**0.262*****	**0.461*****	**0.207****	
	(0.058)	(0.081)	(0.067)	
Other center care	0.264***	0.433***	0.115*	
	(0.032)	(0.057)	(0.044)	
Head Start	0.244***	0.387***	0.073	
	(0.036)	(0.053)	(0.076)	
R-squared	0.212	0.189	0.178	
N	1875.	1882.	1706.	
Panel B Middle childhood (Age 9)	**PPVT**	**WJ-Reading**	**WJ-Math**	**Repeat grade**
Pre-K	**0.136***	**0.124***	**0.170*****	**-0.067***
	(0.050)	(0.051)	(0.044)	(0.025)
Other center care	0.100*	0.140**	0.170***	-0.084***
	(0.040)	(0.042)	(0.039)	(0.017)
Head Start	0.098+	0.093+	0.187***	-0.086***
	(0.053)	(0.054)	(0.046)	(0.014)
R-squared	0.216	0.122	0.111	0.087
N	2366.	2360.	2366.	2490.
Panel C Adolescence (Age 15)	**GPA**	**English**	**Math**	**Repeat grade (since age 9)**
Pre-K	-0.003	-0.099	-0.021	-0.007
	(0.062)	(0.060)	(0.066)	(0.015)
Other center care	-0.023	-0.105+	-0.025	-0.016
	(0.061)	(0.058)	(0.047)	(0.013)
Head Start	-0.019	-0.086	0.006	0.004
	(0.063)	(0.071)	(0.040)	(0.019)
R-squared	0.098	0.072	0.057	0.055
N	2402.	2323.	2328.	2465.

Panel D Young adulthood (Age 22)	High school graduation	High school graduation on time	Junior college or college completion	Bachelor degree
Pre-K	**0.058****	**0.067***	0.024	**0.031**+
	(0.021)	(0.026)	(0.019)	(0.016)
Other center care	0.030*	0.047+	0.032+	0.041**
	(0.013)	(0.024)	(0.018)	(0.014)
Head Start	0.046*	0.061*	0.034	0.041+
	(0.021)	(0.027)	(0.030)	(0.023)
R-squared	0.076	0.111	0.117	0.092
N	2076.	2058.	2076.	2076.

Source*:* Data from the FFCWS age 5, 9, 15, and 22 follow-up surveys. **Note**: For continuous outcome variables, the coefficients represent the standardized mean difference in child outcomes at different ages between children who attended pre-K and those who exclusively used home-based childcare in the year before kindergarten. For binary outcome variables (i.e., grade repetition and young adult educational achievements), the coefficients represent the mean difference in likelihood, expressed in percentage points. Models include demographic covariates, including mother's race and ethnicity, mother's marital and cohabiting status at the child's birth, mother's education at birth, mother's employment status at child age 1, child's prior childcare arrangement at age 3, child's sex, low birth weight status, child's age at the time of the survey, and state fixed effects. Robust standard errors, clustered at the state level, are presented in parentheses. ***p < .001, **p < .01, *p < .05, +p < .10.

Table 3-4. Associations between pre-K attendance and child cognitive outcomes, by subgroups

Panel A. Early Childhood (Age 5)								
PPVT	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	**0.262*****	**0.253*****	0.147	**0.277*****	**0.302**+	0.084	**0.336*****	**0.211***
	(0.058)	(0.051)	(0.101)	(0.047)	(0.154)	(0.159)	(0.051)	(0.082)
R^2	0.212	0.169	0.262	0.169	0.219	0.264	0.263	0.199
N	1875.	1496.	766.	1093.	475.	268.	896.	979.
WJ	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	**0.461*****	**0.464*****	**0.309****	**0.561***** ^{W}	**0.422***	0.056	**0.509*****	**0.426*****
	(0.081)	(0.087)	(0.084)	(0.100)	(0.152)	(0.184)	(0.087)	(0.098)
R^2	0.189	0.179	0.154	0.200	0.260	0.255	0.228	0.159
N	1882.	1499.	772.	1097.	477.	270.	906.	976.
Leiter	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	**0.207****	**0.257***	0.063	**0.256**+	0.116	0.114	**0.253***	**0.169**+
	(0.067)	(0.096)	(0.103)	(0.122)	(0.101)	(0.114)	(0.096)	(0.093)
R^2	0.178	0.167	0.228	0.157	0.312	0.277	0.180	0.163
N	1706.	1351.	718.	1000.	424.	247.	834.	872.
Panel B. Age 9								
PPVT	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy

Pre-K	**0.136***	**0.128*^{H}**	-0.019	0.093^{W}	**0.300***^{W}	-0.085	**0.115***	**0.163***
	(0.050)	(0.052)	(0.067)	(0.078)	(0.079)	(0.075)	(0.047)	(0.074)
R^2	0.216	0.167	0.241	0.138	0.227	0.316	0.240	0.226
N	2366.	1850.	1063.	1340.	619.	346.	1128.	1238.
WJ-Reading	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	**0.124***	**0.127***	0.034	**0.196***^{W}	**0.213*^{W}**	-0.221	0.103	**0.147+**
	(0.051)	(0.046)	(0.121)	(0.050)	(0.077)	(0.215)	(0.078)	(0.078)
R^2	0.122	0.108	0.163	0.140	0.133	0.149	0.169	0.109
N	2360.	1848.	1054.	1338.	610.	351.	1123.	1237.
WJ-Math	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	**0.170*****	**0.152****	0.027	**0.200*^{W}**	**0.328***^{W}**	-0.163	0.113	**0.253*****
	(0.044)	(0.054)	(0.074)	(0.092)	(0.071)	(0.160)	(0.081)	(0.067)
R^2	0.111	0.110	0.158	0.109	0.130	0.202	0.142	0.120
N	2366.	1851.	1060.	1334.	620.	352.	1125.	1241.
Repeat grade	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	**-0.067***	**-0.054+**	**-0.062***	-0.065	**-0.087+**	-0.007	**-0.038+**	**-0.093***
	(0.025)	(0.030)	(0.031)	(0.044)	(0.047)	(0.056)	(0.022)	(0.039)
R^2	0.087	0.077	0.091	0.117	0.118	0.200	0.101	0.097
N	2490.	1941.	1139.	1396.	643.	382.	1180.	1310.
Panel C. Age 15								
GPA	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	0.014	-0.004	0.095	0.077	-0.036	-0.071	-0.040	0.049
	(0.070)	(0.077)	(0.099)	(0.105)	(0.095)	(0.117)	(0.110)	(0.069)
R^2	0.091	0.093	0.219	0.086	0.121	0.184	0.095	0.105
N	2162.	1698.	1037.	1223.	556.	330.	1043.	1119.
Repeat grade (since age 9)	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	-0.008	-0.014	0.003	-0.002	-0.027	0.038	-0.017	-0.007
	(0.015)	(0.020)	(0.017)	(0.018)	(0.031)	(0.033)	(0.025)	(0.014)
R^2	0.054	0.047	0.097	0.062	0.131	0.180	0.047	0.082
N	2218.	1732.	1064.	1251.	565.	346.	1067.	1151.
Panel D. Age 22								
High school gradua-tion	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	**0.058****	**0.051+**	**0.037+**	**0.056***	**0.084+**	-0.016	**0.074***	0.043
	(0.021)	(0.030)	(0.021)	(0.022)	(0.047)	(0.058)	(0.029)	(0.033)
R^2	0.076	0.069	0.120	0.079	0.155	0.191	0.084	0.114
N	2076.	1600.	1046.	1163.	516.	343.	1075.	1001.
High school gradua-	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy

tion on time								
Pre-K	**0.067***	**0.054***	0.046	**0.084***	0.046	-0.051	**0.087****	0.045
	(0.026)	(0.027)	(0.034)	(0.040)	(0.049)	(0.094)	(0.031)	(0.040)
R^2	0.111	0.095	0.154	0.129	0.171	0.208	0.101	0.120
N	2058.	1586.	1040.	1150.	513.	341.	1069.	989.
Junior college or college complet-ion	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	0.024	0.013	0.035	**0.049*^{W}**	0.002	-0.099	0.043	-0.002
	(0.019)	(0.025)	(0.039)	(0.021)	(0.035)	(0.061)	(0.033)	(0.025)
R^2	0.117	0.112	0.128	0.117	0.164	0.259	0.145	0.115
N	2076.	1600.	1046.	1163.	516.	343.	1075.	1001.
Bachelor degree	Full	Lower education	Higher education	Black	Hispanic	White	Girl	Boy
Pre-K	**0.031+**	0.016	0.036	**0.028+**	0.030	-0.018	0.046	0.013
	(0.016)	(0.015)	(0.041)	(0.016)	(0.031)	(0.040)	(0.032)	(0.012)
R^2	0.092	0.096	0.153	0.107	0.126	0.256	0.125	0.085
N	2076.	1600.	1046.	1163.	516.	343.	1075.	1001.

Source*:* Data from the FFCWS age 5, 9, 15, and 22 follow-up surveys. **Note**: For continuous outcome variables, the coefficients represent the standardized mean difference in child outcomes at different ages between children who attended pre-K and those who exclusively used home-based childcare in the year before kindergarten. For binary outcome variables (i.e., grade repetition and young adult educational achievements), the coefficients represent the mean difference in likelihood, expressed in percentage points. Superscripts 'H' above coefficients for children of mothers with lower education (High school degree or less) indicate the statistical significance of subgroup differences in the coefficients compared to children of mothers with higher education. Similarly, superscript 'W' above coefficients among Black and Hispanic children indicate significant differences in association compared to their white counterparts. Models include demographic covariates, including mother's race and ethnicity, mother's marital and cohabiting status at the child's birth, mother's education at birth, mother's employment status at child age 1, child's prior childcare arrangement at age 3, child's sex, low birth weight status, child's age at the time of the survey, and state fixed effects. Robust standard errors, clustered at the state level, are presented in parentheses. ***p < .001, **p < .01, *p < .05, +p < .10.

Appendix

Table 3-A1. Summary of findings from the literature on short, middle, long-term effects of pre-K on child outcomes

Overall pre-K effects for full sample			
Research design	Short-term	Middle-term	Long-term
Non-experimental study	**Higher** test scores at kindergarten entry[a,b]		**Higher** high school graduation and college enrollment[n]
Quasi-experimental study (RD, DID)	**Higher** reading and math scores[c,d,e,t]	**Higher** standardized reading and math test score at fourth grade or beyond[i,j,k,p,r] Or **Null** effect[o]	
Experimental study	**Higher** literacy math test scores[g]	**Null** effect[h,m] Or **Lower** grades by 3rd grade[g,l]	**Higher** high school graduation and college enrollment[m]
Heterogeneous pre-K effects by subgroups			
Subgroup	Short-term	Middle-term	Long-term
Parent SES	**Lower-SES** group showed larger test score gains[e,t] Or **No significant** difference by SES[d]	**Lower-SES** group showed larger achievement gains[k,p,q,i,r] Or **No significant** difference by SES[j]	**No significant** difference by SES[m,n]
Race and ethnicity	**Hispanic** students showed larger test score gains[e] Or **No significant** difference by race and ethnicity[d]	**Black and/or Hispanic** students showed larger achievement gains[k,p,i] Or **No significant** difference by race and ethnicity[j]	**No significant** difference by race and ethnicity[m,n]
Sex	**No significant** difference by child sex[e]	**Boys** showed larger effects[s] Or **No significant** difference by child sex[i,j]	**Boys** showed larger effects[m] Or **No significant** difference by child sex[n]

Note on superscripts: a. Bassok et al. (2019); b. Magnuson et al. (2007); c. Barnett et al. (2018); d. Gormley et al. (2005); e. Weiland & Yoshikawa (2013); f. Gormley et al. (2011); g. Lipsey et al. (2018); h. Weiland et al. (2020); i. Fitzpatrick (2008); j. Gormley et al. (2018); k. Watts et al. (2023); l. Durkin et al. (2022); m. Gray-Lobe et al. (2023); n. Gormley et al. (2023); o. Bartik & Hershbein (2018); p. Bai et al. (2020); q. Cascio & Schanzenbach (2013); r. Ladd et al. (2014); s. Muschkin et al., 2020; t. Cascio (2023)

Table 3-A2. Summary of pre-K programs in 15 states included in FFCWS baseline sample

State	Beginning year	Pre-K enrollment rate for 4-year-olds in 2001-2002 (Head Start enrollment)	Income eligibility	Hours of operation	Quality standards (NIEER), Spending per child enrolled
Illinois	1985	22% (10%)	**No.** Eligibility criteria and screening methods are established locally based on community needs. (e.g., about 67% of the enrolled children were eligible for free or reduced-price meals (FARMs).	Locally determined (most programs operate on a half-day schedule, 5 days per week)	9/10 $3,094
Maryland	2002 Bridge to Excellence in Public Schools Act	15% (8%)	**Yes.** Children whose family income is at or below 185% of the federal poverty line (FPL) are eligible for FARMs.	Half-day, full-week	6/10 $1,751
Michigan	1985 Michigan School Readiness Program	19% (12%)	**Yes.** Children eligible for free or reduced-price meals must comprise 50% of all children served.	Half-day, part-week	5/10 $3,205
Massachusetts	1985 Community Partnerships for Children	12% (8%)	**Yes.** 125% of the state's median income	Determined locally (75% of programs offer full-day service)	4/10 $4,826
New Jersey	1998 Abbott program and non-Abbott early childhood program aid	21% (15% enrolled in Abbott + 6% enrolled in early	**Yes.** Abbott: Districts in which at least 40% of students are eligible for free or reduced-price lunch Non-Abbott early childhood program aid is for districts in which 20-40% of students are eligible for free or reduced-price meals.	Full-day Full-week	9/10 $11,396 for Abbott, $4,385 for non-Abbott early

		childhood program aid) (6%)			childhood program aid
New York	1997 Universal prekindergarten	25% (10%)	**No.** There is no explicit eligibility rule based on income. However, children from low-income households were given enrollment priority.	Determined locally (85% of enrollees attended a half-day program)	4/10 $3,622
Texas	1984 Public School Prekindergarten	39% (10%)	**Yes.** Children qualified for free or reduced-price lunch	Half-day, 5 days/week	$2,186 2/10
Wisconsin	1873 Four-year-old kindergarten	18% (10%)	**No.**	Half-day/ 5 days/week	$3,518
California	1965 State Preschool Program	14% (11%)	**Yes.** 60% of the state's median income	Half-day, 5 days/week	$3,080 3/10
Ohio	1990 Public School Preschool Program	8% (19%)	**Yes.** Children with family incomes below 185% of the federal poverty line. (families with income above this cutoff can enroll their child with parent fees)	Determined locally (most run half-day, 4 days/week)	3/10 $5,015
Virginia	1995 Virginia Preschool Initiative	6% (8%)	**Yes.** Determined locally	Full-day, 5 days/week	$3,194 5/10
Tennessee	1998	2% (13%)	**Yes.** Children eligible for free or reduced-price meals are given priority for enrollment.	Full-day, 5 days/week	$2,226 8/10

	Early Childhood Education Pilot project (Tennessee Voluntary Pre-K was launched in 2005)				
Florida	2005 Florida Voluntary Prekindergarten Education Program	n/a	n/a	n/a	n/a
Indiana	2014 On My Way Pre-K	n/a	n/a	n/a	n/a
Pennsylvania	2004 Education Accountability Block Grant	n/a	n/a	n/a	n/a

Source: Barnett, W. S., Robin, K. B., Hustedt, J. T., & Schulman, K. L. (2003). *The State of Preschool 2003: State Preschool Yearbook*. National Institute for Early Education Research. **Note**: Quality standards indicate the number of quality criteria a state meets. Ten quality standards include 1) meeting early learning development standards, 2) curriculum supports, 3) having a teacher's degree of BA or higher, 4) teacher specialized training in ECE, 5) assistant teacher degree is child development associate credential or equivalent, 6) provide staff professional development, 7) maximum class size is 20 or lower, 8) staff-child ratio is 1:10 or better, 9) offer screening and referral for disability, 10) continuous quality improvement system.

Table 3-A3. Placebo test: Associations between Pre-K attendance and age 3 outcomes

	PPVT (age 3)	Externalizing behavior problem (age 3)	Internalizing behavior problem (age 3)
Pre-K	0.081	0.013	-0.032
	(0.079)	(0.048)	(0.052)
Other center care	0.055	-0.022	0.028
	(0.061)	(0.068)	(0.064)
Head Start	0.110+	0.019	0.090
	(0.059)	(0.062)	(0.071)
R-squared	0.146	0.049	0.093
N	1772.	2351.	2351.

Source*:* Data from FFCWS age 3 follow-up survey. **Note**: The table shows the standardized mean difference in child outcomes at age 3 between children who attended pre-K and those who did not use center-based childcare in the year before kindergarten. Models include demographic covariates, including mother's race and ethnicity, mother's marital and cohabiting status at child's birth, mother's education at child's birth, mother's employment status at age 1 (nonemployment, part-time employment, full-time employment), primary child care arrangement at age 3 (parental care, informal care, family daycare, center-based care), mother's cognitive test scores (WAIS-R similarities subtest), the child's sex and low birth weight status, and child's age when the survey was taken, and state fixed-effects. Robust standard errors are clustered at the state level. *** p<.001, ** p<.01, * p<.05, + p<.1

Table 3-A4. LDV estimates of the associations between pre-K attendance and child cognitive outcomes (full sample)

Early childhood (Age 5)	PPVT (OLS)	PPVT (OLS) LDV sample	PPVT (LDV)	WJ (OLS)	WJ (OLS) LDV sample	WJ (LDV)
Pre-K	**0.262*****	**0.319*****	**0.272*****	**0.461*****	**0.583*****	**0.559*****
	(0.058)	(0.066)	(0.067)	(0.081)	(0.086)	(0.084)
Other center care	0.264***	0.253***	0.216***	0.433***	0.463***	0.446***
	(0.032)	(0.049)	(0.037)	(0.057)	(0.066)	(0.066)
Head Start	0.244***	0.318***	0.263***	0.387***	0.414***	0.386***
	(0.036)	(0.048)	(0.043)	(0.053)	(0.045)	(0.046)
R-squared	0.212	0.197	0.304	0.189	0.195	0.221
N	1875.	1380.	1380.	1882.	1388.	1388.
Early childhood (Age 5)	Leiter (OLS)	Leiter (OLS) LDV sample	Leiter (LDV)			
Pre-K	0.207**	0.209*	0.192*			
	(0.067)	(0.084)	(0.081)			

Other center care	0.115*	0.098	0.071			
	(0.044)	(0.068)	(0.063)			
Head Start	0.073	0.083	0.061			
	(0.076)	(0.091)	(0.089)			
R-squared	0.178	0.161	0.187			
N	1706.	1257.	1258.			
Middle childhood (Age 9)	PPVT (OLS)	PPVT (OLS) LDV sample	PPVT (LDV)	WJ-reading (OLS)	WJ-reading (OLS) LDV sample	WJ-reading (LDV)
Pre-K	**0.136***	**0.144***	0.078	**0.124***	**0.116***	0.066
	(0.050)	(0.070)	(0.059)	(0.051)	(0.047)	(0.044)
Other center care	0.100*	0.057	0.011	0.140**	0.154**	0.119*
	(0.040)	(0.049)	(0.041)	(0.042)	(0.042)	(0.046)
Head Start	0.098+	0.135	0.058	0.093+	0.106*	0.048
	(0.053)	(0.080)	(0.078)	(0.054)	(0.049)	(0.054)
R-squared	0.216	0.209	0.309	0.122	0.140	0.190
N	2366.	1494.	1494.	2360.	1486.	1486.
Middle childhood (Age 9)	WJ-math (OLS)	WJ-math (OLS) LDV sample	WJ-math (LDV)	Repeat grade (OLS)	Repeat grade (OLS) LDV sample	Repeat grade (LDV)
Pre-K	**0.170*****	**0.164*****	**0.120***	**-0.067***	**-0.078****	**-0.071***
	(0.044)	(0.069)	(0.055)	(0.025)	(0.026)	(0.027)
Other center care	0.170***	0.161***	0.130**	-0.084***	-0.098***	-0.093***
	(0.039)	(0.046)	(0.043)	(0.017)	(0.022)	(0.022)
Head Start	0.187***	0.181***	0.128+	-0.086***	-0.105***	-0.097***
	(0.046)	(0.076)	(0.073)	(0.014)	(0.022)	(0.021)
R-squared	0.111	0.132	0.173	0.087	0.108	0.115
N	2366.	1490.	1490.	2490.	1522.	1522.
Adolescence (Age 15)	GPA (OLS)	GPA (OLS) LDV sample	GPA (LDV)	Repeat grade since age 9 (OLS)	Repeat grade since age 9 (OLS) LDV sample	Repeat grade since ate 9 (LDV)
Pre-K	-0.003	-0.046	-0.058	-0.007	-0.016	-0.014
	(0.062)	(0.073)	(0.072)	(0.015)	(0.015)	(0.014)
Other center care	-0.023	-0.051	-0.057	-0.016	0.004	0.005
	(0.061)	(0.075)	(0.074)	(0.013)	(0.016)	(0.016)

Head Start	-0.019	0.000	-0.013	0.004	-0.005	-0.003
	(0.063)	(0.082)	(0.081)	(0.019)	(0.029)	(0.029)
R-squared	0.098	0.108	0.113	0.055	0.066	0.068
N	2402.	1484.	1484.	2465.	1529.	1529.
Young adulthood (Age 22)	High school graduation (OLS)	High school graduation (OLS) LDV sample	High school graduation (LDV)	High school graduation on-time (OLS)	High school graduation on-time (OLS) LDV sample	High school graduation on-time (LDV)
Pre-K	**0.058****	0.029	0.028	**0.067***	**0.051+**	**0.045+**
	(0.021)	(0.028)	(0.028)	(0.026)	(0.029)	(0.027)
Other center care	0.030*	0.020	0.020	0.047+	0.037	0.035
	(0.013)	(0.020)	(0.020)	(0.024)	(0.033)	(0.032)
Head Start	0.046*	0.021	0.020	0.061*	0.034	0.027
	(0.021)	(0.034)	(0.034)	(0.027)	(0.039)	(0.039)
R-squared	0.076	0.085	0.086	0.111	0.136	0.144
N	2076.	1303.	1303.	2058.	1291.	1291.
Age 22 outcomes	College completion (OLS)	College completion (OLS) LDV sample	College completion (LDV)	Bachelor degree (OLS)	Bachelor degree (OLS) LDV sample	Bachelor degree (LDV)
Pre-K	0.024	0.031	0.025	**0.031+**	**0.040***	**0.040***
	(0.019)	(0.019)	(0.024)	(0.016)	(0.016)	(0.019)
Other center care	0.032+	0.035+	0.017	0.041**	0.039*	0.028
	(0.018)	(0.020)	(0.021)	(0.014)	(0.015)	(0.017)
Head Start	0.034	0.057	0.051	0.041+	0.051*	0.047*
	(0.030)	(0.038)	(0.038)	(0.023)	(0.022)	(0.022)
R-squared	0.117	0.095	0.129	0.092	0.071	0.101
N	2076.	1303.	1303.	2076.	1303.	1303.

Source*:* Data from FFCWS age 5, 9, 15, and 22 follow-up surveys. **Note**: The table shows the standardized mean difference in child outcomes between children who attended pre-K and those who did not use center-based childcare in the year before kindergarten. Models include demographic covariates, including mother's race and ethnicity, mother's marital and cohabiting status at child's birth, mother's education at child's birth, mother's employment status at age 1 (nonemployment, part-time employment, full-time employment), primary child care arrangement at age 3 (parental care, informal care, family daycare, center-based care), mother's cognitive test scores (WAIS-R similarities subtest), the child's sex and low birth weight status, and child's age when the survey was taken, and state fixed-effects. LDV model controls for child PPVT scores measured at age 3. Robust standard errors are clustered at the state level. *** p<.001, ** p<.01, * p<.05, + p<.1

Conclusion

This dissertation examines the multifaceted role of publicly funded pre-kindergarten (pre-K) programs. Across three papers, it provides empirical evidence on the role of pre-K in addressing disparities in early childhood education, supporting parental employment and economic security, and laying the foundation for learning.

The first paper documents that income-based disparities in preschool enrollment among three- and four-year-olds narrowed between the mid-1990s and early 2010s, largely because high-income families reduced their use of center-based early childhood education (ECE), while enrollment among low- and middle-income families remained stable or modestly increased. Supplemental analyses suggest that the expansion of state-funded pre-K programs may have helped buffer low- and middle-income families—especially those with four-year-olds, the primary target of most state programs—from declines in ECE enrollment. However, this converging trend stalled in the late 2010s and slightly reversed during the post-pandemic years, revealing persistent income-based gaps in preschool participation. A key driver of these gaps is the compositional difference in maternal education: low-income families are disproportionately likely to have mothers without a college degree, and children of less-educated mothers are less likely to be enrolled in preschool. These findings highlight the need for more comprehensive policies that address both affordability and structural barriers to access, particularly for children of mothers with low income and limited post-secondary education.

The second paper investigates the effects of New York City's universal pre-K expansion for three-year-olds on maternal employment and family economic well-being. It finds that the program led to increases in maternal employment, higher income-to-needs ratios (as measured by the Supplemental Poverty Measure), and reductions in material hardship for lower-income

families. These gains were concentrated among partnered mothers, who experienced immediate increases in employment and reductions in hardship. In contrast, single mothers showed delayed employment gains without measurable improvements in material well-being. These findings suggest that universal pre-K serves as an effective work support for lower-income families, enabling them to participate in the workforce, increase earnings and meet basic needs. However, single mothers may face additional constraints, such as the lack of a co-parent to share caregiving responsibilities, limiting their ability to capitalize on new child care availability. The possibility that increases in earnings are offset by reductions in public benefits warrants further policy investigation.

The third paper explores how the benefits of pre-K attendance unfold from early childhood through young adulthood. It finds strong and consistent improvements in early cognitive test scores and a reduced likelihood of grade retention in early grades. Although the test score gains fade in later childhood and adolescence—a pattern frequently documented in prior literature—pre-K attendance is still associated with improved educational attainment in young adulthood, including higher rates of high school graduation on time and bachelor's degree completion. These results lend support to the "institutional gateway" model, which posits that early educational success being on track facilitates later achievement through a cascade of reinforcing effects on beliefs, behaviors, and institutional engagement, even if early cognitive advantages diminish over time. Moreover, the long-term benefits are more pronounced for Black children than for their white peers, suggesting a compensatory role of pre-K in mitigating racial disparities in educational attainment.

Taken together, the findings from this dissertation demonstrate the dual role of publicly funded pre-K programs in supporting both parents and children and offer several implications for

social work policy and practice. For families with limited economic resources, public pre-K can expand access to early education, increase parental work opportunities, and improve financial well-being. For children, especially those from marginalized backgrounds, pre-K offers developmental benefits that extend into adulthood. These findings suggest that social work policy advocates should engage in sustained efforts to promote high-quality and stable pre-K systems. Such efforts should articulate both the immediate work support benefits for families and the long-term developmental gains for children. Alongside direct income supports—such as Temporary Assistance for Needy Families (TANF), Supplemental Nutrition Assistance Program (SNAP), and housing assistance—pre-K can function as an essential in-kind support for families.

Social workers play a critical role in ensuring families can access and benefit from these programs. They can conduct outreach to connect eligible families with public pre-K, assist with application and enrollment, and offer case management services that bridge child care, employment, and education supports. In school-based settings, social workers can help parents access workforce development resources and facilitate smooth transitions for children from home to pre-K and into primary education—an essential component of the "institutional gateway" effect. Further, social work advocacy should support culturally responsive program designs that reflect the diversity of the families served.

This dissertation also offers important implications for future social work research. First, future studies should investigate local child care supply characteristics that contribute to disparities in children's access to early education. This includes the availability of full-day, full-year, and publicly subsidized slots; structural quality indicators such as staff credentials, class size, and licensing compliance; and the racial and cultural composition of providers. Understanding how these features shape equitable access can inform targeted advocacy.

Second, the finding that universal pre-K reduces material hardship among low-income families suggests that economic improvements may serve as an indirect pathway through which pre-K attendance benefits children's development. Social work researchers should examine this potential mechanism more closely—particularly how increased household resources relate to parental psychological well-being, parenting practices, and child well-being. Such work could bridge the gap between early education and anti-poverty literatures.

Third, the delayed employment response observed among single mothers highlights the need for research exploring the specific barriers they face in leveraging pre-K to support work. This includes issues such as unpredictable work schedules, limited access to extended-hour care, transportation gaps, or administrative burdens in program enrollment. A deeper understanding of these constraints can inform more inclusive and responsive policy design.

Finally, to further test the "institutional gateway" model, social work scholars should examine the social and emotional effects of pre-K attendance, including children's subjective well-being, self-efficacy, peer relationships, and school engagement during middle childhood and adolescence. Comparative research across pre-K programs and implementation contexts can yield insights into which features most effectively promote well-being of families and children.

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