

Reading on Grade Level:
Perspective and Context from Baltimore

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Abstract

Using an integrated administrative dataset, we examine a birth cohort of children born in Baltimore as they navigate a set of publicly-provided early childhood programs, enter kindergarten, and advance through the early elementary grades. We find that attending Head Start for two years or the public pre-kindergarten (Pre-K) program for one year is associated with high initial levels of literacy performance relative to students who attended neither program. Students who attended both programs in sequence performed the highest of all upon kindergarten entry. Literacy gains did not persist, however, with equivalence reached by second grade at the latest. Differences in other outcomes persisted to the end of the observed period. Students who attended Head Start for two years or Head Start followed by Pre-K had higher scale scores in mathematics at the beginning of third grade, and students who attended either program or both were less likely to repeat a grade during their early elementary years.

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Introduction

Scholars of the early learning system in the United States generally refer to it as “fragmented” (e.g., Clifford & Crawford, 2009; Pianta, Barnett, Burchinal, & Thornburg, 2009). This fragmentation is manifest in both the access to and the nature of learning opportunities prior to kindergarten. As a result, similar children may participate in disparate early childhood experiences prior to kindergarten entry by virtue of the opportunities available to them in their community and the ability of their families to navigate those opportunities. Most children enter kindergarten with some sort of preschool experience (Pianta, Barnett, Burchinal, & Thornburg, 2009) usually in a half-day program (NCES, 2015). These differences in experience have implications for how ready a child is for school (Barnett, 2011; Camilli, Vargas, Ryan, & Barnett, 2010; Duncan & Magnuson, 2013; Reynolds, Temple, & Ou, 2010).

That being said, investments in early learning offer one of the highest potential rates of return, especially when those investments are directed towards children from disadvantaged backgrounds (García, Heckman, Leaf, & Prados, 2016; Gertler, et al., 2014; Heckman, 2006). High quality early childhood programming—often funded with public dollars—can offer long-term payoffs. Most of these persistent benefits are in outcomes other than test scores; the evidence of persistent academic impacts is mixed (Bailey, Duncan, Odgers, & Yu, 2017; Hill, Gormley, & Adelstein, 2015). The seminal evidence of the benefits of early childhood programs was provided by studies with limited generalizability, but recent evidence suggests that these benefits are present in large-scale, real-world settings (Dodge, Bai, Ladd, & Muschkin, 2016).

We build upon this literature by examining an integrated administrative dataset to examine a birth cohort of children in Baltimore as they participate in the programs available to them in the city, enter kindergarten, and advance through the early elementary grades. We

examine associations between program participation and immediate and longer-term measures of test score and non-test score outcomes. We find that different combinations of early childhood programs are associated with large differences in literacy outcomes, but these differences do not persist as the children advance through the early elementary grades. There is suggestive evidence that children who attended Head Start performed better on mathematics at the first opportunity to observe mathematics performance in third grade. We also find that children who attended early childhood programs were less likely to be chronically absent in kindergarten or first grade (but not in second) or to repeat kindergarten or first grade.

Background

Early Childhood Program Options

Young children thrive when they maintain continuity while experiencing increasingly challenging situations that encourage their rapid growth potential (Elder, 1998; Zigler & Kagan, 1982). The math and literacy skills of low-income children are a full year behind those of high-income children at the time of kindergarten entry, and these gaps do not diminish by the time the children reach eighth grade (Duncan & Murnane, 2014). Early education programs have been shown to increase school readiness, especially for disadvantaged children (Duncan & Sojourner, 2013; Gormley, Phillips, & Gayer, 2008; Weiland & Yoshikawa, 2013). Recent research has also examined how birth circumstances influence elementary school outcomes (Figlio, Guryan, Karbownik, & Roth, 2014) and how different pathways through early childhood programs yield different literacy outcomes (Jenkins, Farkas, Duncan, Burchinal, & Vandell, 2016).

Baltimore offers two large early childhood programs to meet the needs of its residents: Head Start and Pre-K. The Head Start program is funded with federal dollars and operated through the office of the Mayor of Baltimore. Pre-K is funded through the local school budget

and operated by the Baltimore City Public Schools. Each program enrolls thousands of children each year who eventually attend kindergarten in Baltimore City Public Schools. In Baltimore, as in many other cities, Head Start serves three- and four-year-old children for the two years before kindergarten and Pre-K serves four-year-olds in the year before kindergarten. Consequently, families of four-year-olds who are eligible for both programs can choose between the two.

Despite the large body of research on the effectiveness of individual types of early childhood programs in improving children's early academic skills, relatively few studies have directly compared the outcomes of children who attended Head Start to those who attended state or local Pre-K. Henry and colleagues (2006) use propensity score matching to address selection and compare Head Start to Georgia's pre-k program, finding that state pre-k participants had statistically significant but only modestly higher scores at kindergarten entry relative to similar Head Start participants. Gormley and colleagues (2010) calculate separate regression discontinuity estimates for each age-4 program in Tulsa, Oklahoma, and find larger effects for Oklahoma pre-k participants than for Head Start. The effects of Head Start and pre-k vary depending on the comparison treatment condition (Ludwig & Phillips, 2008). Zhai, Brooks-Gunn, and Waldfogel (2011) use propensity scores to match Head Start children to children in different early childhood education programs and found that Head Start was associated with improved cognitive and social outcomes when compared with children who received parental care or other non-center-based care. However, when compared with children who attended pre-k programs (across different states) and center-based care, Head Start children had better social but not academic outcomes.

One recent study found that different sequences or pathways through preschool did make a difference in children's literacy skills. Using data from Tulsa, Oklahoma, Jenkins and

colleagues (2016) found that children who attended Head Start at age three and then Pre-K at age four had higher pre-reading skills compared to children who attended Head Start for two years.

Head Start & Pre-K Program Characteristics

Head Start and Pre-K have different program goals. Head Start mandates a “whole-child” approach that aims to comprehensively support children’s development across several outcome domains, whereas Pre-K programs—particularly Baltimore’s program—often focus on children’s early academic skills to prepare them for future schooling. These differences may result in differential program effects across the broad scope of children’s outcomes.

Head Start’s comprehensive education and health services coupled with the benefits from having continuity of care (i.e., the same provider) for two years may promote children’s school readiness (Puma et al., 2012; Rimm-Kaufman & Pianta, 2000). Yet, state and local Pre-K programs often have a stronger academic focus compared to Head Start and may provide critical academic content knowledge to promote children’s language, literacy, and math skills (Hulsey et al., 2011; Jenkins, et al., 2016). State and local Pre-K programs may also be able to address learning difficulties that require more substantial intervention (i.e., establish an Individualized Education Plan), which may more smoothly transition students into elementary school compared with a transition from a Head Start program.

<Insert Table 1 Here>

The distinctions between the two programs as instantiated in Baltimore are shown in Table 1. Perhaps most importantly, Head Start is a means-tested program intended for children from families below the federal poverty level (e.g., \$24,250 for a family of four in 2016). The Baltimore Pre-K program gives priority to children who are eligible for free or reduced price meals, which includes incomes as high as 185% of the federal poverty level. The credentials

required to teach in the Baltimore City Public Schools are higher than those for Head Start. City Schools teachers must have a bachelor's degree and hold a Maryland teaching credential, whereas Head Start teachers can have an associate's degree and have only started the credentialing process. Prior to 2014, Head Start in Baltimore was a half-day program while Pre-K was a full-day program (they currently are both full-day programs). City Schools developed its own curriculum for Pre-K that is aligned with the Maryland content standard (and its own kindergarten program) whereas Head Start programs use one of many authorized national curricula (such as Creative Curriculum or I Am Moving, I Am Learning). Class sizes are similar, but Pre-K classes can be somewhat larger (20-23 vs. 17-20). All Pre-K programs are located in elementary school buildings; children are assigned based on their residence so they will attend the same school for kindergarten if they continue to reside in the zone. Some Head Start programs use City Schools buildings, but operate in other facilities as well. Head Start families can attend the location of their choice. Finally, Head Start takes a "whole child" approach that includes family members. Their services in addition to early childhood programming include health care, dental care, and job training for parents, among other things. Pre-K programming focuses on academic preparation and includes some additional services (meals are provided, for example), but the scope of services focuses on the child and includes standard school services.

Head Start, which serves *both* three- and four-year-old children, has gradually become the largest provider of care for low-income three-year-old children. Three-year-olds represent the growing majority age group in Head Start, increasing from 24 percent in 1980 to 40 percent in 2007, and comprising 63 percent of first-time Head Start children in 2010 (Aikens, Klien, Tarullo, & West, 2013; Tarullo, Aikens, Moiduddin, & West, 2010). However, approximately

one-third of children who first enroll in Head Start at age three switch to other care arrangements at age four (Caronongan, Moiduddin, West, & Vogel, 2014), including state and local pre-kindergarten programs.

What is the optimal combination of Head Start and Pre-K? All working families need care for their children and these two programs offer it—along with other programming—at no cost to eligible families. Children in Baltimore enroll in neither program, one of the programs, or in both programs in substantial numbers each year. When children are three years old, Pre-K is not an option, but at age four families have a choice between the two programs.

Potential Implications of Different Combinations

Age four marks an important developmental time in a child's life, with dramatic shifts in development, including new reasoning abilities, improved memory, more advanced language capabilities, and reduced behavior problems (Blair & Raver, 2015; Flavell, 1988; Nelson, 1996). Providing enrichment at this period could have lasting implications for a child's growth and development. There is emerging concern, however, that an academically rigorous program (such as City Schools Pre-K) may not be developmentally appropriate for four-year-old children (Christakis, 2016). Short-term gains in kindergarten readiness might erode over time as children disengage in school, as would be observed in attendance, literacy skills in the early grades, grade repetition, and third grade achievement. This is not just idle speculation: recent studies suggest that initial gains “fade out” over time (Hill, et al., 2015; Jenkins, et al., 2016) or even reverse (Lipsey, Farran, & Hofer, 2015).

On the other hand, the City Schools Pre-K program is integrated—curricularly and even physically—with the kindergarten program. This alignment is a feature of which few preschool programs can boast (Engel, Claessens, and Finch, 2013; Magnuson, Ruhm, and Waldfogel,

2007). As a result of the potential consequences of the fragmentation between early learning programs and kindergarten, some researchers have advocated for an integrated “preschool to grade three” (PK-3) approach to early education (Bogard and Takanishi, 2005; Kagan and Kauerz, 2012).

Why might the sequence matter? One possibility is that children who stay in Head Start at age four will benefit from the continuity of services from one year to the next. By maintaining stability in children’s developmental contexts over time, the continuity of Head Start’s whole child approach may be particularly effective in promoting children’s school readiness for the low-income families served by Head Start. Children who enter kindergarten with higher levels of social development, for example, are less likely to experience disciplinary problems in school, repeat a grade, or be referred for special education (Pianta & Cox, 1999; Pianta & McCoy, 1997).

On the other hand, two years of a program may not be better than one. The marginal benefit of attending a program as a four-year-old that resembles the experience of a three-year-old is likely to be small (Arteaga, Humpage, Reynolds, & Temple, 2014; Reynolds et al., 2011; Tarullo, Xue, & Burchinal, 2013; Nores & Barnett, 2010). As Reynolds explained in a study of dosage in the Chicago Parent Child program, “an additional year that simply repeats learning activities of the first year would not be expected to make much difference” (1995: 23). Switching to another program at age four may provide opportunities for children to experience new, challenging environments that promote their readiness for school. The Baltimore City Schools Pre-K program offers former Head Start students the opportunity to receive a novel age four specific learning experience with a strong academic focus.

Student Outcomes: Which Ones and When?

Discussion of program impacts—or their duration—begs the question of which outcomes are considered. Most studies focus on literacy development, and for good reason, but children develop in many ways. There is some evidence that mathematics achievement is associated with early childhood program participation (Hill, Gormley, and Adelstein, 2015 ; Dodge, Bai, Ladd, & Muschkin, 2016). Furthermore, non-test score outcomes such as referral to special education or repeating a grade are associated with early childhood program enrollment (Dodge, et al., 2016). Some studies have found even longer-term impacts on meaningful adult outcomes (Bailey, et al., 2017). In this study, we focus primarily on literacy in kindergarten through third grade, but we also investigate mathematics performance in third grade as well as non-test score outcomes such as chronic absence, grade repetition, or referral to special education.

Research Questions

In sum, we address two research questions in this analysis:

- How do families take advantage of the early childhood opportunities available to them?
- How are those opportunities associated with early elementary school outcomes?

The first question is a descriptive exercise to help us understand how families in Baltimore avail themselves of the programs to which they are entitled. The second question addresses both reading and mathematics test scores as well as other outcomes such as chronic absence, grade repetition, and special education placement, both in kindergarten and later. Collectively, these results contribute to the emerging discussion of what how best to allocate resources to benefit young children from disadvantaged backgrounds.

Data & Methods

Baltimore's Early Education Data Collaborative

To address these questions we use data from Baltimore's Early Education Data Collaborative (EEDC). The EEDC integrates data from multiple city agencies in Baltimore in order to better understand the opportunities provided for Baltimore's youth. The development of the EEDC began in late 2013. In early 2014 a Memorandum of Understanding (MOU) was circulated among the parties. The MOU was first fully executed in 2015 and revised in 2016. It currently includes eight parties and is in effect until December 2018. The work of the EEDC is supervised by the Institutional Review Boards at Johns Hopkins University, Baltimore City Public Schools, and the Maryland Department of Health and Mental Hygiene.

<Insert Figure 1 Here>

The agencies that contribute data to the EEDC are shown in Figure 1. The Baltimore City Health Department (Health Department) provides the base Vital Statistics data upon which the rest of the database is built. The Vital Statistics data include all babies born to Baltimore residents. To these data are added records from home visiting programs for mothers and infants (provided by the Health Department, the Family League of Baltimore, and the Maryland Family Network [an extensive but not exhaustive list of providers]), referral records from the Infants and Toddlers program for children who may have a developmental delay, foster care records from the Baltimore City Department of Social Services, and records from Baltimore City Head Start (Head Start) and Baltimore City Public Schools (City Schools). Outcome data in grades kindergarten through three are provided by City Schools.

The EEDC is a longitudinal cohort study that is both retrospective and prospective. All children in Maryland are obliged to attend kindergarten if they are five years

old on September 1 of a given year. The first EEDC cohort consists of children born between September 2, 2007 and September 1, 2008 and who would thus be “on-time and first-time” kindergarteners in the 2013-14 school year by virtue of being five years old on September 1, 2013.

Matching Process

Records were linked across agencies using child’s first and last name and birth date. The final match was conducted at the Health Department and a de-identified dataset was produced for analysis. The matching process was iterative. To be matched, birthdate had to match exactly but first and last name could be approximate (probabilistic or “fuzzy” matching [Christen, 2012; Wasi & Flaaen, 2015]). After formatting names consistently across datasets (omitting punctuation, for example, and documenting alternate spellings over time within agencies), we first exactly matched on first name, last name, and date of birth. With the Vital Statistics serving as the master population file, we matched each source file to the Vital Statistics data. Eighty-six to ninety-six percent of all matches, depending on the data file, were matched exactly on first name, last name, and date of birth.

As a second step, probabilistic or “fuzzy” matching methods allowed us to match mildly discrepant names. The algorithm assigned each possible match a score ranging from 0 to 1 rating the probability of the match with 1 indicating an exact match. Matches over 0.90 were automatically accepted, and matches over 0.67 were reviewed clerically. The following rules were applied during manual inspection of fuzzy matches: first and last names were compared in order to determine if a match was reasonable. In most cases, minor discrepancies in first and last names prevented records from being matched in the exact merge procedure. In the end, 6,683 of 9,692 (59%) viable births were matched to subsequent program records. Put another way, 75%

of the 2013-14 Kindergarten class in City Schools was matched to its birth records.

Characteristics of Birth Cohort and Matched Sample

<Insert Table 2 Here>

As shown in Table 2, the mothers and children who ended up using the publicly-provided services offered by the EEDC partners did not resemble the full birth cohort. For example, the mothers in the matched sample were on average one year younger (24.9 compared to 25.9), fewer were married (19% compared to 30%), a greater proportion were African American (81% compared to 69%), and were more likely to be receiving financial assistance for pregnancy and birth related costs (77% compared to 67%) than the full birth cohort. The proportion of mothers reporting sixteen or seventeen years of education is substantially lower in the matched group than in the birth cohort (12% compared to 27%). These educational attainment differences at the top of the range are offset by larger groups of mothers reporting less than twelve years of education (33% vs. 27%) or exactly twelve years of education (41% vs. 36%) at the time of their child's birth.

As Figure 2 shows, the likelihood that a family used these services was not equally distributed across the city; children born in the relatively privileged census tracts to the north of the city and near the harbor were less likely to use the services provided by the EEDC partners. In some of the less prosperous areas of city over 80% of babies were identified in at least one agency's data.

<Insert Figure 2 Here>

Program Sequences

<Insert Figure 3 Here>

<Insert Table 3 Here>

As shown in Figure 3 and Table 3, many Baltimore families use publicly available services in early childhood, and they do so in many different ways. 5,746 children in the birth cohort attended kindergarten. 1,070 of these children were first observed in kindergarten and not in any of the earlier programs (see Figure 3). Just counting Head Start and Pre-K and not any of the earlier programs, the number of children who bypassed Head Start and Pre-K on the way to kindergarten is 1,329 (see Table 3). Some children attended Head Start as a three-year-old for one year but were not observed in the year prior to Pre-K (134), some entered Head Start late as a four-year-old (163), some attended the program for two years (589), a large number attended the Pre-K program (2,679 [2,218 without any of the other programs]), and many children attended Head Start for one year followed by Pre-K (852).

Characteristics of Children by Program Sequence

<Insert Table 4 Here>

The characteristics of the children and their mothers (from the Vital Statistics data) are shown in Table 4. Most of the characteristics differ across the program sequences. For example, the proportion of mothers reporting 16 or 17 years of education is highest among the “no program” groups (19%) and the proportion of mothers receiving financial assistance with medical care (Medicaid or Maryland Children’s Health Program [MCHP]) is lowest (70%). Other measures do not differ, however, including some of the birth health measures (birthweight and preterm birth, for example).

Explanatory Variables

Among the 5,746 Baltimore-born children who were matched to their kindergarten records (the analytic sample), the 1,329 who entered without enrolling in Head Start or Pre-K serve as the reference category (“no program”). Presumably these children were cared for

informally or by the private or parochial sector. The other combinations of programs serve as the explanatory variables in the analysis, with a focus on the three most common sequences: Head Start at Age 3 and 4, Pre-K Only, and Head Start + Pre-K.

Outcomes

Multiple outcomes are available at different periods of time, as shown in Table 4. The bulk of the outcomes consist of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS; Good & Kaminski 2003) assessment. The DIBELS is administered multiple times per year by classroom teachers; six total are available, from the beginning and end of kindergarten, first, and second grade. We treat the outcome as binary (on benchmark/not on benchmark) in order to maintain consistency across different tests and because that is how the results are presented to teachers and families. Many students in the sample (69%) were on benchmark at the beginning of kindergarten, which proves to be a high mark. The largest decline is during the summer between kindergarten and first grade (65% to 42%), presumably due to both summer learning loss and the increasing difficulty of the assessment.

At the beginning of third grade a different assessment is available, the i-Ready, for the 2016-17 school year. The i-Ready is an adaptive assessment that is aligned to the Common Core. Students are assessed three times per year (beginning-, middle-, and end-of-year) for 30-60 minutes each time (Curriculum Associates 2014). We also characterize the i-Ready outcomes as being on benchmark or not. At the beginning of third grade, 21% of the students in the cohort were considered on benchmark (see Table 5). The i-Ready also assesses mathematics at the beginning of third grade. In Fall 2016, 5% of the students in our sample were considered on benchmark in mathematics according to the i-Ready.

We also examine chronic absence (missing 10% or more days of school) in kindergarten, first, and second grade, grade repetition at the end of kindergarten and first grade, and assignment of an Individualized Education Program (IEP) by the 2015-16 school year, when the cohort was expected to be in second grade. Chronic absence rates are between 25% and 30% each year, grade repetition was 4% each year, and 18% of children in the sample had an IEP by the end of second grade.

<Insert Table 5 Here>

Estimation

Our outcomes are binary, so we estimate logistic regression models with robust standard errors as shown in Equation 1.¹ The model is also represented schematically in Figure 4.

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \beta_1 HS_{Age3}_{ij} + \beta_2 HS_{Age4}_{ij} + \beta_3 HS_{Age3\&4}_{ij} + \beta_4 PK_{ij} + \beta_5 HSPK_{ij} + \sum \beta_{ij} X_{ij} \quad (1)$$

<Insert Figure 4 Here>

The coefficients for the program sequence indicators (β_1 to β_5) address our research questions about the differences associated with program experience relative to the reference group of children. The vector of additional variables ($\sum \beta_{ij} X_{ij}$) includes exposure to the other programs in the data (home visiting, Early Head Start, foster care, and referral to the infants and toddlers program) as well as the Vital Statistics data. These adjustments include mother's education (reference group: <12 years), birth circumstances (weight, preterm), parity (the number of live births the mother had including the focal child's birth), financial assistance with

¹ We also estimated the scale scores when available, with one exception (noted below) the interpretation of the scale score models resembled the logistic regression models.

medical costs (Medicaid or MCHP), marital status, whether the father was identified on the birth certificate, and the mother's race/ethnicity (reference group: African-American).

Limitations

The rich demographic and geographic covariates allow us to account for many features that are difficult to observe, but they do not entirely account for selection into programs. This issue especially pertains to the families that enroll in both Head Start and Pre-K: having a savvy parent or guardian who can navigate a fragmented system is likely also related to student outcomes. An additional challenge is that the reference group is heterogeneous. Some children will attend kindergarten without being observed in other data because they are privileged: they attend a private or parochial program or they can stay home with a family member who volunteers to care for them. The same sequence of events could also correspond to a child who has very few resources, even to take advantage of a free program, perhaps because it is not compulsory. In future iterations of this analysis, we will take advantage of the Vital Statistics data on the census tract in which the mother resided at the time of the child's birth. We also will pursue matching methods, both to take advantage of the richness of observable data and to assess the balance or common support between the groups.

Another current limitation is that the model treats each outcome as a separate event and does not explicitly model time. In the future we will estimate growth models to formally test the time trends by computing an intercept (beginning of kindergarten) and slope (time trend). This will allow us to estimate directly the potential for both initial differences and relative differences in the growth over time.

Finally, the current analysis does not fully account for attrition in the sample. It is possible that unbalanced attrition could erode observed differences over time. Future analyses

will examine the characteristics of the attrition sample to determine if the students who left the sample are more or less academically accomplished than those who stayed. As a sensitivity check, we also estimated all of the models using only the sample of students that persisted until the 2015-16 school year. With one exception—the likelihood of being chronically absent in second grade—the results are similar in magnitude and the conclusions are the same.

Results

Literacy Outcomes

<Insert Table 6 Here>

The results of the analysis of DIBELS and i-Ready literacy scores are shown in Table 6. The estimated differences by program sequence are all relative to students who attended neither program (N = 1,329). The small number of students who attended Head Start for one year and then neither program or who attended Head Start for a single year before kindergarten were indistinguishable from the children in the reference group who never attended Head Start or Pre-K. As Table 6 shows, attending Head Start for two years (0.635), attending Pre-K (1.567), and attending Head Start followed by Pre-K (2.009) are all associated with higher levels of literacy performance at the beginning of kindergarten relative to the children who were not enrolled in either program.

Some of the initial differences in early literacy associated with program attendance are very large, particularly at the beginning of kindergarten. The estimate for attending Head Start for two years, for example, corresponds to an odds ratio of 1.89. That is, children who attended Head Start for two years are nearly twice as likely to be on benchmark in literacy at the beginning of kindergarten. The associations with Pre-K attendance at the beginning of kindergarten are even larger, equating to odds ratios of 4.79 for Pre-K and 7.46 for the

combination of Head Start and Pre-K.

These large differences are not observed later in the children's schooling. Children who attended Head Start for two years are indistinguishable from the reference group by the end of kindergarten, and children who attended the Pre-K program resemble the reference group by the beginning of first grade. Children who attended both programs—who began kindergarten nearly eight times as likely to be on benchmark in literacy—fare better than the reference group at the beginning of second grade but cannot be distinguished from them by the end of second grade. The third grade assessment is a different test, and it generally shows that program sequences are not associated with the literacy test in third grade (with the exception of a negative estimate for the Pre-K Only group in the middle of third grade).

Not all of the associations in the model attenuate over time. For example, children who are referred to the Infants & Toddlers program due to a concern about a developmental delay are consistently less likely to be on benchmark. The coefficients follow a relatively constrained range from -0.358 to -0.639 across time periods and test formats. These correspond to odds ratios between 0.53 to 0.70, suggesting that whatever behaviors were evident at an early age to prompt a concern about a developmental delay continue to be negatively associated with achievement across the period.

Similarly, maternal education is consistently associated with being on benchmark in literacy across time and tests. The estimates for each category fall within a relatively narrow range across time and test formats (12 years of education vs. < 12 years: 0.311 to 0.497; 13-15 years of education vs. < 12 years: 0.586 to 0.800; 16+ years of education vs. < 12 years: 1.091 to 1.849), with higher levels of maternal education associated with a higher likelihood of being on benchmark.

Parity, a proxy for family size, is consistently negatively associated with literacy performance. Children who were born later in their mother's birth order are less likely to be on benchmark. For example, the estimate of the association between a unit increase in parity and the log odds of being on benchmark at the beginning of kindergarten is -0.07 , which corresponds to an odds ratio of 0.93 .

Eligibility for financial assistance with medical costs related with the child's birth (Medicaid or MCHP) is also negatively associated with literacy performance. The estimates stay within a relatively narrow range in kindergarten and first grade (-0.188 to -0.249) and are larger in second and third grade (-0.377 to -0.431). These estimates suggest that in the early grades children whose mothers required financial assistance were about 80% as likely to be on benchmark in the early grades and about 66% as likely to be on benchmark in the later grades relative to their peers whose mothers did not require financial assistance.

Other Outcomes

<Insert Table 7 Here>

Results for other outcomes—chronic absence, grade retention, special education referral, and 3rd grade mathematics—are shown in Table 7. Attending Head Start for two years, Pre-K only, or Head Start followed by Pre-K is associated with a lower likelihood of chronic absence in kindergarten and first grade. On this outcome, the Head Start for two years (-0.639 and -0.784) and Head Start followed by Pre-K (-0.629 and -0.769) estimates are similar in magnitude. The estimates for the children who attended Pre-K only are closer to zero (-0.418 and -0.592). Program participation is not associated with chronic absence in second grade, but this outcome is the one in which attrition appears to play a role. Limiting the sample to students who were still enrolled in Baltimore City Schools in 2015-16, the estimates for attending Head Start for two

years (-0.302) and Head Start followed by Pre-K (-0.245) can be distinguished from zero, but they are smaller than those observed in earlier years.

All three programs—Head Start for two years, Pre-K, and Head Start followed by Pre-K—are associated with lower levels of grade retention in kindergarten and first grade. Students who attended both programs were dramatically less likely to repeat kindergarten (-1.732, odds ratio: 0.178). Students who attended Head Start for two years (-1.006, odds ratio: 0.37) or Pre-K (-1.065, odds ratio: 0.34) were similarly unlikely to be retained in kindergarten. Although the magnitude of the estimates was smaller in first grade, retention rates were lower in first grade relative to the reference group for children who attended Head Start for two years (-0.595, odds ratio: 0.55), Pre-K (-0.414, odds ratio: 0.66), and both Head Start and Pre-K (-0.750, odds ratio: 0.47). Once again, the combination of the programs is associated with the largest differences relative to the group of children who attended neither program.

Few elements in the model are associated with referral to special education except for the small number of children who attended Head Start as a four-year-old but not before (0.702, odds ratio: 2.0). The other strong association is between referral for the Infants & Toddlers screening program (1.422, odds ratio: 4.15). That is, there are signs even before children are three years old that they will struggle in elementary school. Since the Infants & Toddlers program is intended as a screening of children under age three for a possible Individual Family Service Plan (IFSP), a precursor for an Individualized Education Program (IEP), this high correlation is not necessarily surprising.

<Insert Table 8 Here>

Program participation is not associated with the likelihood of being on benchmark in mathematics in third grade. Proficiency in mathematics is a threshold that few students meet,

however (5% total). As shown in Table 8, however, students who attended preschool for two years—either Head Start or Head Start and Pre-K—had higher scale scores (3.337 and 5.590 scale score points respectively, which is equivalent to 0.12 and 0.20 standard deviations of the outcome).

As with literacy performance, maternal education is strongly associated with chronic absence, grade retention, and mathematics performance. Financial assistance is associated with higher rates of chronic absence, with suggestive evidence of associations with other outcomes. In other words, intergenerational features appear to be consequential.

Discussion & Conclusion

How Families Navigate Programs

Using an integrated administrative dataset, we examine a birth cohort of children born in Baltimore as they navigate a set of publicly-provided early childhood programs, enter kindergarten, and advance through the early elementary grades. We find that families navigate the programs available to them in myriad ways, and that many of them attend at least one program prior to enrolling in kindergarten. Over sixty percent of the matched kindergarten students entered via the Pre-K program, over thirty percent had some experience with Head Start (ten percent for two consecutive years), and fifteen percent of the matched kindergarten students attended both Head Start and Pre-K. Nearly a quarter of the matched kindergarten students did not have experience with either program, however.

How Sequences are Associated with Outcomes

Our second research question addressed how these program sequences were associated with student outcomes in the early elementary grades. Attending Head Start for two years or the public pre-kindergarten (Pre-K) program for one year is associated with high initial levels of

literacy performance relative to students who attended neither program. Students who attended both programs in sequence performed the highest of all upon kindergarten entry. Literacy gains did not persist, however, with equivalence reached by second grade at the latest. Differences in other outcomes did persist to the end of the observed period. Students who attended Head Start for two years or Head Start followed by Pre-K had higher scale scores in mathematics at the beginning of third grade, and students who attended either program or both were less likely to repeat a grade during their early elementary years.

The small number of children who attended Head Start for a single year but were not observed as a four-year-old could generally not be distinguished from the children who never attended a program. Both groups are small, but some of the estimates are near zero. Curiously, children who attended Head Start for one year as a three-year-old performed substantially better in elementary school if they followed up Head Start with Pre-K. If the single year of Head Start was followed by a gap, however, the children performed similarly to children who experienced neither program. There is substantial evidence that the effects of Head Start “fade out” (Leak et al., 2013; Puma, Bell, Cook, & Heid, 2010); among these children with lack of continuity of care, we find fade out occurs even before kindergarten begins.

Bailey and colleagues (2017) offer three possible explanations for this the long-term persistence—or lack thereof—of early gains: skill-building, foot-in-the-door, and sustaining environments. Skill-building focuses on the autoregressive nature of skill development, or “skills beget skills,” to focus on how developing skills allows children to take advantage of future educational environments. Foot-in-the-door processes also focus on the individual child and his or her ability to avoid risk at critical periods. Sustaining environments broadens the perspective to include the schools and classrooms in which children find themselves and notes

that to maintain their advantage they must continue their growth trajectories in the absence of enrichment. By design, all of the children in this study find themselves in the same educational environment: Baltimore City Public Schools. There is little reason to expect that these elementary classrooms sustain children differently based on their prior experiences.

We observe very large differences in early literacy skills associated with prior experience. The odds of being on benchmark in literacy at the beginning of kindergarten are nearly eight times higher among children who attended both Head Start and Pre-K. This is a major “boost,” and in fact, Bailey et al. (2017) describe the hypothesized skill-building process as akin to inoculation, in that children are assumed to be endowed with sufficient skills that they can exploit the educational environment around them. That is a large responsibility, however, to place on a child alone.

Given that these apparent initial differences narrow within a few years, the next question is why. One explanation is that literacy for an entering kindergartner is materially different than literacy for a second grader—the expectations differ substantially. What appears to be occurring is that children enter kindergarten with a set of skills that represent mastery at the beginning of elementary school, but that they are not acquiring new skills as time passes to the point at which their performance converges with their peers. The overall literacy performance declines somewhat over time as the standard is raised (see Table 5), which suggests that the acquisition of new skills is challenging for all children, regardless of their skill level at entry.

Differences based on program experience persist in other outcomes, and the findings with respect to grade retention are particularly noteworthy. Early retention may function as a “foot-in-the-door” process; children who are retained early will remain behind for the duration of the course of their education. In addition to the potential harm to the individual student (Hong &

Yu, 2007; Jimerson, 1999; McCoy & Reynolds, 1999; Silbergitt, et al., 2006), grade retention has a clear financial cost: the district's per-pupil expenditure. In fiscal year 2013, Baltimore City Public Schools spent \$15,050 per student in kindergarten through twelfth grade (Cornman, 2016). Allocations specific to the pre-k program are difficult to identify independently since they take place in existing elementary school buildings, but in fiscal year 2017 the district allocated \$32M to serve a projected 4,691 students, or \$6,822 per student (Baltimore City Public Schools, 2016). To the extent that allocations on Pre-K reduce later allocations on repeated grades in early elementary school, the fiscal case for the Pre-K program is strong.

Future Work

As this work progresses, we will continue to add data sources to the EEDC, add subsequent birth cohorts, and follow the children as they progress through school. Currently, the database includes four birth cohorts who are expected to be in kindergarten through third grade in the 2016-17 school year. A number of analytical efforts are obvious next steps. First, we will investigate student attrition more thoroughly to identify who is leaving the cohort. Next, we will examine potential heterogeneity in student outcomes based on student origin, with differences by maternal education as a starting place. Third, we will attempt to identify causal effects by estimating propensity score matching models of program involvement. Matching with multiple potential treatments is not a simple undertaking, but strategies for up to three treatments (e.g., Head Start for two years, Pre-K, and Head Start + Pre-K) have recently been developed using multinomial logistic regression models (e.g., McCaffrey, et al., 2016). Propensity score models are only as good as the observable data available, but the Vital Statistics data offer the potential for a strong matching model, especially once we use the information about the census tract in which the mother resided when the child was born.

Conclusion

Our findings also support the intentional decisions made by Baltimore City Head Start and Baltimore City Public Schools program staff. The alignment of the Pre-K curriculum to the literacy standards seems to pay off in the early years; children who enter kindergarten from the Pre-K program are dramatically more likely to have early literacy skills as measured on the DIBELS. Moreover, in 2014 Baltimore City Head Start was granted more local control by virtue of a federal pilot program. The program used this flexibility to target three-year-old children for a single year and encourage them to transition to City Schools Pre-K (Wenger, 2014). This allows Head Start to serve a bigger portion of the three-year-old population each year, and the combination of Head Start and Pre-K appears to be optimal. In Baltimore, efforts to make the system less fragmented appear to be successful, but much work remains to ensure that the children build upon their early experiences and reach their full potential as they progress through school.

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Tables & Figures

Tables

Table 1: Characteristics of Head Start and Baltimore City School Pre-K Programs

	Head Start	City Schools Pre-K
Definition of Financial Need	Federal Poverty Guidelines (e.g. \$24,300/yr for family of 4)	National School Lunch Program (\leq 185% Federal Poverty)
Staff Educational Requirement	Associates Degree or Higher	Bachelor's Degree or Higher
Maryland Teaching Credential for Staff	In Progress	Required
Length of Program Day	Part Day (pre-2014)/Full Day (post-2014)	Full Day
Curriculum	Varies	Developed by Baltimore City Schools
Curricular Alignment	Varies	Aligned to Maryland Standards and Common Core State Standards
Average Class Size	17-20	20-23
Program Location	Varies (some in City Schools)	Baltimore City Schools buildings
Location Attended	Family Choice	Zoned by Residence
Means Tested	Yes	Priority Given to Low-Income Students
Focus	"Whole Child"	Academic Preparation
Program Services	Health care, dental care, meals, family services coordination	Standard school-based services

Sources: baltimorecityschools.org; human-services.baltimorecity.gov/head-start; personal communication.

Table 2: Characteristics of Complete 2007-2008 Birth Cohort and Matched Sample

	Birth Cohort	Matched Sample	Difference	P-value (matched vs. unmatched)
Maternal Educ.: < 12 Years	27.0%	32.8%	5.8%	0.000
Maternal Educ.: 12 Years	36.1%	41.1%	5.0%	0.000
Maternal Educ.: 13-15 Years	14.3%	14.0%	-0.4%	0.137
Maternal Educ.: 16+ Years	22.6%	12.2%	-10.4%	0.000
Inadequate Birth Spacing (< 18 mo.)	32.0%	30.7%	-1.3%	0.001
Birthweight (g)	3,133.8	3,086.1	-47.7	0.000
Mother's Age	25.9	24.9	-1.0	0.000
Clinical Estimate of Gestation	38.3	38.2	-0.1	0.000
Low Birthweight (<2500g)	12.0%	13.8%	1.8%	0.000
Very Low Birthweight (<1500g)	1.8%	2.3%	0.5%	0.000
Preterm Birth (<37 weeks)	12.6%	14.1%	1.6%	0.000
Teen Birth (<20 y.o.)	17.8%	22.0%	4.3%	0.000
Parity	1.1	1.2	0.1	0.000
Female	49.4%	49.3%	-0.1%	0.719
Financial Assistance	66.5%	76.5%	9.9%	0.000
Married at Birth	30.0%	19.4%	-10.6%	0.000
Father's Name on Certificate	67.1%	61.6%	-5.5%	0.000
Smoked during Pregnancy	10.4%	11.5%	1.1%	0.000
Hispanic	6.4%	6.0%	-0.4%	0.021
American Indian	0.2%	0.2%	0.0%	0.386
Asian	2.2%	0.7%	-1.5%	0.000
African-American	68.5%	80.6%	12.1%	0.000
White	22.4%	12.2%	-10.2%	0.000
Other Race/Ethnicity	0.4%	0.3%	-0.1%	0.117
N	9,692	6,683		

Note: p-value computed using two-sample (matched vs. unmatched) t-test.

Table 3: Common Program Sequences Prior to Kindergarten

	Freq.	Percent	Cum.
No Program	1,329	23.13	23.13
Head Start Age 3	134	2.33	72.08
Head Start Age 4	163	2.84	74.92
Head Start Age 3 & 4	589	10.25	85.17
Pre-K	2,679	46.62	69.75
Head Start & Pre-K	852	14.83	100
Total	5,746	100	

Table 4: Mother and Child Characteristics by Program Experience Prior to Kindergarten

	No Program	HS Age 3	HS Age 4	HS Age 3+4	Pre-K Only	HS+Pre-K	Total	p-value
Maternal Educ.: < 12 Years	35%	44%	40%	33%	33%	35%	34%	0.043
Maternal Educ.: 12 Years	35%	41%	41%	48%	43%	47%	42%	0.000
Maternal Educ.: 13-15 Years	12%	15%	14%	14%	14%	14%	14%	0.238
Maternal Educ.: 16+ Years	19%	0%	5%	5%	10%	5%	10%	†
Birthweight (std.)	-0.043	-0.247	-0.089	-0.136	-0.101	-0.046	-0.086	0.084
Low Birthweight (< 2500g)	14%	14%	14%	15%	14%	11%	13%	0.307
Very Low Birthweight (< 1500g)	2%	2%	3%	3%	2%	2%	2%	0.437
Teen Birth (< 20 years old)	23%	35%	25%	24%	22%	24%	23%	0.052
Preterm Birth (< 37 weeks)	14%	19%	14%	14%	13%	14%	14%	0.713
Inadequate Birth Spacing (< 18 mo.)	17%	14%	14%	12%	19%	17%	17%	0.000
Parity	1.224	1.157	1.067	1.078	1.269	1.187	1.218	0.038
Mother Smoked During Pregnancy	13%	15%	15%	9%	11%	9%	11%	0.017
Financial Assistance	70%	87%	84%	86%	76%	86%	78%	0.000
Married at Birth	25%	13%	11%	14%	18%	12%	18%	0.000
Father's Name on Birth Certificate	62%	54%	51%	63%	61%	56%	60%	0.007
White, Asian, Hispanic, or Other Race/Ethnicity	27%	10%	17%	13%	16%	11%	17%	0.000
N	1,329	134	163	589	2,679	852	5,746	

Notes: p-value from James's test for equal means, allowing heterogeneous covariances matrices across groups. † Singularity in Head Start Age 3 group (mean = 0.0) invalidates test statistic (p = 0.000 with group omitted).

Table 5: Outcome Measures

Outcome	Obs.	Mean
DIBELS On Benchmark: Beginning Kindergarten	4,237	69%
DIBELS On Benchmark: End of Kindergarten	4,342	65%
DIBELS On Benchmark: Beginning of First Grade	4,390	42%
DIBELS On Benchmark: End of First Grade	4,255	50%
DIBELS On Benchmark: Beginning of Second Grade	4,086	52%
DIBELS On Benchmark: End of Second Grade	3,477	52%
i-Ready Reading On Benchmark: Beginning 3rd Grade	3,303	21%
i-Ready Mathematics On Benchmark: Beginning 3rd Grade	3,715	5%
Chronic Absence in Kindergarten	5,746	29%
Repeated Kindergarten	5,746	4%
Chronic Absence in First Grade	5,606	30%
Repeated First Grade	5,606	4%
Chronic Absence in Second Grade	4,865	25%
Individualized Education Plan in 2015-16	5,177	18%

Note: Chronic absence defined as missing at least 10% of enrolled days.

Table 6: Literacy Benchmarks Over Time

	DIBELS On Benchmark						i-Ready: Beginning of Gr. 3	i-Ready: Middle of Gr. 3
	Beginning K	End K	Beginning Gr. 1	End Gr. 1	Beginning Gr. 2	End Gr. 2		
Early Education Experience (reference: neither program)								
Head Start Age 3 Only	0.173 (0.218)	-0.379 (0.212)	-0.076 (0.214)	0.123 (0.207)	0.285 (0.207)	-0.100 (0.232)	-0.305 (0.343)	-0.113 (0.267)
Head Start Age 4 Only	0.134 (0.211)	-0.291 (0.208)	-0.291 (0.219)	-0.145 (0.207)	-0.0271 (0.204)	-0.234 (0.231)	0.0316 (0.284)	-0.388 (0.273)
Head Start Age 3 & 4	0.635*** (0.131)	0.055 (0.126)	-0.065 (0.124)	0.077 (0.123)	0.010 (0.127)	0.003 (0.138)	-0.119 (0.178)	-0.167 (0.154)
Pre-K Only	1.567*** (0.094)	0.269** (0.085)	0.150 (0.081)	0.151 (0.081)	0.053 (0.084)	0.010 (0.093)	-0.112 (0.114)	-0.213* (0.103)
Head Start & Pre-K	2.009*** (0.134)	0.483*** (0.114)	0.324** (0.106)	0.333** (0.106)	0.268* (0.110)	0.142 (0.118)	-0.0343 (0.151)	-0.172 (0.135)
Home Visiting	0.187 (0.165)	-0.132 (0.141)	-0.097 (0.154)	-0.101 (0.146)	-0.132 (0.147)	-0.055 (0.163)	-0.998** (0.312)	-0.527* (0.217)
Early Head Start	-0.476* (0.235)	0.075 (0.221)	-0.157 (0.220)	-0.195 (0.222)	-0.257 (0.215)	-0.105 (0.264)	0.202 (0.358)	-0.0138 (0.336)
Infants & Toddlers	-0.358*** (0.106)	-0.583*** (0.093)	-0.639*** (0.098)	-0.426*** (0.094)	-0.434*** (0.0951)	-0.477*** (0.103)	-0.501*** (0.152)	-0.487*** (0.127)
Foster Care	0.0330 (0.263)	0.349 (0.250)	0.173 (0.234)	0.0804 (0.231)	-0.397 (0.249)	-0.019 (0.258)	-0.156 (0.408)	-0.0292 (0.316)
Maternal Educ.: 12 Years (reference: < 12 Years)	0.311*** (0.084)	0.388*** (0.077)	0.471*** (0.076)	0.497*** (0.075)	0.435*** (0.076)	0.369*** (0.083)	0.389*** (0.117)	0.451*** (0.0982)
Maternal Educ.: 13-15 Ye	0.695*** (0.133)	0.586*** (0.117)	0.732*** (0.109)	0.657*** (0.108)	0.709*** (0.112)	0.640*** (0.119)	0.723*** (0.149)	0.800*** (0.132)
Maternal Educ.: 16+ Year	1.849*** (0.227)	1.181*** (0.167)	1.091*** (0.136)	1.460*** (0.151)	1.259*** (0.158)	1.267*** (0.170)	1.527*** (0.169)	1.391*** (0.164)
Birthweight (std.)	0.020 (0.054)	0.042 (0.050)	0.066 (0.050)	0.072 (0.047)	0.051 (0.048)	0.085 (0.051)	-0.0594 (0.0668)	0.0233 (0.0603)
Teen Birth (< 20 years old)	-0.044 (0.099)	0.114 (0.090)	0.022 (0.087)	-0.078 (0.086)	-0.010 (0.088)	-0.109 (0.095)	-0.0631 (0.128)	-0.0157 (0.110)
Preterm Birth (< 37 week)	-0.215 (0.142)	-0.141 (0.127)	-0.0914 (0.128)	0.0372 (0.126)	0.0644 (0.128)	0.144 (0.137)	0.0227 (0.185)	0.0819 (0.161)
Low Birthweight (< 2500g)	-0.075 (0.164)	0.067 (0.148)	0.008 (0.144)	0.043 (0.143)	-0.121 (0.146)	0.079 (0.156)	-0.390 (0.210)	-0.105 (0.183)
Parity	-0.070* (0.028)	-0.037 (0.025)	-0.085** (0.027)	-0.085*** (0.024)	-0.086*** (0.026)	-0.096*** (0.029)	-0.124** (0.0395)	-0.0639* (0.0320)
Financial Assistance	-0.249* (0.107)	-0.207* (0.096)	-0.188* (0.085)	-0.229** (0.088)	-0.405*** (0.091)	-0.431*** (0.097)	-0.400*** (0.109)	-0.377*** (0.102)
Married at Birth	0.234 (0.126)	0.102 (0.111)	0.098 (0.100)	0.224* (0.104)	0.171 (0.107)	0.155 (0.114)	0.345** (0.132)	0.254* (0.123)
White, Asian, Hispanic, or	-0.314** (0.104)	-0.067 (0.094)	0.028 (0.091)	0.110 (0.093)	0.199* (0.095)	0.079 (0.101)	0.484*** (0.120)	0.395*** (0.111)
Father's Name on Birth C	0.206** (0.080)	0.101 (0.072)	0.187** (0.070)	0.100 (0.069)	0.050 (0.070)	0.055 (0.077)	0.180 (0.102)	0.156 (0.0879)
Constant	-0.292 (0.157)	0.359* (0.141)	-0.592*** (0.134)	-0.272* (0.133)	0.094 (0.137)	0.190 (0.152)	-1.368*** (0.195)	-0.800*** (0.168)
N	4,208	4,313	4,467	4,361	4,182	3,557	3,370	3,232

Notes: Coefficients in log-odds (logit) scale; Robust standard errors in parentheses; *p < 0.05, **p < 0.01, ***p < 0.001.

EARLY CHILDHOOD IN BALTIMORE

Table 7: Other Outcomes Over Time

	Chronic Absence in Kindergarten	Chronic Absence in Gr. 1	Chronic Absence in Gr. 2	Repeated Kindergarten	Repeated Gr. 1	Special Education (2015-16)	i-Ready Math: Beginning of Gr. 3	i-Ready Math: Middle of Gr. 3
Early Education Experience (reference: neither program)								
Head Start Age 3 Only	-0.235 (0.189)	-0.0458 (0.178)	-0.299 (0.222)	-0.0284 (0.352)	0.439 (0.320)	-0.346 (0.280)	-0.596 (0.752)	-0.661 (0.458)
Head Start Age 4 Only	-0.254 (0.187)	-0.201 (0.180)	0.0429 (0.202)	-0.0974 (0.351)	-0.445 (0.442)	0.702*** (0.200)	-0.289 (0.612)	-0.469 (0.400)
Head Start Age 3 & 4	-0.639*** (0.118)	-0.784*** (0.117)	-0.250 (0.130)	-1.006*** (0.293)	-0.595* (0.265)	0.146 (0.140)	-0.219 (0.335)	0.401* (0.186)
Pre-K Only	-0.418*** (0.0754)	-0.592*** (0.0756)	-0.0519 (0.0849)	-1.065*** (0.173)	-0.414* (0.162)	-0.0243 (0.0983)	-0.222 (0.188)	0.118 (0.124)
Head Start & Pre-K	-0.629*** (0.101)	-0.769*** (0.102)	-0.213 (0.111)	-1.732*** (0.324)	-0.750** (0.244)	-0.117 (0.131)	0.329 (0.252)	0.212 (0.164)
Home Visiting	0.232 (0.127)	0.450*** (0.128)	-0.0199 (0.144)	0.273 (0.268)	0.580* (0.230)	0.166 (0.160)	-0.498 (0.531)	-0.654* (0.308)
Early Head Start	0.114 (0.212)	-0.0268 (0.220)	0.169 (0.228)	0.399 (0.453)	0.648 (0.376)	0.320 (0.244)	0.478 (0.555)	0.395 (0.381)
Infants & Toddlers	0.246** (0.0821)	0.134 (0.0849)	0.0769 (0.0931)	0.565** (0.172)	-0.131 (0.192)	1.422*** (0.0882)	-0.699* (0.306)	-0.653*** (0.176)
Foster Care	0.355 (0.204)	-0.0476 (0.207)	-0.372 (0.245)	0.0613 (0.399)	0.346 (0.376)	0.369 (0.258)	0.278 (0.754)	0.013 (0.440)
Maternal Educ.: 12 Years (reference: < 12 Years)	-0.442*** (0.0688)	-0.397*** (0.0689)	-0.422*** (0.0754)	-0.542** (0.169)	-0.334* (0.150)	0.193* (0.0918)	0.136 (0.240)	0.231 (0.129)
Maternal Educ.: 13-15 Ye	-0.680*** (0.109)	-0.701*** (0.109)	-0.722*** (0.122)	-0.727* (0.288)	-1.061*** (0.291)	0.225 (0.131)	0.679* (0.294)	0.818*** (0.162)
Maternal Educ.: 16+ Year	-1.507*** (0.172)	-1.521*** (0.174)	-1.304*** (0.187)	-0.545 (0.362)	-1.751*** (0.507)	-0.0633 (0.165)	1.635*** (0.272)	1.660*** (0.176)
Birthweight (std.)	-0.0997* (0.0457)	-0.102* (0.0453)	-0.0504 (0.0493)	-0.131 (0.109)	-0.0864 (0.107)	0.0632 (0.0538)	-0.0426 (0.114)	0.152* (0.0716)
Teen Birth (< 20 years old)	0.401*** (0.0783)	0.298*** (0.0787)	0.142 (0.0866)	0.227 (0.192)	0.0201 (0.177)	-0.111 (0.106)	-0.108 (0.264)	-0.0212 (0.143)
Preterm Birth (< 37 week)	-0.0339 (0.118)	0.0521 (0.118)	0.122 (0.128)	-0.155 (0.249)	-0.0596 (0.268)	0.0252 (0.143)	-0.703 (0.408)	0.0214 (0.189)
Low Birthweight (< 2500g)	-0.0686 (0.135)	-0.238 (0.136)	-0.191 (0.149)	0.0847 (0.299)	0.0191 (0.284)	0.117 (0.163)	-0.111 (0.435)	0.0244 (0.220)
Parity	0.0820*** (0.0227)	0.0615** (0.0229)	0.0190 (0.0256)	0.147*** (0.0424)	0.0615 (0.0437)	0.0501 (0.0268)	-0.102 (0.0670)	-0.127** (0.0440)
Financial Assistance	0.371*** (0.0916)	0.292** (0.0920)	0.296** (0.101)	0.317 (0.239)	0.297 (0.231)	0.140 (0.106)	-0.256 (0.192)	-0.298* (0.121)
Married at Birth	-0.272* (0.108)	-0.331** (0.109)	-0.233 (0.120)	-0.248 (0.301)	-0.112 (0.236)	0.106 (0.119)	0.600** (0.201)	0.340* (0.144)
White, Asian, Hispanic, or	-0.478*** (0.0959)	-0.546*** (0.0961)	-0.642*** (0.111)	0.347 (0.207)	-0.382 (0.217)	0.131 (0.108)	0.944*** (0.177)	0.770*** (0.124)
Father's Name on Birth C.	-0.137* (0.0645)	-0.186** (0.0648)	-0.115 (0.0710)	-0.192 (0.161)	0.0916 (0.142)	-0.0829 (0.0843)	0.260 (0.206)	0.0156 (0.113)
Constant	-0.603*** (0.130)	-0.317* (0.130)	-1.074*** (0.143)	-2.950*** (0.336)	-2.910*** (0.303)	-2.155*** (0.160)	-3.418*** (0.359)	-1.996*** (0.207)
N	6,065	6,065	6,065	6,065	6,065	5,309	3,788	3,632

Notes: Coefficients in log-odds (logit) scale; Robust standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 8: Mathematics Scale Scores at the Beginning and Middle of Third Grade

	i-Ready Math: Beginning of Gr. 3	i-Ready Math: Middle of Gr. 3	i-Ready Reading: Beginning of Gr. 3	i-Ready Reading: Middle of Gr. 3
Early Education Experience (reference: neither program)				
Head Start Age 3 Only	-2.119 (2.690)	-2.072 (2.855)	-1.025 (5.038)	0.0825 (5.047)
Head Start Age 4 Only	0.710 (2.878)	-0.683 (3.100)	-4.487 (5.786)	-9.724 (5.220)
Head Start Age 3 & 4	3.327* (1.594)	4.434** (1.697)	-1.178 (3.093)	-1.179 (3.293)
Pre-K Only	1.013 (1.095)	2.254 (1.154)	-2.220 (2.096)	-3.497 (2.221)
Head Start & Pre-K	5.590*** (1.392)	5.159*** (1.486)	2.175 (2.693)	0.143 (2.811)
Home Visiting	-5.988*** (1.789)	-4.420* (1.843)	-7.213* (3.457)	-5.568 (3.849)
Early Head Start	-1.994 (3.504)	-1.330 (3.789)	0.0935 (6.557)	0.329 (7.278)
Infants & Toddlers	-10.71*** (1.270)	-8.444*** (1.336)	-20.02*** (2.458)	-17.74*** (2.545)
Foster Care	3.036 (3.044)	2.358 (3.021)	3.463 (5.548)	-3.977 (6.392)
Maternal Educ.: 12 Years (reference: < 12 Years)	4.640*** (0.981)	4.276*** (1.053)	9.881*** (1.918)	8.595*** (1.994)
Maternal Educ.: 13-15 Years	10.48*** (1.444)	10.83*** (1.517)	21.12*** (2.691)	20.32*** (2.847)
Maternal Educ.: 16+ Years	22.29*** (1.757)	20.94*** (1.899)	42.60*** (3.529)	38.85*** (3.584)
Birthweight (std.)	1.480* (0.597)	2.102** (0.651)	0.763 (1.173)	0.967 (1.240)
Teen Birth (< 20 years old)	0.913 (1.093)	1.389 (1.167)	2.343 (2.146)	1.529 (2.223)
Preterm Birth (< 37 weeks)	2.977 (1.567)	2.047 (1.716)	2.831 (3.077)	2.514 (3.283)
Low Birthweight (< 2500g)	-3.290 (1.860)	-0.516 (2.010)	-4.312 (3.563)	-1.661 (3.856)
Parity	-1.168*** (0.324)	-1.611*** (0.357)	-2.489*** (0.623)	-2.972*** (0.670)
Financial Assistance	-3.973*** (1.114)	-5.099*** (1.185)	-10.43*** (2.206)	-12.48*** (2.326)
Married at Birth	4.771*** (1.385)	4.252** (1.513)	9.663*** (2.685)	10.97*** (2.715)
White, Asian, Hispanic, or Other	6.865*** (1.260)	6.625*** (1.343)	11.85*** (2.424)	12.82*** (2.473)
Father's Name on Birth Certificate	0.986 (0.896)	0.666 (0.951)	2.454 (1.722)	3.021 (1.826)
Constant	403.2*** (1.783)	417.2*** (1.903)	465.8*** (3.475)	484.3*** (3.659)
N	3,788	3,632	3,380	3,249

Notes: Robust standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001.

Figures

Figure 1: Cohort 1 Data Sources at Stages of Child’s Life

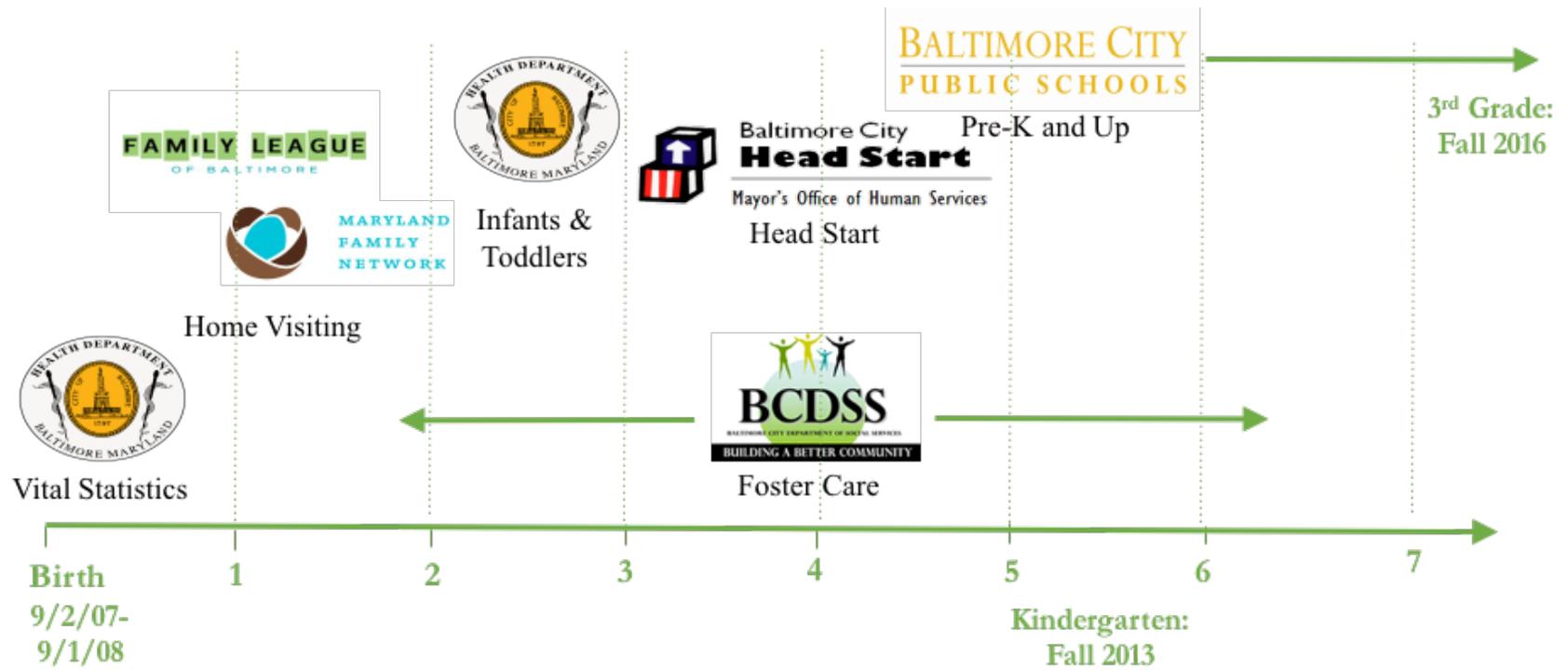


Figure 2: Proportion of Children Born in Each Baltimore Census Tract who were Matched to Agency Records

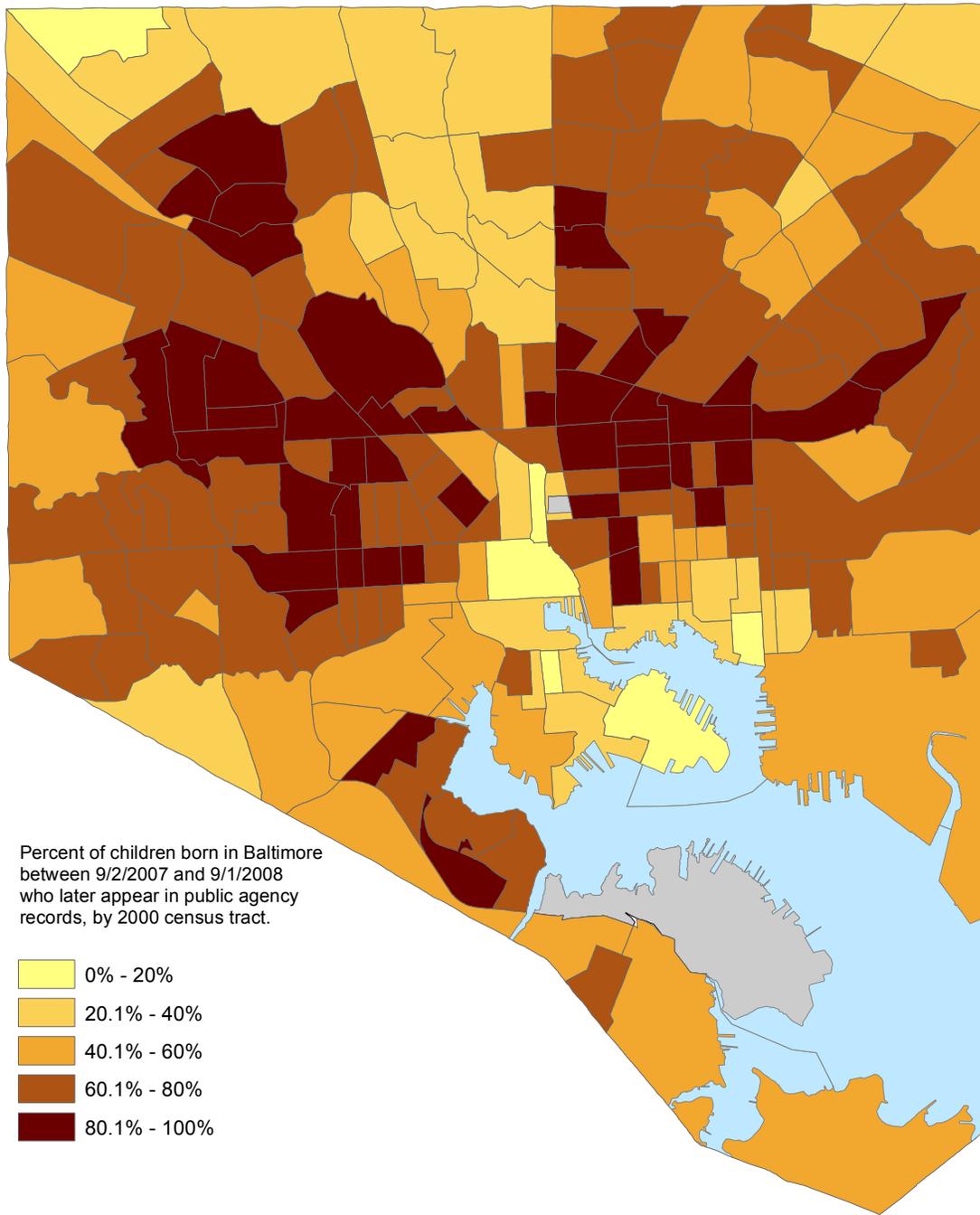
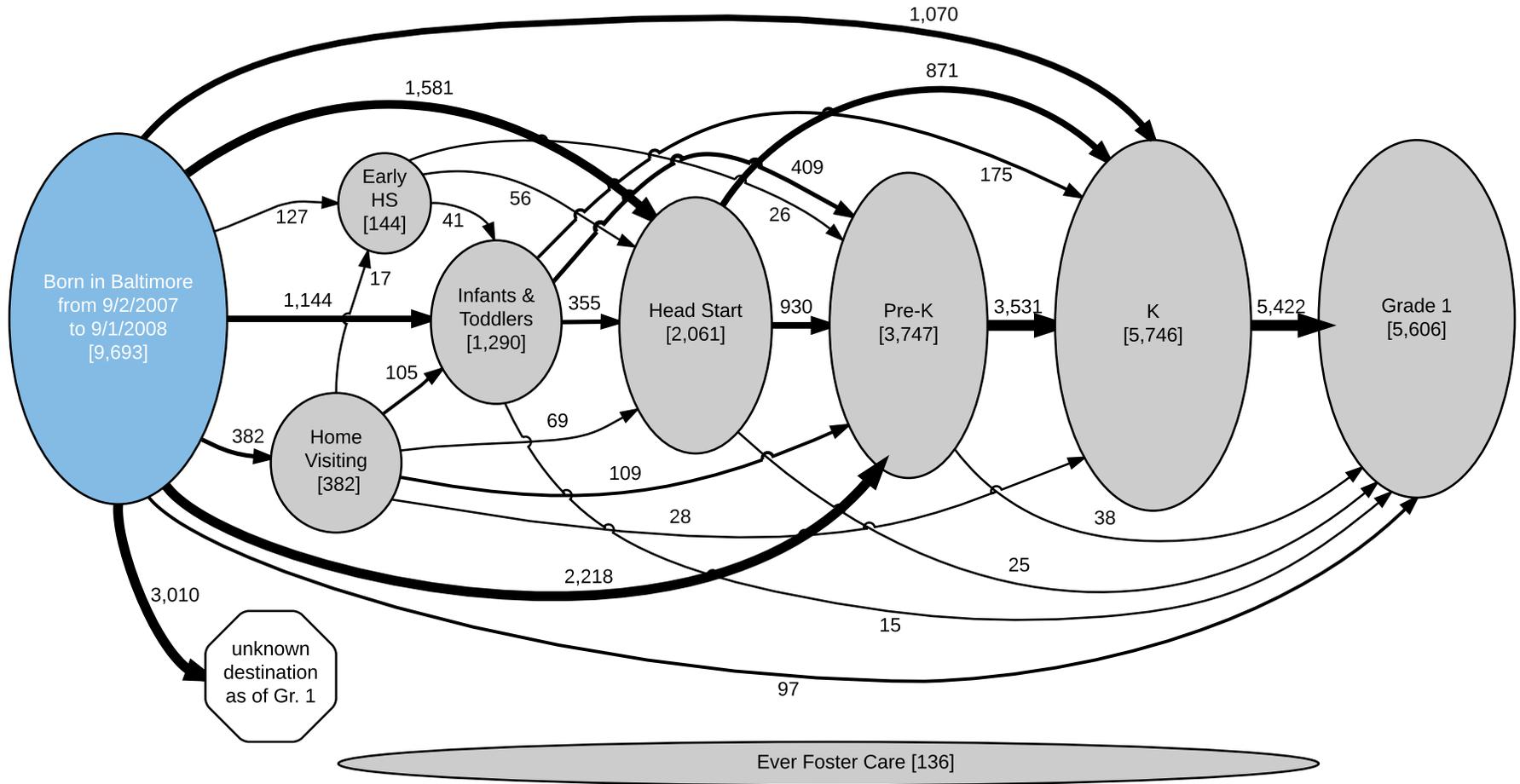


Figure 3: Pathways Followed from Birth to Schooling (>=25)



Note: Pathways with fewer than 25 children suppressed.

Figure 4: Pathways Estimated

