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Preparing Students for Success: Differential Outcomes by Preschool Experience in Baltimore City, Maryland

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Abstract

An early adopter of public preschool (i.e., pre-kindergarten, “pre-k”), evidence from Baltimore City, Maryland can provide insight for those working to improve access to early education opportunities. We followed a cohort of children entering kindergarten in Baltimore City Public Schools during the 2007-2008 year through the 2010-2011 academic year. Students were grouped by pre-k experience: public pre-k (n = 2828), Head Start (n = 839), Head Start plus public pre-k (n = 247), private pre-k (n = 993), or informal care (n = 975). After adjusting for individual- and school-level characteristics, students from the Head Start plus public pre-k group were the most likely to enter kindergarten with the foundational skills and behaviors needed to be successful (vs. all groups, $P \leq .001$). Students in informal care were the least likely to enter kindergarten with this skillset (vs. all pre-k groups $P \leq .001$). Children from informal care were also significantly more likely than all other groups to be chronically absent in kindergarten ($P \leq .001$). By third grade, children from informal care were least likely to be reading on grade level and most likely to have been retained a grade (vs. all pre-k groups $P \leq .001$). Children from disadvantaged populations who were not enrolled in pre-k faced significant difficulties keeping up with their peers throughout elementary school; interventions to improve their transition to school and increase their likelihood of academic success are warranted. Universal preschool is likely to improve education outcomes for children in urban areas.

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Compliance with Ethical Standards

This research qualified as exempt from human subject review according Johns Hopkins University Institutional Review Board, per exemption category 4 of Code of Federal Regulations, Title 45 Part 46. This research used only pre-existing administrative data that were de-identified prior to the investigators receipt.

Informed Consent

The research did not require informed consent.

Conflicts of Interest

The authors declare that they have no conflict of interest.

Keywords

vulnerable populations; preschool; academic achievement; inequality

The transition from early childhood, where the child interacts most with their family, to middle childhood, where the child's environment shifts to include the school setting, has been identified as a key time period during child development and socialization (Black et al., 2017; Ialongo, Kellam, & Poduska, 2000; LeBoeuf et al., 2017). At this point, the child spends substantially less time interacting with the family unit and is now expected to engage in a structured learning environment and create new social networks (Di Folco, Messina, Zavattini, & Psouni, 2017). Children who are not adequately prepared can struggle with this major life transition and, as a result, may have difficulties keeping up with their classmates throughout elementary school and beyond. In addition to optimal cognition, preparation for a successful transition includes both setting-appropriate behavior and attendance, elements that are likely to be affected more by parents than children (Maccoby, 1984; McDermott, Rikoon, & Fantuzzo, 2016).

Children, who receive early education interventions, including Head Start and preschool (i.e., pre-kindergarten, "pre-k") programs, are more likely to be successful in kindergarten and throughout elementary schools (Barnett, 2010; Magnuson & Shager, 2010; Yoshikawa et al., 2013). Specifically, pre-k is associated with higher levels of academic and social readiness upon entry in kindergarten and a lower likelihood of retention in their first year of school (Ansari & Winsler, 2016; Coley, Votruba-Drzal, Collins, & Miller, 2016; Yoshikawa et al., 2013; Zhai, Waldfogel, & Brooks-Gunn, 2013; Phillips et al., 2017). Once they enter elementary school, students who attended pre-k show more cognitive growth (Ready, 2010), perform better on standardized tests (Yoshikawa et al., 2013), and have better health outcomes (i.e., childhood obesity, mental health, and social competence) in elementary school (D'Onise, Lynch, Sawyer, & McDermott, 2010). Other studies provide evidence for much longer-term effects including reduced likelihood of juvenile delinquency, increased likelihood of high school graduation and college attendance, and higher income among other effects that continue into adulthood (Reynolds, Temple, Robertson, & Mann, 2001; Yoshikawa et al., 2013).

Though early education has important implications for outcomes across the life span, children in the United States from the most disadvantaged families are less likely to attend pre-k (Barnett, 2010; Barnett & Yarosz, 2004; Ready, 2010). Low-income families must deal with multiple life challenges, such as unemployment, home instability (Gasper, DeLuca, & Estacion, 2010; Schafft, 2006), food insecurity (Basch, 2011), and issues with health and health care access (Moonie, Sterling, Figgs, & Castro, 2008), while also facing structural obstacles, such as geographic restraints and limited seats for enrollment, that can restrict their access to pre-k (Coley, Votruba-Drzal, Collins, & Miller, 2014; Crosnoe, Purtell, Davis-Kean, Ansari, & Benner, 2016). Even when public pre-k is freely available, these barriers can still prevent children from being enrolled. Children from low-income households also have higher rates of absenteeism in kindergarten and have fewer resources available to help them make up for lost instruction. While children from disadvantaged populations are least

likely to attend preschool, evidence suggests they make the greatest gains in reading and math skills by attending preschool (Magnuson & Shager, 2010; Magnuson, Meyers, Ruhm, & Waldfogel, 2004; Magnuson, Ruhm, & Waldfogel, 2007; Ready, 2010; Yoshikawa et al., 2013).

Academic achievement is strongly affected by success in early education (D'Onise et al., 2010; Yoshikawa et al., 2013) while academic success is a leading determinant of health outcomes across the lifespan (D'Onise et al., 2010; Marmot, 2005; Yoshikawa et al., 2013). Increasing access to pre-k is a priority for low-income populations to improve both academic and health outcomes across the lifespan (Barnett, 2010; Heckman, Grunewald, & Reynolds, 2006; Marmot et al., 2008; Yoshikawa et al., 2013). Understanding the potential impacts of expanding access to early education opportunities, Trust for America's Health recommends high-quality universal pre-k programs to support the connections between learning and health (Trust for America's Health, 2019). Furthermore, the World Health Organization supports universal access to preschool globally as one of the leading solutions for reducing health inequities and improving population heath (Dahlgren & Whitehead, 2006; Solar, 2010).

In light of the evidence supporting the importance of transitional period on academic outcomes throughout primary and secondary education, investments in early childhood education have increased in the United States in recent decades (Magnuson & Shager, 2010; White House, 2015). While pre-k is not universal in the US, the Federal Head Start program and locally funded (state or city) public preschool are two major efforts to expand access. Alongside other early childhood initiatives, the federal government has supported efforts to expand access to early education through the "Preschool for All" initiative (White House, 2015). However, in the absence of public policy requiring pre-k enrollment, there are likely to be inequities in pre-k enrollment, even in the case of free and publicly available pre-k programming (Coley et al., 2014; Crosnoe et al., 2016).

The State of Maryland was an early proponent of pre-k expansion through the 2002 Bridge to Excellence Act. In Baltimore City, public pre-k expansion has been a priority for over a decade (Connolly & Olson, 2012). Baltimore City Public Schools serves a large population of students predominantly coming from impoverished backgrounds; local efforts to support the expansion pre-k were initiated in 2006. This urban center is a natural setting in which we can observe the association between enrollment in early education, school readiness, and elementary school success among a predominately low-income population of children. Using administrative data from Baltimore City Public Schools (BCPS) and Head Start, we follow a cohort of children from pre-k (2006-07) through 3rd grade (2010-11). While observational study designs have significant limitations for establishing causality, the current study provides policy makers with an opportunity to see how non-compulsory, but widely available, public pre-k is associated with the foundational skills and behaviors that prepare students for success upon entry to elementary school. Further, we can observe how children who do not enroll in pre-k in this context fare in comparison to those who did receive pre-k education.

Evidence from this study may also inform early education interventionists about pathways by which various pre-k programs influence early education outcomes. In a nationally representative sample of low-income children, children from private pre-k outperformed their counterparts from public pre-k, Head Start, and informal care on some (i.e., mathematics and reading) but not all (i.e., externalizing behavior and prosocial skills) indicators when they were transitioning to kindergarten (Coley et al., 2016). In contrast, a study limited to Miami, Florida found low-income children who attended public pre-k performed better than their peers in private pre-k on kindergarten readiness across domains (Ansari & Winsler, 2016). In conjunction with previous research, this study can offer insights for improving current efforts and standardized approaches for preparing children to thrive in the student role in an urban setting in the US (Ansari & Winsler, 2016; Coley et al., 2016; Magnuson & Shager, 2010; Yoshikawa et al., 2013; Zhai et al., 2013). Through the evaluation of several domains, we aim to identify specific areas where children from different programs vary in their skillset upon entry to kindergarten and their academic success in elementary school.

Materials and Methods

Setting and Study Population

Baltimore City has a population of approximate 615,000, of which 20.9% are children under the age of 18; nearly one third of the children in the city come from households with income below the federal poverty level (2016 American Community Survey 1-year estimates, 2017). Head Start provides pre-k and other child development support services for (1) families with incomes below the federal poverty line and (2) children with disabilities. At the time children in this cohort were eligible for pre-k, BCPS used a priority system for enrollment with public pre-k spaces going to children who “qualify for the free and reduced-price meals program *or* are homeless *or* receive special education services.” To qualify for Free and Reduced Priced Meals (FARM), children must come from family incomes ≤ 185% of federal poverty level; if pre-k slots remained near the beginning of the school year, enrollment in public pre-k was opened to the rest of the children in the city. The other option for pre-k in the city was private nursery school and daycare. Another group of children did not attend any public pre-k, Head Start, or private pre-k and were supervised in their home or other informal care settings.

The cohort was defined as children entering kindergarten for the first time in BCPS in the 2007-2008 academic year. In 2007, 78.0% of children in elementary school at BCPS were eligible for FARM. Students were classified according to their enrollment in pre-k: BCPS public pre-k (n = 2,828), Head Start (n = 839), Head Start and public pre-k (n = 247), private pre-k (i.e., nursery school or daycare; n = 993), and informal care (i.e., did not attend a formal pre-k program; n = 975). Children with missing data on pre-k experiences were excluded (7.7% of all children, n = 492). Among children who attended the public pre-k program, 20.3% (n=574) were neither enrolled in special education nor receiving FARM; meanwhile, 79.8% of children (n=778) in informal care met these criteria for priority enrollment. Despite outreach to enroll students in public pre-k, these data suggest a significant number of eligible children were not enrolled in public pre-k at the beginning of

the year when the remaining open seats were given to students who did not meet priority criteria. The cohort of students was followed through the 3rd grade (2006-2007 through 2010-2011). All data included in this study were collected through standard BCPS administrative procedures and no additional data were collected for this study.

Measures

Student characteristics.—For each year of enrollment, BCPS provided student sociodemographic data for race and ethnicity, age, sex, eligibility for FARM (Department of Agriculture, 2006), receipt of special education services, English language proficiency, and school attended.

School-level characteristics.—School-level data for the entire student population (i.e., not just the students included in the study cohort), were obtained from the Maryland State Department of Education public website for each academic year in the current study ("Maryland report Card," 2016). School-level data for race (85.8% African American), ethnicity (4.2% Hispanic), and FARM status (78.7%) were available for all elementary schools in the district (n = 5882).

Foundational skills and behaviors at kindergarten entry.—Students entering kindergarten in BCPS were assessed in the fall of 2007 using the Maryland Model for School Readiness (MMSR), a 30-indicator observational assessment completed by teachers and based on a modified version of the Work Sampling System (2013; Meisels, Marsden, Jablon, & Dichtelmiller, 2015). Teachers were provided with guidelines for rating children on each of the MMSR indicators and received specialized training on student assessment. Annually, those administering the MMSR are required to participate in a professional development program where they work to hone their evaluation skills specific to the MMSR and improve the validity of their evaluation through case studies and individualized feedback from trained assessment professionals (Maryland Department of Education, 2013).

Student readiness is indicated “if the child demonstrates the foundational skills and behaviors that prepare him/her for curriculum based on the kindergarten standards” (Maryland State Department of Education, 2018). Seven domains were incorporated into the overall measure of kindergarten readiness: personal and social development (e.g., interpersonal relations, shows self-control), language and literacy (e.g., conveys ideas clearly, phonetic awareness), mathematical thinking (e.g., number and shape recognition), scientific thinking (e.g., seeks out information through observation and exploration), social studies (e.g., describe peoples living patterns, awareness of different types of work), the arts (e.g., engages in creative opportunities), and physical development (e.g., coordination, able to perform self-care tasks) (Maryland Department of Education, 2013). The composite measure derived from this assessment is a kindergarten readiness indicator for overall proficiency (Maryland Department of Education, 2013).

Previous research on the reliability of the MMSR found internal consistency to be very high and each domain score was strongly correlated with the overall kindergarten readiness indicators (Maryland Department of Education, 2013). Evidence for reliability in the current study sample was very similar in strength. The internal consistency of the 30-item measure

was very high (Cronbach's $\alpha = 0.97$) as were the domain specific measures. Consistency within domains ranged from: high (social studies domain $\alpha = 0.87$) to very high (the arts domain $\alpha = 0.94$). In line with previous research in the school district, we collapsed the domain specific scores as well as the overall kindergarten readiness measure into dichotomous indicators: kindergarten ready and not kindergarten ready (combined "approaching readiness" and "developing readiness") (Connolly & Olson, 2012).

Another element of school preparedness is consistence attendance, which we measured using an indicator for chronic absenteeism. Local policies define chronic absenteeism as missing more than one-ninth (selected as 20 days absent of 180 school days) of their days enrolled. Attendance data were available for all students in the cohort.

3rd grade outcomes.—Students in Grade 3 take the Maryland School Assessment for reading, math, and science. We limited our analyses to reading and math to allow for comparison across elementary school in these subjects. Student performance is assessed on a continuous scale and then summarized using proficiency ratings of basic, proficient, and advanced. Scoring "proficient" (or "advanced") is used to indicate mastery of the grade curriculum, while "basic" indicates that the student needs additional work to perform at grade level. Categorical scores were determined using a benchmark standard setting procedure used by the Maryland State Department of Education. As a cumulative measure of grade retention between kindergarten and 2nd grade, we included off-time status by the 2010-2011 academic year, during which matriculating with their cohort would have been expected to be in 3rd grade. Those who were off-time had been retained in one or more grades during the observation period.

Missing data.—Administrative records for all students in the cohort included data on sex, race, ethnicity, limited English proficiency, attendance, off-time status, and eligibility free and reduced price meals. Less than 0.5% of students were missing data on their age. Sufficient evidence for calculating the composite kindergarten readiness score was not available for 3.8% of students. Less than 5% of students were missing data for standardized testing in third grade (reading 3.9%, math 4.0%) and off-time status was available for all students. Missing data were associated with sociodemographic characteristics (i.e., FARM, race/ethnicity, sex) and therefore met criteria for "missing at random" (vs. missing completely at random, Rubin, 1987). To maximize statistical power and minimize bias in the analysis, we imputed missing data. Evidence suggests this option is preferred over list-wise deletion (i.e., complete case analysis) for more precise results when data are missing at random (Rubin, 1987; Allison, 2002). With Stata version 12, we generated 20 data sets using the imputation by chained equation method. The data were analyzed to produce averages for the parameters and standard errors used to impute missing data.

Unadjusted statistics were used to describe variation in demographic characteristics and study outcomes for the cohort according to pre-k experience. Linear and logistic two-level mixed-effects regression models were used to examine differences in preparation for success and 3rd grade outcomes. Level-one variance is attributable to individuals; level-two is modeled at the school-level. To assess clustering of standardized testing at the school level, we calculated intraclass correlations for 3rd grade standardized testing. School-wide means

for proficiency in 3rd grade test scores were statistically significant and included with sociodemographic characteristics (% receiving FARM, % African American, and % Hispanic) to adjust for contextual effects. All level-two covariates were centered at the grand mean.

Since African American students comprised the vast majority of the students at BCPS, we presented probability estimates for this population group while adjusting for sociodemographic characteristics at the individual and school-level. Between group comparisons for all outcomes were assessed through replication of the model with each pre-k group used as the reference group.

Study population.—A substantial majority (82.8%) of the cohort remained in BCPS for the entire four-year period of observation. Each year, there were small, but statistically significant differences between groups in the percent of the cohort who exited the study. Differences between groups culminated in a seven percentage point difference between the proportion of Head Start (86.2%) and private pre-k (78.6%) students who remained in year 4. Of those remaining in the cohort until the end of the study, 85.2% had matriculated to third grade on time.

We further explored variation in the likelihood of remaining in BCPS through the end of the study by population subgroups. African American children were significantly more likely than all other racial and ethnic groups to remain in the cohort through the entire follow up period: African American 83.1%, White non-Hispanic 69.5%, Hispanic 77.9%, other groups (i.e., American Indian, Asian, and Pacific Islander) 66.3%. Students receiving free and reduced priced meals (FARMs) in kindergarten were more likely to remain in BCPS through 3rd grade compared with students not receiving FARM (85.2% vs. 79.5%, respectively $P \leq .05$). Compared to their peers, students entering kindergarten with limited English proficiency were more likely to remain in BCPS through follow up (93.1% vs. 83.8%, respectively $P \leq .05$).

Results

Population Characteristics and Outcomes

Characteristics of the 2007-08 kindergarten population are presented in Table 1 according to pre-k experiences (i.e., informal care, public pre-k, Head Start, public pre-k and Head Start combination, and private pre-k). The average age at entry to kindergarten was 5.5 years (*SD* = 0.3) for all groups. There were statistically significant differences by race/ethnicity: the public pre-k and Head Start combination group (94.3% non-Hispanic African American) was the least diverse group and the private pre-k group (79.1% non-Hispanic African American) was the most diverse group.

More than 80% of children from the public pre-k, Head Start, and informal care groups received FARM in kindergarten, a greater proportion than in the private pre-k group (62.3%, ANOVA $P \leq .05$). Differences in special education status were notable across groups, with proportions ranging from 5.0% of students from private pre-k and 14.6% of the public pre-k and Head Start combination group (ANOVA $P \leq .001$). Only 3.9% of students entering

kindergarten were identified as having limited English proficiency (ranging from Head Start public pre-k and Head Start combination 0.4% - Head Start 5.4%, ANOVA $P \leq .01$).

Primary study outcomes are also presented in Table 1 according to pre-k experiences with statistically significant between group differences for all outcomes (ANOVA $P \leq .001$). For the cohort, 57.3% of students were prepared for kindergarten according to the composite measure of foundational skills and behaviors ("K ready"); however, across groups this outcome ranges from 39.0% for children from informal care to 67.0% for children who attended both Head Start and public pre-k. By the final year of observation, students from informal care were the most likely to be off time (26.8%) while students from private pre-k were least likely (9.2%). Across groups, 14.8% of students were off time by 3rd grade. Of the students matriculating to third grade on time, 72.1% were reading on grade level. The proportion of students reading on grade level in 3rd grade ranged from 66.9% for students from informal care to 76.5% for students from private pre-k. In math, the proportion of students scoring within the expected range for their grade level ranged from 70.%% for the informal care group to 81.0% for private pre-k group (ANOVA $P \leq .001$).

Multi-level Regression Models

In Table 2, odds ratios in Table 2 were derived with informal care as the comparison group. Other between group comparisons are described in text only.

All comparisons between pre-k groups and informal care were statistically significant in this analysis ($P \leq 0.001$). As shown in Table 2, students from all pre-k groups were between 2.31 (private pre-k) and 4.13 (public pre-k and Head Start combination) times as likely to have the foundational skills and behaviors, including consistent attendance, to prepare them for success in elementary school at entry to kindergarten (compositive measure, all $P \leq 0.001$). For the seven subdomains, the largest differences between pre-k groups and informal care were for language and literacy and mathematical thinking domains where students from the public pre-k and Head Start combination group were more than five times as likely to have the skills than those from informal care.

The highest proportion of students identified as "K ready" on the composite measure were from the the public pre-k and Head Start combination group (vs. each group $P \leq .001$). This group performed significantly better than the other pre-k groups on nearly all of the subdomains; the only exceptions were for the math and arts domains for which the difference between the combinaiton group and public pre-k were not significant. Following the combination group, public pre-k students performed signifcantly better than Head Start and private pre-k students on the composite score and several domains: personal and social development, language and literacy, mathematical thinking, scientific thinking, social studies and the arts. Students form Head Start outperformed students from private pre-k on the personal and social development, mathematical thinking, while students from private pre-k did better than Head Start students on scientific thinking, social studies, and physical development. Head Start and private pre-k students performed similarly on the composite readiness measure as well as the subdomains language and literacy and art ($P > 0.05$). Between pre-k group differences on chronic absenteeism were significant between the public

pre-k group and all other groups. Other between pre-k groups differences on chronic absenteeism were not statistically significant.

For third grade reading, students from all pre-k groups were more likely to perform on grade level than students from informal care (OR range 2.11-3.05, $P \leq 0.001$, Table 2). For third grade math, three pre-k groups were more likely to perform on grade level than the students from informal care: public pre-k, public pre-k and Head Start combination group, and private pre-k (OR range 1.64-2.01, $P \leq 0.001$). Between pre-k group differences on 3rd grade standardized tests varied by outcome. For reading, students from from Head Start and the combination group outperformed students from both private (both, $P \leq 0.001$) and public pre-k (both, $P \leq 0.01$). For math, all other pre-k groups outperformed students from Head Start ($P \leq 0.001$). Other between group differences on 3rd grade testing were not statistically significant.

Students in each of the pre-k groups were significantly less likely to be off time (i.e., had not matriculated to 3rd grade) by the end of the study than students from informal care (OR range 0.41-0.08, Table 2). All between pre-k group differences on the likelihood of being off time by the end of the study were statistically significant with students from the public pre-k and Head Start combination group least likely to be off-time.

Discussion

Consistent with previous research, this study provides evidence that pre-k programming is associated with improved kindergarten readiness, attendance, and elementary school success as indicated by standardized testing and on time grade completion (Heckman et al., 2006; Reynolds & Temple, 2008; Yoshikawa et al., 2013). The majority of children from informal care entered school with limited preparation for success and appeared to face challenges keeping pace with their peers in the current study. By the 3rd grade students in the informal care group were substantially more likely as children in any pre-k group to be retained for one or more academic years. Evidence from this study suggests children who do not enroll in pre-k, even when public pre-k is available, represent a particularly high need population that warrant intervention to improve their transition to the role of a student and subsequent success in school.

The current study provides insight on how enrollment may vary in the context of publicly available pre-k programs within a largely low-income and predominantly African American population. The majority of children entering kindergarten were eligible for FARM, but some differences in the proportion eligible between groups did emerge. Consistent with previous research (Barnett & Yarosz, 2004; Crosnoe et al., 2016), children in private pre-k programs were least likely to come from a FARM household and more likely to be White; however, the majority of the population from private pre-k was eligible for FARM and identified as African American. Variation between other groups in the proportion receiving FARM and the proportion that were African American was small in magnitude.

In the adjusted analysis, children who attended pre-k were more likely than children from informal care with the foundational skills and behaviors to prepare them for success in

elementary school. The seven domains of kindergarten readiness measured in this study are consistent with previous evidence that children from informal care lag behind their peers across all domains (Ansari & Winsler, 2016; Coley et al., 2016; Heckman et al., 2006; Lipsey et al., 2018; Magnuson et al., 2007; Yoshikawa et al., 2013). Differences in chronic absenteeism in kindergarten were significant in the current study, adding evidence for an additional measure of the foundational skills and behaviors to successfully transition to elementary school to the literature on the value added for pre-k attendees.

In the between pre-k group analysis, differences in foundational skills and behaviors were notable. Most strikingly, the students who attended both public pre-k and Head Start were the highest performers on most of the assessments of foundational skills and behaviors including the overall composite measure and six of the seven subdomains; they were also the least likely to have been retained a grade during the observation period. Children from public pre-k were more likely than students from both private pre-k and Head Start to be kindergarten ready overall and across all domains with a single exception for the physical development domain (private pre-k > public pre-k). In another study with restricted geography (Miami), children from public pre-k were more likely to be kindergarten ready than children from private pre-k (Ansari & Winsler, 2016). These patterns conflict with evidence from a nationally-based sample of low-income populations which found a greater likelihood of kindergarten readiness among students who had attended private pre-k when compared to those from public pre-k (Coley et al., 2016). It is possible that programming in public pre-k was more homogenous and/or superior in studies with restricted geography compared to that of the nationally representative study, both potential explanations for the difference in findings between these studies (Ansari & Winsler, 2016; Coley et al., 2016).

Differences in standardized testing between children who do not attend pre-k were replicated in the current observational study (Ansari et al., 2016; Markovitz et al., 2015; Reynolds & Temple, 2008). Between pre-k group differences on standardized testing were inconsistent.

In the adjusted analysis, students from Head Start and the Head Start and public pre-combination group performed better on 3rd grade reading than those from private pre-k and public pre-k alone. In contrast, for math the Head Start group was less likely to be on grade level than all other pre-k groups. Students from all pre-k groups were more likely than those from informal care to be reading on grade level and less likely to be off time by 3rd grade. This conflicts with other research showing a diminished difference between pre-k and informal care groups by 3rd grade (Lipsey et al., 2018). Similar to differences between studies in the foundational skills and behaviors assessed in kindergarten, a potential explanation for differences between studies on third grade outcomes is variation in the homogeny and effectiveness of various pre-k programs when assessed across a larger geography in state versus citywide evaluations (Lipsey et al. 2018).

Interpretation of differences in outcomes by pre-k program in the current study requires consideration of the nonrandom assignments into a pre-k program and other factors known to affect pre-k program selection. Despite eligibility for priority enrollment, a substantial number of families did not enroll their children in public pre-k. In addition to the variables included in this study, there were many are other important differences between groups that

affected whether or not children enrolled in early education opportunities including parental education and employment (Crosnoe et al., 2016). Other studies have illustrated the importance of other factors (teachers, home environment, parent education, etc.) that can influence students' academic success and long-term effects of pre-k programs (Barnett, 2011; Lipsey et al., 2018). Further research is needed to determine how to best reach and enroll eligible populations in the free early education opportunities available in Baltimore City and other urban school districts across the country.

Our analysis was limited by a lack of data on elements and quality of instruction used in different pre-k settings. While we did not have evidence on the quality of private pre-k or the information of the various experiences of children in informal care, we do know that an assessment of the state-level requirements for public pre-k found Maryland programs met most of the criteria (7 of 10) for quality pre-k programming (Barnett et al., 2006) including teacher education requirements, small class sizes and staff teacher ratios, comprehensive early learning standards, and health screening services. Previous research presents Maryland's public pre-k as an exemplar of high quality education (Bartik & Hershbein, 2018; Minervino, 2014); in contrast, the state's Head Start program was identified as below average quality (Barnett & Friedman-Krauss, 2016). Evidence from this study supporting Head Start programming in combination with public pre-k is an important contribution to the literature; however, the exact circumstances of how the children receive both programs (i.e., two years of pre-k programming, early Head Start versus Head Start, or concurrent enrollment in two years of programming) is a limitation of the data.

The secondary data used in this study was of high quality with limited missing data. To limit biases and increase precision of results, we used multiple imputation. Though we attempted to control for sociodemographic characteristics in the current study, we were limited to the variables collected as part of standard administrative processes in public schools. A more specific measure of family income (e.g., < federal poverty level, between 100-200%, 200-300%, etc.) may have provided additional insight into variation among students from low-income households. To inform community engagement and collaborative outreach efforts across service sectors, future studies may benefit from incorporating data from other public service agencies such as child welfare and social services.

This study took place during the first phase of pre-k program expansion in Baltimore City (2006). Phases two and three of the expansion project brought in additional pre-k programs to the city. Efforts to increase the rate of enrollment among priority families have included both geographically focused efforts and collaboration with other public service programs working with the same population (e.g., Nurse Home Visiting). While enrollment has increased, a substantial number of students in the city continue to enter kindergarten without having attended pre-k (Maryland State Department of Education & Maryland Department of Planning, 2018). The Council of Chief State School Officers report mentions that "children at risk who do not participate in high-quality early education programs are 50% more likely to be placed in special education and 25% more likely to drop out of school", among other poor outcomes (e.g., be involved in crime or never attend college) (Stark & Stark, 2016).

Though targeting pre-k to the most vulnerable populations has been an effective approach, some scientists argue that a universal program would reach more children in need (Barnett, 2010; Lasser & Fite, 2011; LeBoeuf et al., 2017; Trust for America's Health, 2019). Indeed, there is evidence demonstrating that universal pre-k programs improve cognitive outcomes and academic knowledge (Trust for America's Health, 2019). Benefits of universal pre-k programs have been seen in various states (Phillips et al., 2017). In Minessota and Georgia pre-k programs, students from all backgrounds showed improvement across all domains (Markovitz, Hernandez, Hedberg, & Silberglitt, 2015; Schulte, Durana, 2016). In Oklahoma, student test scores improved and grade retention lowered (Gormley et al., 2018). Aside from academic benefits, universal pre-k programs can provide support to families with young children by alleviating some of the financial burden of childcare (Trust for America's Health, 2019). Unfortunately, limited resources have prevented expansion to a universal program across all states (Brown & Wright, 2011; LeBoeuf et al., 2017).

The current study supports the assertion that moving to universal pre-k could have important benefits by reaching an underserved population. Even with expanded availability of public pre-k, some children are still not enrolled (Connolly & Olson, 2012). Based on the results from this study, children coming from informal care represent a particularly vulnerable population with attendance and academic challenges upon entry and throughout elementary school. Increasing pre-k availability as well as community-based outreach to ensure that qualified families are aware, enroll, and attend regularly, could go far to close, or prevent, the achievement gap before children are in kindergarten (Barnett, 2010; Brotman et al., 2011; Lasser & Fite, 2011). To improve transition to school and academic outcomes, children who were not enrolled in pre-k (and their families) are likely to require additional resources when they arrive to kindergarten.

The World Health Organization highlights the improvement of academic outcomes in vulnerable populations as a fundamental element in the global charge to reduce health inequities (Marmot et al., 2008). An extensive body of research supports the effectiveness of pre-k for improving outcomes across the lifespan (Heckman et al., 2006; Gormley Jr, Phillips, & Anderson, 2018; Maryland State Department of Education & Maryland Department of Planning, 2018; Yoshikawa et al., 2013). While results may be generalizable to other urban settings in the US, this research should be replicated in rural areas, predominantly White or Hispanic populations, and districts with exemplar academic achievement. Expansion of pre-k seats is an important step to increasing access; however, ensuring pre-k reaches the populations most in need is a critical requirement to earn the greatest return on intervention efforts.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Kindergarten Study Population and Primary Study Outcomes

	Total n=5882	**Informal care n=975**	**Public Pre-K n=2828**	**Head Start n=839**	**Public Pre-K & Head Start n=247**	**Private Preschool n=993**	**ANOVA χ^2**
Age (mean, sd)	5.5 (0.3)	5.5 (0.4)	5.5 (0.3)	5.5 (0.3)	5.5 (0.3)	5.5 (0.3)	**
% male	50.4	51.7	49.6	52.4	51.8	49.2	ns
% FARM	78.7	81.9	80.4	86.1	87.6	62.3	***
% Special Education	9.2	8.7	9.7	11.6	14.6	5.0	***
Race & Ethnicity							
% African American	85.8	82.1	87.3	90.6	94.3	79.1	***
% White non-Hispanic	8.8	12.0	7.1	2.9	3.6	16.4	
% Hispanic (any race)	4.2	4.2	4.4	6.1	1.2	2.9	
% LEP	3.9	4.2	4.1	5.4	0.4	2.8	**
% Chronically absent (K)	17.6	28.5	15.5	15.7	17.0	14.4	***
	n=5657	n=975	n=2662	n=794	n=236	n=990	
% K ready - Composite	57.3	39.0	64.1	51.6	67.0	59.6	***
	n=3987	n=553	n=1981	n=587	n=176	n=690	
% Reading at 3rd grade level	72.1	66.9	72.7	70.0	70.5	76.5	**
	n=3989	n=552	n=1982	n=587	n=177	n=691	***
% Math at 3rd grade level	76.8	70.8	73.1	73.1	75.7	81.0	
	n=4871	n=788	n=2373	n=723	n=207	n=780	
% Grade retention (by 3rd)	14.8	26.8	12.4	16.5	11.1	9.2	***

ANOVA and χ^2 test

* P≤.05

** P≤.01

*** P≤.001

FARM Free and Reduced Meals, K Kindergarten, LEP Limited English Proficiency

Table 2

Multi-level regression models, preschool versus informal care

	Public Pre-K	Head Start	Public Pre-K & Head Start	Private Pre-K
Foundational Skills and Behaviors in Kindergarten	Odds ratio (95% CI)			
Composite K Readiness	3.46 (3.25-3.69) ***	2.39 (2.20-2.59) ***	4.13 (3.61-4.73) ***	2.31 (2.14-2.50) ***
Personal and Social Development	1.93 (1.81-2.05) ***	1.51 (1.39-1.64) ***	2.22 (1.95-2.53) ***	1.36 (1.26-1.47) ***
Language and Literacy	4.91 (4.58-5.26) ***	3.05 (2.79-3.33) ***	6.75 (5.91-7.70) ***	3.23 (2.97-3.51) ***
Mathematical Thinking	4.95 (4.63-5.29) ***	3.31 (3.04-3.61) ***	5.17 (4.51-5.92) ***	3.03 (2.79-3.29) ***
Scientific Thinking	2.89 (2.70-3.10) ***	1.46 (1.33-1.60) ***	3.93 (3.43-4.51) ***	1.85 (1.69-2.01) ***
Social Studies	3.07 (2.86-3.29) ***	1.62 (1.47-1.77) ***	3.65 (3.18-4.18) ***	2.18 (2.00-2.37) ***
The Arts	2.66 (2.50-2.84) ***	2.02 (1.86-2.20) ***	2.43 (2.12-2.79) ***	2.05 (1.90-2.22) ***
Physical Development	2.25 (2.11-2.40) ***	1.82 (1.67-1.98) ***	3.59 (3.10-4.17) ***	2.47 (2.28-2.68) ***
Chronic absenteeism	0.54 (0.51-0.58) ***	0.62 (0.58-0.68) ***	0.65 (0.57-0.74) ***	0.62 (0.57-0.67) ***
3rd Grade Outcomes	Odds ratio (95 % CI)			
Reading on grade level	2.11 (1.84-2.41) ***	3.05 (2.57-3.62) ***	2.99 (2.32-3.86) ***	2.02 (1.68-2.42) ***
Math on grade level	1.78 (1.55-2.06) ***	1.17 (0.98-1.40) ***	2.01 (1.56-2.59) ***	1.64 (1.35-1.99) ***
Off-time by endpoint	0.21 (0.20-0.25) ***	0.41(0.36-0.45) ***	0.08 (0.07-0.11) ***	0.27 (0.23-0.30) ***

*P≤.05

**P≤.01

***P≤.001

CI Confidence Interval, K kindergarten

All models adjusted for individual (race and ethnicity, age, sex, limited English proficiency, and eligibility for free and reduced meals) and school level characteristics (% African American, % Hispanic, % eligible for free and reduced meals, and school wide average on standardized test scores in 3rd grade).