MONTGOMERY
COUNTY PUBLIC
SCHOOLS

Evaluating Lasting Effects of Full-day Prekindergarten Program on School Readiness, Academic Performance, and Special Education Services

Office of Shared Accountability

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EXECUTIVE SUMMARY

The Office of Shared Accountability conducted a study to examine the lasting effects of full-day prekindergarten (pre-K) programs in Montgomery County Public Schools (MCPS). This report summarizes the major findings of the study and offers some recommendations.

The MCPS pre-K and Head Start programs include locally funded pre-K classes as well as locally and federally funded Head Start classes. These classes provide an early learning experience for mostly four-year-old children who meet Head Start and pre-K program income-eligibility guidelines. The pre-K and Head Start programs are integral parts of the MCPS *Early Success Reform* plan (MCPS, 2009a) designed to provide necessary supports for all students to achieve at their highest levels and address the pervasive achievement gaps among student groups.

In 2007–2008, MCPS offered its Title I schools the opportunity to expand their existing Head Start half-day classes into Head Start full-day classes. Ten elementary schools chose to participate and expanded their 13 Head Start half-day classes into full-day classes using Title I funding. Instructional time was extended as a strategy to close achievement gaps among socioeconomic and racial/ethnic groups. For a detailed description of the MCPS pre-K programs, see *Impact of Full-day Prekindergarten Program on Student Academic Performance (*Zhao, Modarresi & Liu, 2009*).*

This study examined whether the increased instructional time in full-day pre-K had a lasting effect on students' school readiness, academic performance, and required special education services in kindergarten after statistically controlling for differences in baseline academic performance, demographic characteristics, and family income. This study addressed the following questions:

1. How did students in the Head Start full-day pre-K program differ from their peers in the Head Start half-day pre-K program on school readiness at the beginning of kindergarten and on reading and mathematics performance by the end of kindergarten?
2. How did students in the Head Start full-day pre-K program differ from their peers in the MCPS half-day pre-K program on school readiness at the beginning of kindergarten and on reading and mathematics performance by the end of kindergarten?
3. How did students in the Head Start full-day pre-K program differ from their peers without the MCPS pre-K experience on reading and mathematics performance by the end of kindergarten?
4. What was the cost of MCPS special education services in 2008–2009? Did students who attended the Head Start full-day pre-K program in MCPS require significantly lower levels of special education services compared to their peers without MCPS pre-K experience?

Summary of Key Findings

The key findings are summarized below in the order of the evaluation questions. Overall, the additional instructional time in the Head Start full-day pre-K program seems to have had a positive lasting impact on students' reading skills by the end of kindergarten.

Students in the Head Start Full-day vs. Students in Head Start Half-day Pre-K Programs

- The two groups were similar in regard to school readiness at the beginning of kindergarten.
- Students in the Head Start full-day pre-K program were 44 percent more likely to meet reading benchmark Level 4 by the end of kindergarten than those in the Head Start half-day pre-K program.
- The larger Head Start full-day pre-K program effect favored African American and male students in the Head Start full-day pre-K program on meeting reading benchmark Level 4.
- The two groups performed at the same level in mathematics by the end of kindergarten.

Students in the Head Start Full-day vs. Students in MCPS Half-day Pre-K Programs

- Male students and students receiving English for Speakers of Other Languages (ESOL) services in Head Start full-day pre-K were significantly more likely to be fully ready for school than their peers in the MCPS half-day pre-K program at the beginning of kindergarten.
- Students in the Head Start full-day pre-K program were 53 percent more likely to meet reading benchmark Level 4 by the end of kindergarten.
- African American students were 94 percent more likely to meet kindergarten reading benchmark at Level 4. Female students were 68 percent more likely, and students receiving Free and Reduced-price Meals System (FARMS) services were 60 percent more likely to meet the kindergarten reading benchmark at Level 4.
- The two groups performed at the same level in mathematics by the end of kindergarten.

Students in Head Start Full-day Pre-K vs. Students without MCPS Pre-K Experiences

- Students in the Head Start full-day pre-K program were 42 percent more likely to meet reading benchmark Level 4 than their peers without MCPS pre-K experience by the end of kindergarten.
- African American students in the Head Start full-day pre-K program were 2.71 times as likely as their peers without MCPS pre-K experience to meet the kindergarten reading benchmark at Level 4.
- Female students and students receiving FARMS services in the Head Start full-day pre-K program were more likely (46 percent and 37 percent, respectively) than their peers to meet the kindergarten reading benchmark at Level 4.
- African American students in the Head Start full-day pre-K program were 55 percent more likely to meet reading benchmark Level 6 by the end of kindergarten.

- The two groups performed at the same level in mathematics by the end of kindergarten.

Special Education Cost and Services in Kindergarten

- In 2008–2009, the average annual cost for kindergarten students receiving special education services in MCPS was $16,230.00, not including services provided to all students such as transportation and general education services.
- The Head Start full-day pre-K students required half as many special education services per week as their peers without MCPS pre-K experience.

Recommendations

1. Examine factors related to mathematics instruction (such as scheduling, grouping, and materials) in pre-K and kindergarten classes in comparison with those employed for reading instruction.
2. Examine current models for ESOL services to determine how to best support the ESOL students.
3. Conduct a formative evaluation of the pre-K program using a multimethod data collection strategy that includes classroom observations, stakeholder surveys, and document analyses. The evaluation information will provide inductively derived success factors that may have contributed to the effectiveness of pre-K programs in improving students' reading skills and reducing required special education services.
4. Replicate the outcome study on a different student cohort to see if the observed findings are replicable. Also, evaluate the long-term impact of full-day pre-K Program in succeeding grades.

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Evaluating Lasting Effects of Full-day Prekindergarten Program on School Readiness, Academic Performance, and Special Education Services

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BACKGROUND
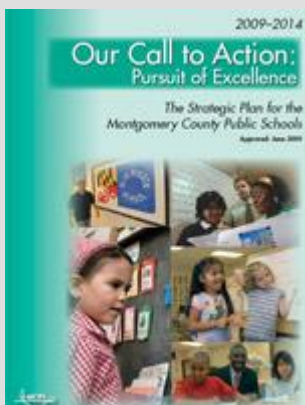
The Early Success Performance Plan focuses on closing the achievement gap and addresses Goal 2 of the MCPS strategic plan, *Our Call to Action: Pursuit of Excellence*—Provide an effective instructional program.

Montgomery County Public Schools (MCPS) prekindergarten (pre-K) and Head Start programs include locally funded pre-K classes and locally and federally funded Head Start classes. These classes provide an early learning experience for mostly four-year-old children who meet Head Start and pre-K program income-eligibility guidelines. The pre-K and Head Start programs are integral parts of the MCPS *Early Success Performance Plan,* designed to provide necessary supports for all students to achieve at their highest levels and address the pervasive achievement gaps among student groups.

There are three different types of pre-K classes—Head Start full-day, Head Start partial-day, and MCPS partial-day classes. In this report, Head Start full-day, Head Start partial-day, and MCPS partial-day classes are referred to as full-day and half-day programs. These pre-K classes are modeled after effective, high-quality preschool programs, and provide early education services to children who are eligible for Free and Reduced-price Meals System (FARMS) services in the school district. All pre-K classes provide scientifically based and literacy-focused instruction five days a week for approximately 180 days per year. Classes are taught by state-certified early childhood education teachers with the support of paraeducators. The class ratio is two adults per class of 20 children. The MCPS pre-K curriculum and instruction are designed to promote children's cognitive, physical, social, and emotional development. Teaching teams use an interdisciplinary, whole-child approach with emphasis on language, literacy, and mathematics. The MCPS pre-K and Head Start programs also provide children with lunch, health care, social services, and transportation at no cost.

In 2007–2008, MCPS offered its Title I schools the opportunity to expand their existing Head Start half-day classes into Head Start full-day classes. Ten elementary schools chose to participate and expanded their 13 Head Start half-day classes into full-day classes using Title I funding. The expansion was intended to provide additional instructional time to children highly impacted by poverty, mobility, and limited English proficiency. Both full-day and half-day pre-K classes

provide a high-quality educational experience to eligible pre-K children. However, full-day classes offer additional instruction in mathematics, literacy, the arts, music, physical education, social interaction, oral language, and vocabulary development. The Head Start full-day classes last 6 hours and 15 minutes each day, while the Head Start half-day classes last 3 hours and 15 minutes each day. MCPS half-day pre-K classes last 2 hours 30 minutes on a regular school day. A more detailed description of the MCPS pre-K programs is available from the publication *Impact of Full-day Prekindergarten Program on Student Academic Performance (*Zhao, Modarresi & Liu, 2009*).*

The MCPS Prekindergarten/Head Start Unit in the Division of Early Childhood Programs and Services provides a range of support for pre-K and Head Start children and families. All Head Start students are screened for developmental, sensory, and behavioral concerns within 45 calendar days of their entry into the program, as required by the *Head Start Program Performance Standards.* This timely and systematic screening approach identifies children for appropriate intervention.

A diverse group of specialists works with parents, teachers, and children. Instructional specialists provide ongoing training and support on curriculum and instructional practices. They regularly observe classes and provide feedback to teachers to help maintain high expectations for children and quality instruction across the county. They ensure that classrooms are equipped with prescribed instructional materials.

Teachers are provided with guidance on behavior management and advice on scaffolding learning experiences for children with special needs. Speech/language pathologists screen all Head Start children and administer additional assessments as needed. These ancillary specialists offer language enrichment activities for all children in both pre-K and Head Start classes. They also consult with teachers and parents to present suggestions for enhancing children's speech and language development. Psychologists provide ongoing psychological evaluation, classroom consultation, and behavior management training to teaching teams as well as to parents. Social workers respond to referrals for consultation from teachers and self-referrals from parents, and they also participate in a variety of interventions including classroom observations, case management activities, advocacy, counseling, and furnishing referrals to other agencies.

Family service workers plan and implement monthly parent trainings for Head Start classes at individual schools. For pre-K classes, they arrange for orientation meetings at school sites, solicit policy council representatives, and encourage parents to participate in trainings at centralized locations. These family service workers meet with teachers monthly to gather and share information about family needs, and they provide support and referrals to parents for resources and services as needed.

The MCPS Pre-K/Head Start Unit provides additional program supports to maximize student achievement. Two special classes include expanded services for Head Start children who are experiencing difficulties adjusting to school due to a variety of risk factors. These classes are longer than the typical part-day classes and class size is reduced. Multidisciplinary team meetings are held monthly to plan and coordinate interventions. Training is provided for parents of pre-K and Head Start students on an ongoing basis. Family night events are held in the fall to furnish parents with information about foundational literacy, mathematics skills, and strategies to foster

children's learning at home. In addition to the monthly parent trainings held at Head Start schools, centralized parent trainings are offered to parents on topics such as child growth and development, language and literacy, personal safety, child abuse prevention, health, and nutrition.

Multiple sources of information are utilized to identify special needs of students in pre-K programs. Several screening instruments are used. The *Early Screening Inventory, Revised* instrument is administered by teachers to three-, four-, and five-year-old children to assist in the identification of children with possible developmental delays. The *Attention, Behavior, Language, and Emotions*, *Level 1* instrument is used by teachers for early identification of children in these areas, and the *Prekindergarten/Head Start Speech-Language Screening Instrument* is administered by speech/language pathologists. Vision and hearing screenings are conducted by technicians.

As part of the *Early Success Performance Plan*, MCPS first offered the full-day kindergarten program in 2000 in schools highly impacted by poverty. By fall 2007, the full-day kindergarten program was offered to all MCPS kindergarteners. In 2008–2009, the kindergarten class size was 17 students per class.

The universal full-day kindergarten program operates six hours a day. In full-day kindergarten, a minimum of 90 minutes per day is devoted to literacy and 60 minutes per day is dedicated to mathematics. Students in MCPS pre-K programs and those without MCPS pre-K experience receive the same high-quality kindergarten instruction as defined by the MCPS kindergarten curriculum for art, mathematics, music, physical education, reading/language arts, science, and social studies (MCPS, 2009a). The universal full-day kindergarten program in MCPS provides a unique opportunity to examine pre-K effects by the end of kindergarten.

Literature on Early Childhood Education

There have been many studies since 1966 on Head Start's short- and long-term effects. Positive effects of high-quality early education have been found on cognitive, linguistic, social, and economic outcomes (Barnett, 1998; Barnett & Belfield, 2006). With the expansion of early childhood education, more studies have documented significant benefits of full-day kindergarten for children's academic skills. When compared to children attending part-day kindergarten, those attending full-day kindergarten tend to perform better on tests of reading, mathematics, and science achievement, and have lower levels of required special education services (Cannon, Jacknowitz, & Painter, 2006; Clark & Kirk, 2000; Gullo, Bersani, Clements, & Bayless, 1986; Lee, Burkam, Ready, Honigman, & Meisels, 2006; Walston & West, 2004).

A recent study showed that the added hours of pre-K education were "substantially effective at closing the achievement gap between urban children and their more advanced peers" (Robin, Frede & Barnett, 2006). Laosa (2005) reports that the foundation for strong literacy skills and learning is established before age five. Achievement gaps in reading skills and knowledge that emerge in Grade 4 or later often already existed as children entered school. One key strategy to improve school readiness and overall school performance of children is to provide access to quality early learning opportunities. Quality preschool programs have the immediate impact of positively increasing young children's cognitive growth as they begin school. The positive effects last through elementary grades and beyond (Laosa, 2005).

In spite of the rapid expansion of pre-K in the nation, there is limited literature about the benefit and lasting effect of pre-K programs of different durations (Gilliam & Ziegler, 2001; Gillaim & Ripple, 2004). A recent study by the National Institute for Early Education Research (NIEER) showed that by Grades 1 and 2, pre-K effects on oral and conceptual knowledge still remained strong. Mathematics effects of pre-K persisted and grade retention was cut in half (Frede, Jung, Barnett, & Figueras, 2009).

The lasting effects of full-day early education programs also include special education placement (DeCesare, 2004). A recent study from Pittsburgh's Early Childhood Program focused, over a three-year span, on 10,000 Pennsylvania children raised in poverty and enrolled in state full-day and half-day pre-K programs. The study found a sharp reduction in special education services for students who attended the pre-K programs (Ian, 2009).

Hustedt, Barnett, Jung, & Goetze (2009) analyzed the economic impact of pre-K programs and found that these programs can improve educational outcomes by reducing the number of children retained, lowering the number of children eligible for special education, and increasing graduation rates. Based on their evaluation study of the New Mexico pre-K programs, Hustedt et al. estimated "$5.00 in benefits are generated in New Mexico for every dollar invested in New Mexico pre-K" (2009, p.5). Students who attended pre-K programs are more likely to have better educational outcomes with higher earnings and are less likely to engage in criminal behavior, to be victims of abuse and neglect, and to use welfare services.

Educational Significance

Even though increasingly larger numbers of American children attend full-day kindergarten programs, full-day pre-K programs are less common. All MCPS kindergarten students attend full-day kindergarten classes. The first MCPS full-day pre-K program offered in 2007–2008 provided the school district an opportunity to examine the lasting effects of time and intensity of pre-K programs by following its first full-day pre-K cohort.

This study uses statistical methods to control for initial differences and to yield unbiased estimates of the treatment impact. It intends to examine the lasting effects of full-day pre-K on at-risk students by the end of kindergarten, and to contribute to the limited literature on sustained positive effect for full-day pre-K programs.

METHODOLOGY

Evaluation Questions

This study examined whether more instructional time in the full-day pre-K program had lasting effects on kindergarten students' school readiness, academic performance, and required special education services, after controlling for differences in baseline academic performance, demographic characteristics, and family income. The study addressed the following questions:

1. How did students in the Head Start full-day pre-K program differ from their peers in the Head Start half-day pre-K program on school readiness at the beginning of kindergarten and on reading and mathematics performance by the end of kindergarten?
2. How did students in the Head Start full-day pre-K program differ from their peers in the MCPS half-day pre-K program on school readiness at the beginning of kindergarten and on reading and mathematics performance by the end of kindergarten?
3. How did students in the Head Start full-day pre-K program differ from their peers without the MCPS pre-K experience on reading and mathematics performance by the end of kindergarten?
4. What was the cost of MCPS special education services in 2008–2009? Did students who attended the Head Start full-day pre-K program in MCPS require significantly lower levels of special education services compared to their peers without MCPS pre-K experience?

Evaluation Design

Since students were not randomly assigned to the pre-K programs, an experimental design was not feasible. In addition, some students who attended MCPS pre-K programs left the district by the end of kindergarten. Therefore, it was necessary to create comparison groups similar to the remaining Head Start full-day pre-K group with a quasi-experimental design as suggested by the literature (Shadish, Cook, & Campbell, 2002). A major problem with employing the quasi-experimental design in educational settings is that students in the full-day pre-K and comparison groups may have important preexisting differences that can influence their achievement after exposure to the intervention and consequently threaten the internal validity of the findings (Gay & Airasian, 2000).

In this study, the threat to internal validity was partially avoided by incorporating several student background variables and baseline performance into an estimation of the full-day pre-K effects through the use of the propensity score method. The use of the propensity score method provides an effective avenue for controlling several preexisting differences between the treatment and comparison groups, and thus produces a less biased estimate of the program effects (Modarresi, Connolly, & Wolanin, 2008). The propensity score method was used in two ways: a) *covariate-*adjusted model and b) matching model.

Procedures for Analyses

Covariate-Adjusted Model

Prominent researchers (Campbell & Stanley, 1963) suggest that in order to observe the true treatment effects in a quasi-experimental design, analysis of covariance (ANCOVA) should be conducted. An ANCOVA procedure was utilized in this study to evaluate the lasting effect of Head Start full-day pre-K programs when outcome measures were continuous (Kirk, 1995). Binary logistic regression models were used where the outcome variables were dichotomous (e.g., met the reading benchmark vs. not met the benchmark) to examine the program effects. The odds ratios calculated from the logistic regression models were used to compare whether the probability of a certain event occurring (e.g., meeting the reading benchmark) is the same between the treatment and comparison groups. Propensity scores based on students' baseline performance,

gender, race, FARMS, English for Speakers of Other Languages (ESOL), special education participation, and family background measures were computed using logistic regression models (Luellen, Shadish, & Clark, 2005). To balance the nonequivalent groups, the propensity scores were divided into five categories and used as covariates in the ANCOVA as well as logistic models (Rosenbaum & Rubin, 1982, 1983, 1984, 1985). The covariate-adjusted model was used to answer the first evaluation question and to validate results for the second evaluation question.

Propensity Score Matching Model

A propensity score matching model was used to answer Evaluation Questions 2 and 3. A large number of MCPS half-day pre-K students remained in the school system by the end of kindergarten and even more kindergarten students without MCPS pre-K experience came to the school system. These two groups formed large pools from which to select students into comparison groups based on propensity score matching.

The Head Start full-day pre-K students were in the treatment group and the first comparison group consisted of the MCPS half-day pre-K students. The logistic regression model generated a propensity score for every pre-K student who had data on pre-K baseline achievement scores, gender, race/ethnicity, family income per person, and participation in ESOL services. Students in the MCPS half-day pre-K program were matched with those in the Head Start full-day pre-K program depending on proximity of their propensity scores. This was to ensure that the two groups were similar on baseline performance and important demographic characteristics at the beginning of the pre-K year.

The second logistic regression model generated a propensity score for every student who had data on school readiness, gender, race/ethnicity, and participation in ESOL and FARMS services. The treatment group consisted of full-day pre-K students, while the comparison group was selected from kindergarten students who did not attend any pre-K program in MCPS. Students without MCPS pre-K experience were matched with those in the full-day pre-K program based on their propensity scores.

To keep a balanced design, the two comparison groups had the same number of students as the treatment group. Visual basic programs were used to match students when their propensity score difference was the smallest. The proximity of their propensity scores suggested similarity in characteristics for the matched groups. Propensity score matching was conducted with replacement; a student in a comparison group could be selected more than once to match with his/her full-day program counterpart. The matching with replacement method yielded the closest matching. After matching, the demographic characteristics and the mean propensity scores for the matched groups were examined to make sure matching was successful. Independent t-tests and chi-square analyses were used to detect significant differences between the Head Start full-day pre-K group and the comparison groups.

Outcome Measures

This evaluation employed several outcome measures that are based on curriculum and instruction in order to examine how the full-day pre-K participants performed by the end of kindergarten

compared with their peers who did not attend the full-day pre-K program. Research indicates that the instructionally based measures are more sensitive to students' learning than standardized tests. Students tend to do better on the content they have been taught (Walker & Schaffarzick, 1974). The following are the outcome measures for the study:

1. Maryland Model for School Readiness (MMSR) results
2. MCPS Assessment Program in Primary Reading (AP-PR)
3. MCPS Kindergarten Mathematics Performance Assessment (KMPA)
4. Weekly hours of special education services students received in kindergarten

The MMSR has been used in Maryland since 2001 to gauge and monitor the school readiness profiles of all incoming kindergarteners across the state. The Maryland State Department of Education (MSDE) has published MMSR annual reports since 2001. The MMSR consists of an observational assessment tool which is a customized version of the *Work Sampling System®*. It assesses seven developmental domains: personal and social development, language arts literacy, mathematical thinking, scientific thinking, social studies, the arts, and physical development. Every year, teachers evaluate every incoming kindergarten student with the MMSR during the first eight weeks of the school year. The MMSR classifies student school readiness profiles into three groups: "developing readiness," "approaching readiness," and "fully ready." The results are reported in composite score and level of readiness. The MMSR composite score is derived by summarizing all scores across the seven domains. Students who obtain a composite score below 50 are developing readiness, those who score between 50 and 70 are approaching readiness, and those who score higher than 70 are fully ready for school. The MMSR provides a common tool to measure students' school readiness at the beginning of kindergarten across school systems in Maryland (MSDE, 2009).

The AP-PR is a research-based and locally developed assessment used to measure important concepts and skills in the MCPS reading curriculum. The AP-PR results provide formative and summative data. The Text Reading and Comprehension (TRC) subtest of the AP-PR is administered in the fall, winter, and spring each year to students in kindergarten. The data are used to monitor students' reading accuracy and oral retell and oral comprehension, and to guide instructional decisions. The spring benchmark measures skills and knowledge required to meet or exceed the reading standards by the end of kindergarten. To make sure students have sufficient reading skills to be successful at the next grade, those who are on-grade level are expected to score at TRC Level 4 or higher, and those who are reading at an advanced level are expected to score at Level 6 or higher. TRC Level 4 criteria take into account the complexity of the text, reading accuracy, and oral retell skills. Reading accuracy scores indicate whether students can read independently. Oral retell and oral comprehension scores indicate how well students understand reading passages. The percentages of students meeting or exceeding reading benchmarks on the AP-PR were used as outcome measures. Further research shows that kindergarten students who score at Level 4 or higher are more likely to meet or exceed the Grade 1 reading proficiency benchmark, are more likely to be at or above the 50th percentile rank on a national norm referenced test in Grade 2, and are more likely to score proficient on the Grade 3 Reading MSA (Zhao & Von Secker, 2008; Von Secker, Zhao, & Powell, 2008).

The MCPS KMPA is a locally developed mathematics assessment. It consists of four unit assessments measuring performance standards of algebra, geometry, measurement, data, and numbers. The KMPA includes multiple choice and open-ended test items as well as on-grade level and above-grade level test items. The on-grade level test items measure the kindergarten curriculum standards, while the above-grade level items measure Grade 1 curriculum standards. There are 58 score points for the on-grade level assessment with a test reliability of 0.89, as measured by Cronbach's alpha. Cronbach's alpha is a statistic to measure test reliability. The above-grade level assessment has 131 points with reliability of 0.95. The reliability of 0.85 is considered high based on accepted criteria in research (Nunnally, 1978). The KMPA is administered by teachers at the end of each mathematics instructional unit. Total percent correct scores were used as an outcome measure in this study.

In addition to school readiness and academic performance, average weekly hours of special education services received by kindergarten students were calculated as another outcome measure.

Effect Size

Effect size is a commonly used statistic to measure the magnitude of program effect (American Psychological Association, 2001). It measures the standardized difference between group means and examines if the program effect is practically significant. Educational evaluators often use Cohen's (1988) effect size[1] to judge the magnitude of program effectiveness. An effect size of 0.2 is considered as small, 0.5 as medium, and 0.8 or more as large.

Odds ratio[2] is another way to express program effects when the outcome variables are dichotomous such as meeting reading benchmark or not. Odds ratio shows whether the odds of a certain event happening is the same for two groups.

In this study, odds ratio was calculated for two dichotomous outcome measures: 1) meeting kindergarten reading proficiency benchmark at Level 4, and 2) meeting advanced reading benchmarks at Level 6. If the calculated odds ratio is equal to 1, it means an event is equally likely to occur for the two groups (Rosenthal & Rubin, 1982). When the odds ratio is equal to 1, it means that students in full-day pre-K are as likely to meet the kindergarten reading benchmark as those in the comparison group. When the odds ratio is greater than 1, it means that students in full-day pre-K were more likely to meet the kindergarten benchmark than the comparison group. When the odds ratio is below 1, it is asymmetric and can behave very differently and create an undesirable perception (Osborne, 2006); therefore, it is only appropriate to report odds ratios above 1. To

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[1] The following formula was used to calculate the effect size in this evaluation: effect size = $(M_t - M_c)/SD$. The M_t and M_c are adjusted group means for students who participated in Head Start full-day pre-K program and those who did not attend the Head Start full-day pre-K program. *SD* is the standard deviation of their pooled outcome scores.

[2] The following formula was used to calculate the odds ratio in this evaluation: odds ratio = (a x b)/(c x d). For example, a school implemented a dropout prevention program. After intervention, 27 students graduated and 20 dropped out from the program. In a comparison group, 10 graduated and 32 dropped out. The odds ratio is (27 x 20)/(10 x 32)=1.688. The odds ratio of 1.688 means that the prevention program students were 68% more likely to graduate.

compare effect sizes for dichotomous and continuous outcomes, odds ratio was converted to Cohen's d statistics[3].

Special Education Services

To determine the cost of special education per student, the MCPS 2009 operating budget for the Department of Special Education (in dollars) was examined. The total budget was divided by the total students served in the same school year to obtain the average cost per student. Also computed were average weekly hours of special education services kindergarten students received in 2008–2009.

Due to a comprehensive student data system in MCPS, evaluators were able to examine actual hours of special education services students received per week in kindergarten. This is a more precise measure than special education referral or identification.

Study Samples

Original Pre-K Cohort

In September 2007, 2,538 students were enrolled in the three pre-K programs: 391 of the pre-K students were enrolled in the Head Start half-day classes, 260 in the Head Start full-day classes, and 1,887 in MCPS half-day classes. In the Head Start full-day classes, 34.6 percent of the students were African American, 50.4 percent were Hispanic, 9.2 percent received special education services, and 63.5 percent received ESOL services (Table A1, Appendix A).

Table A2 (Appendix A) shows that students in the three pre-K programs were very similar with regard to guardian's age, guardian's education, and family size. However, median family income and median income per person were higher for students in MCPS half-day classes. There are different eligibility requirements for the Head Start and MCPS pre-K programs. Higher average income due to federally mandated program eligibility suggests that students in MCPS half-day classes were financially better off than their peers in the Head Start programs.

Of the original pre-K cohort (Table A1, Appendix A), 2,012 students remained in MCPS by the end of kindergarten in 2009 (Table 1). Among them, 254 students were in the Head Start half-day pre-K program, 216 were in the Head Start full-day pre-K program, and 1,542 were in the MCPS half-day pre-K program. A higher percentage of students receiving ESOL services (67.1 percent) attended the Head Start full-day pre-K program compared with the other two programs.

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[3]The following formula was used to calculate the effect size from odds ratio: $\text{logit } d = \dfrac{\ln(OR)}{pi/\sqrt{3}}$

Table 1
Characteristics for 2007–2008 Pre-K Students Who
Stayed in MCPS Kindergarten in 2008–2009 by Pre-K Program *(N=2,012)*

	Head Start half day		Head Start full day		MCPS half day	
	N	*%*	*N*	*%*	*N*	*%*
Total	254		216		1,542	
Gender						
Male	117	46.1	113	52.3	765	49.6
Female	137	53.9	103	47.7	777	50.4
Race/ethnicity						
African American	135	53.1	77	35.6	476	30.9
Asian American	22	8.7	20	9.3	191	12.4
Hispanic	73	28.7	107	49.5	798	51.8
White	24	9.4	11	5.1	74	4.8
Services Provided						
ESOL	98	38.6	145	67.1	964	62.5

Note. American Indian students were included in the total but not reported separately.

As shown in Table 2, the students who remained in MCPS kindergarten were similar to those in the original pre-K cohort (Table A2, Appendix A) in terms of family income, guardian age and education, and family size. Students in the MCPS half-day pre-K program had higher family income than those in the Head Start full-day and half-day pre-K programs.

Table 2
Family Background for 2007–2008 Pre-K Students Who Stayed
in MCPS Kindergarten in 2008–2009 by Pre-K Program *(N=2,012)*

	Head Start half day N=254		Head Start full day N=216		MCPS half day N=1,542	
	Mean	Median	Mean	Median	Mean	Median
Total family income	$14,539	$13,488	$16,001	$15,705	$28,927	$28,508
Income per person	$3,725	$3,484	$4,161	$4,108	$7,488	$7,485
Female guardian's age	31	30	32	31	32	32
Male guardian's age	36	36	37	38	36	36
Female guardian's education (yrs.)	12	12	12	12	12	12
Male guardian's education (yrs.)	13	12	11	12	12	12
Family size	4	4	4	4	4	4

Note. Income per person was calculated by dividing total family income by family size.

Head Start Full-Day Pre-K and Comparison Groups

Included in the analyses were students who attended the pre-K programs in MCPS with complete information on outcome variables, demographic, and family background. For the kindergarten group without MCPS pre-K experience, students who attended private pre-K nursery schools were excluded. Also excluded were students who repeated kindergarten in 2008–2009 because they belonged to a different pre-K cohort.

RESULTS

Results are displayed in the order of evaluation questions. For the first three questions, student characteristics are described first, followed by results in regard to school readiness at the beginning of kindergarten, and reading and mathematics performance by the end of kindergarten. The final question addresses special education services and does not follow this format.

Students in the Head Start Full-day vs. Students in Head Start Half-day Pre-K Programs

A covariate-adjusted model was used to answer the first evaluation question: How did students in the Head Start full-day pre-K program differ from their peers in the Head Start half-day pre-K program on school readiness at the beginning of kindergarten and on reading and mathematics performance by the end of kindergarten? Results are displayed for the treatment and comparison groups on school readiness at the beginning of kindergarten and students' academic achievement by the end of kindergarten.

Student Characteristics

Table 3 displays family characteristics and baseline performance for the Head Start students who attended the Head Start pre-K programs in MCPS and remained in the school system until the end of kindergarten. The average income per person in a family was slightly higher for students in the Head Start full-day pre-K program compared with those in the Head Start half-day pre-K program. The standard deviations of income per person and parental education were larger for students in the full-day pre-K program. This means there was larger variability in family background for the full-day pre-K group. Baseline performance referred to students' academic performance at the beginning of the pre-K year. The baseline performance in reading for the two Head Start pre-K groups was very close. In mathematics, students in the Head Start full-day program scored slightly lower (49.8 percent) than their counterparts in the Head Start half-day pre-K group (53.7 percent) at the beginning of their pre-K school year.

Table 3
Family Background and Baseline Performance for 2007–2008
Head Start Pre-K Students Who Stayed in MCPS in 2008–2009

	Head Start full day N=254		Head Start half day N=216	
	Mean	SD	Mean	SD
Background				
Income per person	$4,161	$4,116	$3,725	$3,000
Female guardian's education (yrs.)	12	8.2	12	3.0
Male guardian's education (yrs.)	11	4.5	13	3.2
Baseline performance				
Pre-K fall reading	42.5	24.5	43.2	25.0
Pre-K fall math	49.8	26.2	53.7	27.8

Performance Results on MMSR

Descriptive information on school readiness and kindergarten performance of the remaining students in the Head Start full-day and the Head Start half-day pre-K programs without statistical control is shown in Tables A3–A4 (Appendix A).

After controlling for reading and mathematics performance at the beginning of the pre-K year, demographics such as gender, race, family income per person and students receiving ESOL, FARMS, and special education services, there were no statistically significant differences found in school readiness as measured by the MMSR scale score at the beginning of kindergarten for the two Head Start pre-K groups. This means that the two groups were similar on school readiness.

On the MMSR, a score higher than 70 means a student is fully ready for school. The adjusted mean scores calculated with ANCOVA procedures was about 74 for the two groups (Table 4). This indicates that the two groups of students were similar on school readiness. It must be noted that only students in Head Start full-day and Head Start half-day pre-K programs for whom information on all of the selected background variables was available were included in the analyses.

Table 4
Adjusted Mean Scores and Effect Size on Maryland Model of School Readiness
in Fall 2009 by Head Start Pre-K Program

MMSR	Head Start full day pre-K		Head Start half day pre-K		Mean diff.*	Standard error	Effect size
	N	Mean	*N*	Mean			
Scale score	145	74.5	117	74.4	0.02	1.34	0.002

Note. Mean difference may differ by 0.1 due to rounding.
* p value < 0.05.

Performance Results on Kindergarten Reading Benchmarks

The logistic regression procedures[4] were used to examine whether or not kindergarten students who attended the Head Start full-day pre-K program had a higher probability of meeting the kindergarten reading benchmark than their peers who attended the Head Start half-day pre-K program by holding the effects of several student background variables constant. In the regression analyses, only students in the Head Start full-day and Head Start half-day pre-K programs that had provided information on all selected background variables and outcome measures were included.

The results indicate that the probability (or chance) of meeting the Level 4 reading benchmark for those students who attended the Head Start full-day pre-K program was higher than those who attended the Head Start half-day pre-K program. Specifically, the odds ratio was 1.44. This indicates that students who attended the Head Start full-day pre-K program had a 44 percent

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[4] The logistic regression is better suited than ANCOVA when a measure is dichotomously defined as two outcomes (e.g., meeting the benchmark or not meeting the benchmark). The background measures in the logistic regression models included family income per person, special education status, ESOL services, gender, and baseline performance in reading and mathematics.

greater probability of meeting the Level 4 reading benchmark than their peers in the Head Start half-day pre-K program. To elaborate further, the odds of meeting the Level 4 reading benchmark for kindergarten students might increase by 44 percent with additional instructional time provided by the Head Start full-day pre-K program.

The effect size for the participation in the Head Start full-day pre-K program was 0.20 for all students (Figure 1). This finding suggests that overall students who attended the Head Start full-day pre-K program performed better than their peers in the Head Start half-day pre-K program on the kindergarten reading benchmark at Level 4. The effect size is large enough to have practical significance. No effect sizes were calculated for Asian American and White students because of their small numbers.

Among subgroups, the effect size was the largest for African American students (0.38), followed by male students (0.32). This suggests that African American and male students who attended the Head Start full-day pre-K program performed better on the kindergarten reading benchmark Level 4 compared with their peers in the Head Start half-day pre-K program. The differences between the Head Start full-day and Head Start half-day pre-K groups were negligible for Hispanic (-0.07) students, and students receiving FARMS (-0.06) and ESOL (-0.16) services. The negligible effect sizes suggest that students in these subgroups who attended the Head Start full-day pre-K program performed at the same level as their peers in the Head Start half-day pre-K program on reading benchmark Level 4. The negative effect size is slightly higher (-0.19) for female students, but it is not practically significant.
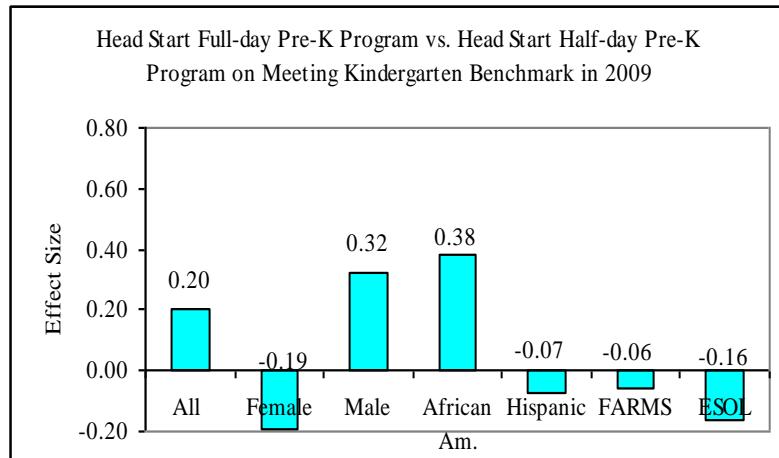
Figure 1. Effect sizes of Head Start full-day pre-K vs. Head Start half-day pre-K program based on kindergarten reading benchmark Level 4 in 2009.

The same analyses were repeated at the advanced reading Level 6. The results revealed that the probability (or chance) of meeting the Level 6 reading benchmark for those students who attended the Head Start full-day pre-K program was only slightly higher than those who attended the Head Start half-day pre-K program. The estimated odds ratio of 1.057 suggests that students in the Head Start full-day pre-K program had only a 5.7 percent greater probability of meeting the benchmark than those students in the Head Start half-day pre-K program. The negligible effect size of 0.03 suggests the two groups performed at the same level for the advanced reading level.

Performance Results on Kindergarten Mathematics

Students in the Head Start full-day pre-K and the Head Start half-day pre-K groups performed at the same level as measured by kindergarten mathematics assessments (Table 5). The mathematics score was based on percent correct. Table 5 shows that the adjusted mean score was 87.2 out of 100 for the Head Start full-day pre-K group and 86.5 out of 100 for the Head Start half-day pre-K group on the kindergarten mathematics on-grade assessment. For the kindergarten above-grade mathematic assessment, the adjusted mean score was 45.1 for the Head Start full-day pre-K group and 44.0 for the Head Start half-day pre-K group. This suggests that the two groups performed at the same level for on-grade and above-grade mathematics assessments.

Table 5
Adjusted Mean Scores and Effect Size of Kindergarten
Mathematics On-Grade and Above-Grade Assessments in 2008–2009
by Head Start Pre-K Program

Outcome	Head Start full day pre-K		Head Start half day pre-K		Mean diff.	Standard error	Effect size
	N	Mean	N	Mean			
K math on grade level	169	87.2	179	86.5	0.73	1.43	0.05
K math above grade level	148	45.1	120	44.0	0.69	3.35	0.03

A summary comparison between students in the Head Start full-day pre-K program and their peers in the Head Start half-day pre-K program is provided below:

- The two groups were similar on school readiness at the beginning of kindergarten.
- Students in the Head Start full-day pre-K program were 44 percent more likely to meet reading benchmark Level 4 by the end of kindergarten than those in the Head Start half-day pre-K program. The effect is educationally significant.
- The larger Head Start full-day pre-K program effect favored African American and male students in the Head Start full-day pre-K program on meeting reading benchmark Level 4.
- The two groups performed at the same level on mathematics by the end of kindergarten.

Students in the Head Start Full-day vs. Students in MCPS Half-day Pre-K Programs

In this section, results are displayed to answer the second evaluation question: How did students in the Head Start full-day pre-K program differ from their peers in the MCPS half-day pre-K program on school readiness at the beginning of kindergarten and on reading and mathematics performance by the end of kindergarten? A propensity score matching model was used to create the comparison group to address the second evaluation question. A covariate-adjusted model was also used to validate results produced with propensity score matching.

Propensity Score Matching[5]

Of 1,282 students who had data on all the matching variables, 150 students were in the Head Start full-day pre-K program and the remainder attended the MCPS pre-K program. Based on proximity of their propensity scores, 150 students in the MCPS half-day pre-K program were selected to match with the 150 students in the Head Start full-day pre-K program. The equal sample size was intended for a balanced design.

Student Characteristics after Matching

After matching, the Head Start full-day pre-K students had slightly lower baseline performance in reading and mathematics and slightly higher family income at the beginning of pre-K (Table 6). Overall, the two groups were similar on selected family background and baseline performance at the beginning of the pre-K year.[6] This suggests that the matching was successful.

Table 6
Family Background and Baseline Performance for 2007–2008 Head Start
Pre-K Students Who Stayed in MCPS in 2008–2009 by Pre-K Program

	Head Start full day N=150		MCPS half day N=150	
	Mean	SD	Mean	SD
Background				
Income per person	$4,237	$2,189	$4,169	$2,563
Female guardian years of education	11.4	4.1	12.0	4.9
Male guardian years of education	11.9	4.6	11.9	4.6
Baseline performance				
Pre-K fall reading	43.7	24.1	46.7	24.4
Pre-K fall math	48.8	26.4	50.2	27.7

Performance Results on MMSR

As shown in Table 7, a higher percentage of students in the Head Start full-day pre-K program were fully ready for school (66.7 percent) at the beginning of kindergarten, compared with their peers in the MCPS half-day pre-K program (62.8 percent).

Among subgroups (Table 7), male and African American students, and students receiving FARMS and ESOL services, a higher percentage of those in the Head Start full-day pre-K program were fully ready for school, compared with their counterparts in the MCPS half-day pre-K program. The differences were significant (p value < 0.05) for male students and students receiving ESOL

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[5] Propensity matching methods were used to statistically control for preexisting differences when comparing students in the Head Start full-day and MCPS half-day pre-K programs. Propensity scores were generated based on gender, race, ESOL status, family income per person, and mathematics and reading scores at the beginning of their pre-K programs.
[6] The mean propensity score was 0.73 for the two groups and the standard deviation of propensity scores was 0.16 for the Head Start full-day pre-K group and 0.15 for the MCPS half-day pre-K group.

services. Results for Asian American and White students should be interpreted with caution due to their small numbers.

In Maryland, 73 percent of all kindergarteners, 69 percent of African American students and 39 percent of Hispanic students were identified as fully ready in 2008–2009 (MSDE, 2009). As shown in Table 7, about 73 percent of African American students and 58.9 percent of Hispanic students who attended the Head Start full-day pre-K were fully ready for school at the beginning of kindergarten.

Table 7
Percentage of Kindergarten Students Ready for School on Maryland Model for
School Readiness in Fall 2009 by Head Start Full-Day
and MCPS Half-Day Pre-K Programs *(N=300)*

	Total *N*	Develop readiness %	Approach readiness %	Fully ready %
All				
HS full-day	150	1.4	31.9	66.7
MCPS half-day	150	4.1	33.1	62.8
Female				
HS full-day	65	1.6	21.0	71.4
MCPS half-day	73	4.2	20.8	75.0
Male				
HS full-day	85	1.2	40.2	58.5
MCPS half-day	77	3.9	44.7	51.3
African American				
HS full-day	54	3.8	23.1	73.1
MCPS half-day	52	4.0	26.0	70.0
Asian American				
HS full-day	13	0	33.3	66.7
MCPS half-day	18	0	33.3	66.7
Hispanic				
HS full-day	74	0	41.1	58.9
MCPS half-day	73	5.5	38.4	56.2
White				
HS full-day	8	0	0	100
MCPS half-day	7	0	28.6	71.4
FARMS				
HS full-day	129	1.6	33.1	65.3
MCPS half-day	128	3.1	35.4	61.4
ESOL				
HS full-day	98	2.1	21.3	76.6
MCPS half-day	94	3.6	30.9	65.5

Note. American Indian students were included but not reported separately. Results should be interpreted with caution for groups with fewer than 30 students. Results may not add up to 100 due to rounding.
HS = head start

Performance Results on Kindergarten Reading Benchmarks

The percentages of students meeting the kindergarten reading benchmark at Level 4 are shown in Table 8. Overall, students in the Head Start full-day pre-K program were more likely to meet the

reading benchmark (90.7 percent), compared to their peers in the MCPS half-day pre-K program (84.7 percent). The same pattern is true for subgroups except White students.

For the Head Start full-day pre-K group, the odds of meeting the kindergarten reading benchmark at Level 4 is 1.53 (Table 8). This means that Head Start full-day pre-K students were 53 percent more likely to meet the kindergarten reading benchmark than their counterparts in the MCPS half-day pre-K program. The odds of meeting the kindergarten benchmark at Level 4 was the largest for African American students (1.94), followed by female students (1.68) and students receiving FARMS services (1.60). An odds ratio of 1.94 means that African American full-day pre-K students were 94 percent more likely to meet the benchmark as their peers in the MCPS half-day pre-K program.

Table 8
Percentage of Students Meeting Kindergarten Reading Level 4 and Level 6 in 2009
by Head Start Full-day and MCPS Half-day Pre-K Programs *(N=300)*

	N	Met Level 4 %	Odds ratio for Level 4	Met Level 6 %	Odds ratio for Level 6
All					
HS full day	150	90.7	1.53	62.7	1.05
MCPS half day	150	84.7		56.0	
Female					
HS full day	65	89.2	1.68	64.6	1.36
MCPS half day	73	84.9		56.2	
Male					
HS full day	85	91.8	1.43	61.2	1.17
MCPS half day	77	84.4		55.8	
African American					
HS full day	54	92.6	1.94	66.7	1.04
MCPS half day	52	82.7		48.1	
Asian American					
HS full day	13	100	NA	53.8	NA
MCPS half day	18	88.9		83.3	
Hispanic					
HS full day	74	87.8	1.25	59.5	0.99
MCPS half day	73	83.6		56.2	
White					
HS full day	8	87.5	NA	75.0	NA
MCPS half day	7	100		42.9	
FARMS					
HS full day	129	89.9	1.60	62.0	1.04
MCPS half day	128	82.0		50.8	
ESOL					
HS full day	98	88.8	1.10	59.2	0.92
MCPS half day	94	86.2		59.6	

Note. American Indian students were included but not reported separately. No odds ratio was calculated for a group if the sample size was fewer than 30 students. Results may not add up to 100 due to rounding.
HS = head start

As illustrated in Table 8, students in the Head Start full-day and MCPS half-day pre-K programs performed at the same level for advanced reading Level 6 (odds ratio = 1.05). However, the

analyses of subgroups indicated female students in the Head Start full-day pre-K program were 36 percent more likely to meet Level 6 than their peers in the MCSP half-day pre-K program (odds ratio = 1.36). For the other subgroups, students in the Head Start full-day pre-K program were as likely to meet Level 6 as their counterparts in the MCPS half-day pre-K program. No odds ratio was calculated for Asian American and White students because their sample size was smaller than 30.

As shown in Figure 2, the effect size for participation in the Head Start full-day pre-K program was 0.23 for all students. The effect size is large enough to have practical significance. This suggests that students in the Head Start full-day pre-K program performed higher on the kindergarten reading benchmark at Level 4, compared with their MCPS half-day pre-K peers. No effect sizes were calculated for Asian American and White students because of their small numbers.

Among subgroups, the effect size was the largest for African American students (0.37), followed by female students (0.29), students receiving FARMS services (0.26), and male students (0.20). This suggests that students in these subgroups who attended the Head Start full-day pre-K program performed better than their MCPS half-day pre-K peers on the kindergarten reading benchmark at Level 4.

The differences between the Head Start full-day pre-K and MCPS half-day pre-K groups are negligible for Hispanic (0.12) students and students receiving ESOL (0.05) services. These negligible effect sizes suggest that students in these subgroups who attended the Head Start full-day pre-K program performed at the same level as their peers in the MCPS half-day pre-K program on reading benchmark Level 4.
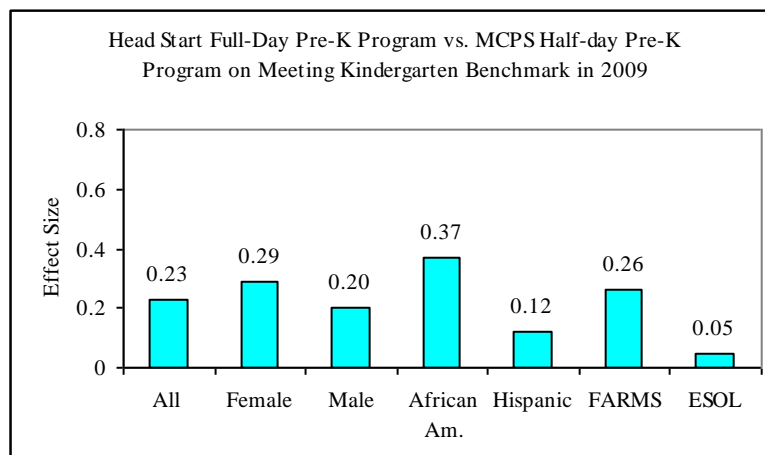

Figure 2. Effect sizes of Head Start full-day pre-K vs. MCPS half-day pre-K program based on kindergarten reading benchmark Level 4 in 2009.

Performance Results on Kindergarten Mathematics

The results show the mean scores on mathematics were the same (87.7) for the two groups (Table 9). This suggests that the Head Start full-day pre-K students performed as well as their peers in the MCPS half-day program on mathematics assessments by the end of kindergarten.

Table 9
Mean Score and Standard Deviation for Kindergarten On-Grade and Above-Grade
Mathematics Assessments in 2008–2009 by Pre-K Program *(N=300)*

	Head Start full day *N=150*		MCPS half day *N=150*	
	Mean	SD	Mean	SD
K on-grade level math	87.7	14.4	87.7	12.1
K above-grade level math	39.4	27.6	41.4	19.3

Note: SD = standard deviation

Validation Analyses with Covariate-Adjusted Model

A covariate-adjusted ANCOVA and a logistic regression model were used to validate results generated by the propensity matching method (Appendix B). Students who attended Head Start full-day pre-K performed significantly higher on the kindergarten reading benchmark Level 4 and performed at same level on advanced reading and mathematics as their peers who attended MCPS half-day pre-K. Detailed information about the replication can be found in Appendix B.

In summary, when students in the Head Start full-day pre-K program are compared with their peers in the MCPS half-day pre-K program, the expectation is that the students in the Head Start full-day pre-K program would perform higher in reading and mathematics. The major findings are as follows:

- Male students and students receiving ESOL services in the Head Start full-day pre-K program were significantly more likely to be fully ready for school than their peers in the MCPS half-day pre-K program at the beginning of kindergarten.
- Students in the Head Start full-day pre-K program were 53 percent more likely to meet reading benchmark Level 4 by the end of kindergarten.
- African American students were 94 percent more likely to meet kindergarten reading benchmark at Level 4. Female students were 64 percent more likely, and students receiving FARMS services were 60 percent more likely to meet the kindergarten reading benchmark at Level 4. The effect is educationally significant.
- The two groups performed at the same level on mathematics by the end of kindergarten.

Students in the Head Start Full-day Pre-K vs. Students without MCPS Pre-K Experience

Results are presented to answer the third evaluation question: How did students in the Head Start full-day pre-K program differ from their peers without the MCPS pre-K experience on reading and mathematics performance by the end of kindergarten? Students' performance on reading and

mathematics by the end of kindergarten were examined. The analyses in this section were conducted with the matching method only.

Propensity Score Matching

Of students who had complete data on selected background variables, 195 students attended the Head Start full-day pre-K program and 7,037 students had no experience in any MCPS pre-K program based on the MMSR data file. Exactly 195 students without MCPS pre-K experience were selected to match the 195 students in the Head Start full-day pre-K program based on their propensity scores. The equal sample size was intended to keep a balanced research design.

Student Characteristics after Matching

After matching, the mean propensity scores and standard deviations for the two groups were very close.[7]. This suggests that students in Head Start full-day pre-K and those without an MCPS pre-K experience were very similar in regard to the level of school readiness and in their demographics at the beginning of kindergarten.

Performance Results on Kindergarten Reading Benchmarks

As shown in Table 10, 51.8 percent of all students in the Head Start full-day pre-K program met the kindergarten reading benchmark at Level 4, compared with 48.2 percent of students without MCPS pre-K experience. The differences in reading achievement were more pronounced at some subgroup levels.

Among subgroups, 91.3 percent of African American students in the Head Start full-day pre-K program met the reading benchmark at Level 4, compared with 80 percent for those without MCPS pre-K experience (Table 10). On kindergarten reading benchmark Level 4, the odds ratio was larger for African American (2.71) and female (1.46) students, and students receiving FARMS services (1.37) in favor of students in Head Start full-day pre-K. The odds ratio of 2.71 means that African American students in the Head Start full-day pre-K program were 2.71 times as likely as their African American peers without MCPS pre-K experience to meet the kindergarten reading benchmark at Level 4.

The analyses for advanced reading Level 6 did not reveal significant differences between those students in the Head Start full-day pre-K program and their peers without MCPS pre-K experience as indicated by the odds ratio of 1.06 (Table 10). However, 71 percent of African American students in the full-day pre-K program scored advanced at reading Level 6, compared to 61.3 percent of African American students without MCPS pre-K experience. The odds ratio for advanced reading Level 6 was also the largest for African American students (1.55). This suggests that African American students in the Head Start full-day pre-K program were 55 percent more likely to meet advanced reading at Level 6 as their peers without MCPS pre-K experience. For female students, the odds ratio was 1.28 on advanced reading. This suggests that female students

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[7] The mean propensity scores were 0.72 for the two matched groups and the standard deviation was 0.16 for the Head Start full-day pre-K group and 0.15 for those without MCPS pre-K experience.

in the Head Start full-day pre-K program were 28 percent more likely to meet the advanced reading at Level 6 as their peers without MCPS pre-K experience.

Hispanic students and students receiving ESOL and FARMS services in the Head Start full-day pre-K program performed at the same level as their peers without MCPS pre-K experience after controlling for demographic characteristics and school readiness at the beginning of kindergarten.

Table 10
Percentage of Students Meeting Kindergarten Reading Level 4 and Level 6
in 2009 by Pre-K Experience *(N=390)*

	N	Met Level 4 %	Odds ratio for Level 4	Met Level 6 %	Odds ratio for Level 6
All					
HS full day	195	51.8	1.42	52.3	1.06
Not in MCPS	195	48.2		47.7	
Female					
HS full day	94	90.4	1.46	70.2	1.28
Not in MCPS	99	86.9		59.6	
Male					
HS full day	101	86.1	1.34	60.4	0.91
MCPS half day	96	77.1		59.4	
African American					
HS full day	69	91.3	2.71	71.0	1.55
Not in MCPS	80	80.0		61.3	
Asian American					
HS full day	17	100	NA	55.6	NA
Not in MCPS	10	90.0		75.0	
Hispanic					
HS full day	100	86.0	1.18	62.0	0.99
Not in MCPS	97	81.4		54.6	
White					
HS full day	9	66.7	NA	55.6	NA
Not in MCPS	8	100		75.0	
FARMS					
HS full day	173	87.3	1.37	64.2	1.07
Not in MCPS	174	81.6		58.0	
ESOL					
HS full day	136	87.5	1.13	62.5	1.00
Not in MCPS	134	85.1		59.0	

Note. American Indian students were included but not reported separately. No odds ratio was calculated for a group if the sample size was fewer than 30 students. Results may not add up to 100 due to rounding.
HS = head start

For all students, the effect size was 0.19 as measured by kindergarten reading benchmark Level 4 (Figure 3). This suggests that students in the Head Start full-day pre-K program performed as well as their peers with the same level of school readiness but without MCPS pre-K experience by the end of kindergarten. No effect sizes were calculated for Asian American and White students because of their small numbers.

Figure 3 also shows that among subgroups, the effect size was the largest (0.55) for African American students in the Head Start full-day pre-K program, followed by female students (0.21). These effect sizes were large enough to have educational significance. The results indicate that African American and female students in the Head Start full-day pre-K program performed higher on reading benchmark Level 4 than their peers without MCPS pre-K experience after controlling for school readiness at the beginning of kindergarten.
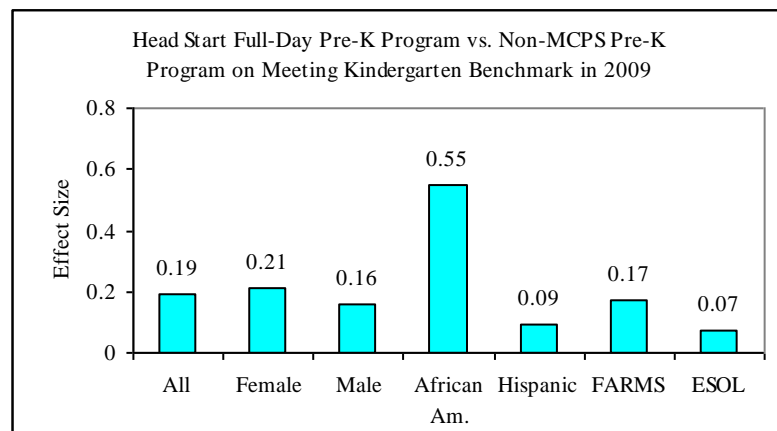

Figure 3. Effect sizes of Head Start full-day pre-K vs. students without MCPS pre-K experience based on kindergarten reading benchmark Level 4 in 2009.

The differences between the Head Start full-day pre-K group and the group without MCPS pre-K experience are negligible for male (0.16) and Hispanic (0.09) students, and students receiving FARMS (0.17) and ESOL (0.07) services. These negligible effect sizes suggest that students in these subgroups who attended the Head Start full-day pre-K program performed at the same level as their peers without MCPS pre-K experience on reading benchmark Level 4. Evidence showed that students in the Head Start full-day pre-K program did not lag behind their peers without MCPS pre-K experience by the end of kindergarten.

Performance Results on Kindergarten Mathematics

The results show that the mean scores in mathematics were very close (88.8 and 86.1) for the two groups (Table 11). This suggests that the Head Start full-day pre-K students performed as well as their peers without MCPS pre-K experience on mathematics by the end of kindergarten, after controlling for demographic characteristics and school readiness at the beginning of kindergarten (Table 11). Evidence showed that the full-day pre-K students were not trailing behind their peers without MCPS experience in mathematics a year later.

Table 11
Mean Score and Standard Deviation of Kindergarten Mathematics On-Grade
and Above-Grade Assessments in 2009 by Pre-K Experience *(N=390)*

	Head Start Full day *N=195*		No MCPS Pre K *N=195*	
	Mean	SD	Mean	SD
K on-grade level math	88.8	13.6	86.1	15.7
K **a**bove-grade level math	40.7	28.0	40.2	25.4

In summary, when students in the Head Start full-day pre-K program were compared to their peers with similar levels of school readiness but without MCPS pre-K experience, the expectation is that the two groups should perform at the same level by the end of the kindergarten. The major findings are as follows:

- Students in the Head Start full-day pre-K program were 42 percent more likely to meet reading benchmark Level 4 than their peers without MCPS pre-K experience by the end of kindergarten.
- African American students in the Head Start full-day pre-K program were 2.71 times as likely as their peers without MCPS pre-K experience to meet the kindergarten benchmark at Level 4.
- Female students and students receiving FARMS services in the Head Start full-day pre-K program were 46 percent and 37 percent, respectively, more likely than their peers to meet the kindergarten reading benchmark at Level 4. The program effects are educationally significant.
- African American students in the Head Start full-day pre-K program were 55 percent more likely to meet reading benchmark Level 6 by the end of kindergarten. The program effect is educationally significant.
- The two groups performed at the same level on mathematics by the end of kindergarten.

Special Education Cost and Services in Kindergarten

This section answers the last evaluation question: What was the cost of MCPS special education services in 2008–2009? Did students who attended the Head Start full-day pre-K program in MCPS require significantly lower levels of special education services compared to their peers without MCPS pre-K experience?

According to the MCPS Fiscal Year 2009 budget, the per pupil cost for elementary students was $14,466 in 2008–2009 (MCPSb, 2009). The FY 2009 budget for Special Education showed that average cost was $16,230 per special education student. The budget for special education excluded services provided to all students, such as transportation and general education classes. Further analyses showed that the majority of kindergarten students who required special education services in 2008–2009 were identified as speech impaired or developmentally delayed.

After propensity score matching to control for demographic characteristics and school readiness at the beginning of kindergarten, students in the Head Start full-day pre-K program received an

average of 3.7 hours of special education services per week in kindergarten, compared to 9.8 hours for students without MCPS pre-K experience (Table 12). This suggests that on the average, full-day pre-K students required less than half of the special education services in kindergarten required by their peers without MCPS pre-K experience. Table A4 describes the average hours of special education services in a week required for kindergarteners in 2008–2009 by pre-K program. It appears that students who attended any pre-K program required fewer special education services when they were in kindergarten.

Table 12
Average Weekly Hours in Special Education Services Received by MCPS
Students in 2009 by Pre-K Experience

	N of students	N of SE students	Mean hours weekly	SD
Head Start full-day Pre-K	195	22	3.7	5.4
No MCPS pre-K	195	47	9.8	9.8

Note.   Includes students in the Head Start full-day pre-K program and their peers of similar demographic characteristics and school readiness but without MCPS pre-K experience based on propensity score matching. SE = special education; SD = standard deviation.

Fewer hours of special education services required means lower costs for the school system. The results of this study are consistent with the literature documenting that early childhood programs may reduce special education services in later grades (DeCesare, 2004; Hustedt et al., 2009).

Further analyses show that the majority of kindergarten students requiring special education services in 2009 were identified as having language or speech impairment, and developmental delay. It is possible that interaction with students in pre-K programs may have helped teachers identify and document children with special needs more accurately and earlier. Through early intervention, achievement gaps and behavior concerns could be addressed proactively and effectively. Early intervention may have contributed to the reduced special education services in kindergarten for the students in any of the MCPS pre-K programs. The investment in the pre-K programs appears to result in cost savings for kindergarten special education services.

DISCUSSION

After exposure to a rigorous curriculum, students of low socioeconomic status attending pre-K classes in MCPS made significant academic gains in reading and mathematics during their pre-K year (Zhao, Modarresi & Liu, 2009). Researchers documented that when instruction is of high quality, additional instructional time can further improve student performance. Increased instructional time can produce better academic performance (Robin, Frede & Barnett, 2006).

The results of this study show that longer instructional time in the Head Start full-day pre-K program seems to have a lasting positive impact on students' reading skills by the end of kindergarten. Due to additional time for instruction in the pre-K year, students who attended a Head Start full-day pre-K program are expected to exhibit higher academic performance than their peers in half-day pre-K programs by the end of kindergarten. As expected, students who attended the Head Start full-day pre-K program were more likely to meet the kindergarten end-of-year reading benchmark at Level 4 than their peers in the Head Start half-day pre-K program with similar demographic characteristics and baseline performance. The positive lasting effect was the most pronounced for African American students in the Head Start full-day pre-K program.

Male students and students receiving ESOL services who attended the Head Start full-day pre-K program were more likely to be fully ready for school at the beginning of kindergarten, compared to their peers in the MCPS half-day pre-K program. All students in the Head Start full-day pre-K program were more likely to meet the kindergarten end-of-year reading benchmark at Level 4 than their peers in the MCPS half-day pre-K program. The larger observed program impact was in favor of African American and female students, and students receiving FARMS services in the Head Start full-day pre-K program. The program effect sizes were large enough to have educational significance.

When students in the Head Start full-day pre-K program were compared with their peers with similar demographic characteristics and school readiness who did not have MCPS pre-K experience, it was expected that the two groups would perform at the same level academically by the end of kindergarten. The results in the study indicate that the Head Start full-day pre-K group performed higher than expected. Students in the Head Start full-day pre-K program were more likely to meet the kindergarten reading benchmark Level 4 compared with their peers without MCPS pre-K experience. The larger sustained impact was for African American and female students, and students receiving FARMS services in the Head Start full-day pre-K program. The program effect sizes were large enough to have practical importance in education.

In general, the Head Start full-day pre-K program effects still existed by the end of kindergarten. There is no evidence to suggest the disappearance of the Head Start full-day pre-K program effect by the end of kindergarten. There is enough evidence to show sustained impact by the end of kindergarten, especially in favor of African American students in the Head Start full-day pre-K program.

However, the larger positive program impact observed for Hispanic students and ESOL recipients during the pre-K year (Zhao, Modarresi and Liu, 2009) seems to have decreased by the end of

kindergarten. Further analyses show most ESOL recipients were of Hispanic origin. The decreased impact may be related to limited English proficiency of these students.

According to second language acquisition theory by Jim Cummins, conversational fluency is often acquired within about two years of initial exposure to the second language (Cummins, 1979). Cognitive Academic Language Proficiency, the language of academic subjects that involves more abstract vocabulary and concepts, can take five to seven years to acquire (Collier, 1987; Klesmer, 1994; Cummins, 1979 and 1981). For many students receiving ESOL services, schools are the main locations where they are exposed to academic English. It may take a longer time for these students to develop Academic English proficiency beyond pre-K programs. Without extended support, these ESOL recipients might gradually lag behind their non-ESOL counterparts. The reduced lasting full-day pre-K impact may even signal the beginning of achievement gaps.

Students who attended the Head Start full-day pre-K program performed at the same level on mathematics as those in the comparison groups. Contrary to the expectation, no significant differences were detected in mathematics between the Head Start full-day pre-K students and their peers in comparison groups. Lack of significant higher performance for the Head Start full-day pre-K students on mathematics may be related to the pre-K curricula which focus more on literacy and language arts.

Students who attended any MCPS pre-K program required fewer weekly hours of special education services, compared with those who did not attend an MCPS pre-K program. The reduction in special education services for Head Start full-day pre-K students is statistically significant.

The investment in the pre-K program may have contributed to cost saving in the form of reduced special education services later. Some plausible reasons may include early identification, early intervention, psychological consultation to teachers and parents, social work services, and intervention to families during the pre-K year. The focused support in pre-K programs may lead to reduced needs for special education services in kindergarten.

Recommendations

1. Examine factors related to mathematics instruction (such as scheduling, grouping, and materials) in pre-K and kindergarten classes in comparison with reading instruction.
2. Examine current models for ESOL services to determine how to best support the ESOL students.
3. Conduct a formative evaluation of the pre-K program using a multimethod data collection strategy that includes classroom observations, stakeholder surveys, and document analyses. The evaluation information will provide inductively derived success factors that may have contributed to the effectiveness of pre-K programs in improving students' reading skills and reducing required special education services.
4. Replicate the outcome study on a different student cohort to see if the observed findings are replicable. Also, evaluate the long-term impact of full-day pre-K program in later grades.

Limitations

Babbie (1992) notes that only a classical experiment with random assignment of subjects to different levels of treatment guards against each of the sources of internal invalidity in a study (e.g., selection bias, maturation, history, mortality). Due to lack of randomization, the current evaluation used statistical control (quasi-experimental design) to investigate lasting impact of the Head Start full-day pre-K program by the end of kindergarten.

A major issue with employing quasi-experimental design is that students in the treatment and comparison groups may have important differences before an intervention that may influence outcomes. The covariate model and propensity score matching can statistically control for differences reflected in the variables used. However, variables not used in the models may result in the observed differences. If so, this will consequently threaten the internal validity of the evaluation findings (Gay & Airasian, 2000; Shadish, Cook, & Campbell, 2002).

In this evaluation study, causal conclusions about the lasting effects of the Head Start full-day pre-K program on kindergarten academic achievement or on special education services may not be definitively inferred from the results. However, the use of propensity scores in the analyses has greatly improved the internal validity of the study.

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APPENDIX A

Table A1
Students' Characteristics for the Original 2007–2008 MCPS Pre-K Cohort
by Program (N=2,538)

	Head Start half day		Head Start full day		MCPS half day	
	N	*%*	*N*	*%*	*N*	*%*
Total	391		260		1,887	
Gender						
Male	184	47.1	140	53.8	949	50.3
Female	207	52.9	120	46.2	938	49.7
Race/ethnicity						
African American	192	49.1	90	34.6	585	31.0
Asian American	28	7.2	23	8.8	235	12.5
Hispanic	138	35.3	131	50.4	972	51.5
White	33	8.4	15	5.8	94	5.0
Services provided						
Special Education	30	7.7	24	9.2	78	4.1
ESOL	127	32.5	165	63.5	1,077	57.1

Note. American Indian students were included in the total but not reported separately.

Table A2
Family Background for the Original 2007–2008 MCPS
Pre-K Cohort by Pre-K Program (N=2,538)

	Head Start half day		Head Start full day		MCPS half day	
	Mean	Median	Mean	Median	Mean	Median
Total family income	$13,872	$13,200	$15,944	$15,523	$28,638	$28,000
Income per person	$3,616	$3,485	$4,153	$4,108	$7,452	$7,467
Female guardian's age	31	30	32	31	32	31
Male guardian's age	36	37	37	37	36	36
Female guardian's education (yrs.)	12	12	12	12	12	12
Male guardian's education (yrs.)	12	12	12	12	12	12
Family size	4	4	4	4	4	4

Table A3
Percentage of Kindergarten Students Ready for School on
Maryland Model of School Readiness Report in Fall 2009
by Head Start Pre-K Program

	Total N	Develop readiness %	Approach readiness %	Fully ready %
All				
HS full day	209	1.0	28.7	70.3
HS half day	244	4.9	31.1	63.9
Female				
HS full day	99	1.0	20.2	78.8
HS half day	133	3.8	24.1	72.2
Male				
HS full day	110	0.9	36.4	62.7
HS half day	111	6.3	39.6	54.1
African American				
HS full day	76	2.6	21.1	76.3
HS half day	125	4.0	31.2	64.8
Asian American				
HS full day	19	0	31.6	68.4
HS half day	22	4.5	22.7	72.7
Hispanic				
HS full day	104	0	36.5	63.5
HS half day	73	6.8	35.6	57.5
White				
HS full day	9	0	0	100
HS half day	24	4.2	25.0	70.8
FARMS				
HS full day	186	1.1	29.6	69.4
HS half day	216	5.1	30.6	64.4
ESOL				
HS full day	142	0.7	32.4	66.9
HS half day	98	9.2	31.6	59.2

Note. American Indian students were included but not reported separately. Results should be interpreted with caution for groups with fewer than 30 students. Results may not add up to 100 due to rounding.
HS = head start

Table A4
Percentage of Students Meeting Kindergarten Reading Level 4
and Level 6 in 2009 by Head Start Pre-K Program

	N	Met Level 4 %	Odds ratio for Level 4	Met Level 6 %	Odds ratio for Level 6
All					
HS full day	254	88.4	1.79	63.4	1.44
HS half day	216	84.3		59.1	
Female					
HS full day	103	89.3	2.01	66.9	1.89
HS half day	137	87.6		61.3	
Male					
HS full day	113	87.6	1.56	60.2	0.91
HS half day	117	80.3		56.4	
African American					
HS full day	77	92.1	6.05	68.8	3.51
HS half day	135	82.9		57.0	
Asian American					
HS full day	20	100	NA	65.0	NA
HS half day	22	95.5		77.3	
Hispanic					
HS full day	107	85.1	0.54	58.9	0.47
HS half day	73	82.2		56.2	
White					
HS full day	11	72.7	NA	63.6	NA
HS half day	24	87.5		62.5	
FARMS					
HS full day	192	87.5	1.65	62.5	1.42
HS half day	225	84.4		57.8	
ESOL					
HS full day	145	86.9	0.60	60.7	0.47
HS half day	98	81.6		52.0	

Note. American Indian students were included but not reported separately. No odds ratio was calculated for a group if the sample size was fewer than 30 students. Results may not add up to 100 due to rounding.
HS = head start

Table A5
Average Weekly Hours in Special Education Services Received by MCPS
Kindergarten Students in 2009 by Pre-K Experience

	N of students	N of SE students	Mean hours weekly	SD
Head Start full day	254	24	3.5	5.2
Head Start half day	216	29	4.9	7.4
MCPS half day	1542	93	4.2	6.6

Note. Includes students who stayed in the MCPS with complete data by the end of kindergarten, without statistical control.
SE = special education; SD = standard deviation.

APPENDIX B

**Replicating Kindergarten Reading and Mathematics Results from Matching Procedures
With Covariate-Adjusted Logistic Regression Model**

Replicating Results for MMSR and Kindergarten Mathematics Assessments

The analyses from the matching procedures were repeated using a covariate-adjusted ANCOVA model. Where sample sizes were adequate, the demographics and background variables were included in the ANCOVA models along with the propensity score to control for any remaining imbalance between groups of students not accounted for by the categorized propensity score. Five hundred students in the MCPS half-day pre-K program were selected randomly to maintain a more balanced design for comparison. Among them, 286 students with complete data on all the measures were included in the analyses. On average, there were no significant differences between the performance of the two groups of students on the mean score for school readiness and mathematics achievement. Findings are presented below in Table B1.

Table B1
Adjusted Means and Treatment Effect for Students in the Head Start Full-day Pre-K
and MCPS Half-day Pre-K Programs

	Adjusted Means				Treatment Effect		
	Head Start full-day students		MCPS half-day students		Mean difference	St. error	Effect size
Outcome Measure	Mean	N	Mean	N			
MMSR composite	75.00	145	74.58	286	0.42	1.30	0.04
K on-grade math	86.60	148	86.89	286	-0.29	1.58	-0.02
K above-grade math	41.11	148	44.81	286	-3.69	2.98	-0.14

Replicating Results for Meeting Kindergarten Benchmarks

The analyses from the matching procedures were repeated using a covariate-adjusted logistic regression model. Where sample sizes were adequate, the demographics and background variables were included in the analyses along with the propensity score to control for any remaining imbalance between groups of students not accounted for by the categorized propensity score. Five hundred students in MCPS half-day classes were selected randomly to maintain a more balanced design for comparison. Among them, only those students with complete data on all the measures were included in the analyses.

The results indicate that the probability (or chance) of meeting the Level 4 reading benchmark for those kindergarten students who attended the Head Start full-day pre-K program (n=150) was higher than for students in the MCPS half-day pre-K program (n=292). Specifically, the odds ratio was 1.49 in favor of the Head Start full-day pre-K participants on meeting the Level 4 reading benchmark. This finding indicates that kindergarten students who attended the Head Start full-day pre-K program had a 49 percent greater probability of meeting the Level 4 reading

benchmark than their peers who attended the MCPS half-day program in the previous year. This finding is further supported by the calculated effect size (0.22).

The same analyses were repeated for advanced reading at Level 6. The probability (or chance) of meeting the advanced reading Level 6 benchmark for those kindergarten students who attended the Head Start full-day pre-K program (n=150) was only slightly higher than for those who attended the MCPS half-day pre-K program (n=292). The estimated odds ratio of 1.036 suggests that students who received the Head Start full day program in the previous year had only a 3.6 percent greater probability of meeting the kindergarten advanced reading Level 6 benchmark than those students with MCPS half-day pre-K experience. The negligible effect size (0.02) supports the findings from the logistic regression.