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Enrollment in Public-prekindergarten and School Readiness Skills at Kindergarten Entry:

Differential Associations by Home Language, Income, and Program Characteristics

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Abstract

The present study examined differences in school readiness skills in the fall of kindergarten between pre-K attendees and non-attenders (n = 2,581) among children in a large, diverse county. Also considered was the extent to which skills associated with pre-K enrollment varied as a function of children's background characteristics and features of their pre-K program. Results revealed pre-K attenders demonstrated better academic and executive function skills in the first months of kindergarten than non-attenders; no consistent differences were detected for teachers' reports of children's socioemotional adjustment. Differences in academic skills and self-regulation associated with attendance in pre-K were largest for dual language learners and children from the lowest-income families. Children enrolled in private pre-K programs demonstrated less optimal socioemotional skills at kindergarten entry.

Keywords: low-income children; public pre-kindergarten; school readiness, Dual Language Learners

Enrollment in Public-Prekindergarten and School Readiness Skills at Kindergarten Entry: Differential Associations by Home Language, Income, and Program Characteristics

Public investment in early childhood education serves as an important means of mitigating opportunity and performance gaps that have long-term consequences for individual children and for society (Phillips et al., 2017; Yoshikawa et al., 2013). At present, roughly seven in ten 4-year-olds attend preschool (Friedman-Krauss et al., 2018); more than 40 states now serve about 1.5 million children and Head Start serves an additional one million children per year (Friedman-Krauss et al., 2018). Even with the growing evidence regarding the short-term benefits of pre-K participation, there is a need for examining the conditions under which those benefits are the largest or most likely to last (Barnett et al., 2018; Phillips et al., 2017). That is, not all pre-K programs or classrooms are equally effective and not all children benefit equally from program participation. Understanding variations in programs' benefits is particularly salient in the context of the rapid growth in young dual language learners (DLLs) who may disproportionately benefit from early education experiences while at the same time press on such programs for providing language-appropriate educational experiences (Batalova & McHugh, 2010). As such, investigating variation in pre-K enrollee outcomes as a function of program, classroom, and demographic variation, particularly within the increasingly diverse demography of families who enroll their children in pre-K, may illuminate what can be done to improve those benefits, regardless of their magnitude.

To better understand the conditions that contribute to variation in the association between children's performance and pre-K attendance, the present study examines differences in school readiness skills in the fall of kindergarten in the 2016-2017 academic year between pre-K attenders and a group of non-attenders (matched for pre-K eligibility and elementary school), and

the extent to which any detected associations varied as a function of children's home language and income status, the program auspice, and quality of the pre-K classroom. The current study was conducted within a large a diverse jurisdiction, which has been operating a public pre-K model for more than a decade. The reported results not only contribute to the literature on large-scale implementation studies of contemporary pre-K programs, but more uniquely, examines possible variation in those benefits as a function of the nature and quality of the feeder pre-K program and classroom, as well as heterogeneity in home language and income-status, demographic features shaping the design and delivery of early learning programs (Batalova & McHugh, 2010).

Attendance in Pre-K and Children's School Readiness

Even though the majority of low-income children attend a public preschool, it remains the case that almost half perform poorly in academic and social-emotional skills (Isaacs, 2012; Williford, Downer, Hamre, & Pianta, 2014), with only a quarter of children across the country meeting expectations for literacy and math when they enter kindergarten (Bernstein, West, Newsham, & Reid, 2014). Particularly relevant to the present study and to contemporary pre-K programs, the risk of low performance at kindergarten entry is exacerbated for children who enter school acquiring two languages simultaneously, and learn a second language while continuing to acquire their first (i.e., DLLs; Hindman & Wasik, 2015).

Public pre-kindergarten programs are an opportunity to ameliorate these gaps, as indicated by the analysis of Barnett and colleagues (2018) showing modest, population-level, pre-K effects for language skills, somewhat greater benefits for math, and large effects for early literacy across several states. Similar patterns have been documented in studies of targeted state-funded pre-K programs in New Jersey, North Carolina, Maryland, and Texas, finding small to

modest effects on reading and math in addition to reductions in retention and special education rates (Andrews, Jargowsky, & Kuhne, 2012; Barnett et al., 2013; Frede, Jung, Barnett, & Figueras, 2009; Ladd, Muschkin, & Dodge, 2014).

Notwithstanding the consistent detection of modest pre-K impacts, it is important to emphasize the ample evidence of variation in such benefits, whether across states (Barnett et al., 2018), across time or grade levels (Lipsey et al., 2018), or across program auspices or classroom quality (Pianta et al., in press). Perhaps more important to note is the changing nature of pre-K enrollment, program emphasis, and saturation in a given community or state (Barnett et al., 2017), each of which may influence estimates of effects across time and conditions. Over the past decade, preschool for children from low-income families has increased in its coverage of this population, while demographic shifts in the population of young children from low-income families and shifts in program eligibility requirements have led to a large proportion of DLLs in pre-K (e.g., Cannon, Jacknowitz, & Karoly, 2012). Moreover, as states have looked to expand early education programs to younger children (e.g., 3-year-olds) and to serve a higher percentage of the low-income population, private providers and community-based programs have enrolled children through mechanisms such as publicly funded slots, thus diversifying the auspices under which programs operate. And as the pre-K sector has matured programmatically over the course of the last two to three decades, the emphasis on programs having an educational focus, on curricula and assessment, and on accountability has increased notably, a trend that has likely shifted the nature of experiences offered to children in classrooms. For these reasons—shifts in population demographics, mixed auspices operating programs, press to increase educational focus and outcomes—today's pre-K programs may not be the same as pre-K in 1995 or 2010. Analysis of associations between enrollment and children's learning from contemporary, mixed-

auspice programs, serving highly diverse language and cultural backgrounds, with increased attention to educational aims can illuminate further the conditions under which pre-kindergarten may have its highest potential.

Heterogeneity in Pre-K Effects

To better understand the benefits of pre-K educational experiences, identify conditions under which programs have greatest benefit, and examine explanations for declining longer-term effects, investigations must extend beyond reporting average effects of enrollment to focus on for whom pre-K works, under what conditions, and for which outcomes (Duncan & Magnuson, 2013; Phillips et al., 2017). As noted above, this shift in focus is even more important in the context of shifting demography in the under-five population, increasing attention on improving classroom quality, and expanding access through mixed auspice services. The present study considers heterogeneity in pre-K effects by: 1) child and family characteristics, 2) program characteristics, and 3) child outcomes.

Heterogeneity in pre-K effects by child and family characteristics. The child characteristics most often identified as accounting for school success reflect combinations of financial, educational, and cultural variables that often forecast poor performance for a large number of children (Duncan, Ludwig, & Magnuson, 2007; Reardon, 2011). Children from low-income backgrounds are almost a year behind at school entry in academic and language skills (Denton, Flanagan, & McPhee, 2009; Halle et al., 2009)—factors that publicly funded pre-K programs were designed to counteract. And although pre-K experience can benefit children from all family backgrounds, evidence also shows that children from low-income households benefit more (Bassok, 2010; Gormley & Gayer, 2005; Loeb, Bridges, Bassok, Fuller, & Rumberger, 2007; Magnuson, Ruhm, & Waldfogel, 2007; Weiland & Yoshikawa, 2013). This apparent

benefit of pre-K is not confined to state-run programs but was also detected in Head Start (Bloom & Weiland, 2015). Thus, as states' early learning systems continue to evolve, stakeholder decisions that have large financial and programmatic consequences—for example, how to reach out to underserved communities and which communities to target—could be informed by understanding the nature and extent of differences in programs' impact for children of different income backgrounds.

In addition to income, another demographic factor of pressing importance for pre-K programs is the rising numbers of DLLs and how to best respond to their educational needs. DLL children represent the fastest growing segment of the student body of the U.S. educational system (Batalova & McHugh, 2010) and are disproportionately distributed in the early grades. Accordingly, this demographic trend has far-reaching implications for education policy and practice, and it has resulted in increased interest in the school experiences of this population of children. Although linguistically diverse children are less likely than their non-minority peers to be enrolled in pre-K (Cannon et al., 2012), the expansion of publicly funded programs has increased DLL accessibility drastically. However, there are challenges in how to best support these children educationally (Garcia & Jensen, 2009). DLLs often enter preschool programs with little to no English exposure (Hindman & Wasik, 2015), and confront the task of learning a second language before having mastered their first. Nevertheless, research has found that pre-K participation can offer substantial benefits to DLL children when there are sufficient linguistic supports (Thomas & Collier, 2002). For example, a recent re-evaluation of the Head Start Impact Study by Bloom and Weiland (2015) revealed that DLL and Spanish-speaking children benefitted more from enrollment in Head Start than monolingual English speakers. Similar patterns have also emerged in other national (e.g., Magnuson, Lahaie, & Waldfogel, 2006) and

community evaluations (Gormley, 2008). Thus, these early learning programs could be particularly important for equalizing educational opportunity and outcomes in linguistically diverse populations and communities.

Heterogeneity in pre-K effects by program characteristics. Early education programs for 4-year olds operate under varying types of auspices and provide classroom experiences of varying quality, both of which may influence the benefits that accrue to attendees (Pianta et al., 2009; Barnett et al., 2018). For example, most state programs, such as the ones described earlier in Tennessee, Texas, and Oklahoma, may be operated by and/or located within public elementary schools, separate stand-alone child care centers, or Head Start centers. In some instances, pre-K operators blend funds from varying sources (e.g., state general funds, Title I, local funds, Head Start). Because of the confluence of funding streams, locations, operators, and funding levels, it has often been difficult to discern the extent to which one form of program provides greater benefits than others (Pianta et al., 2009). And although there is some evidence to suggest that, on average, public school-operated and -located programs may provide a greater benefit for children's academic success (Ansari et al., 2017; Grindal & Lopez, 2015; Magnuson et al., 2007), there is also compelling evidence that the benefits of programs vary widely across program sites, with programs located outside of schools also producing notable gains for children.

As noted earlier, the present investigation focuses on all students served by public pre-K programs across a large and diverse county. Low-income families may enroll their child in pre-K operated under three clearly-defined auspices: those located in and operated by the public school division; federally-funded Head Start; and community-based private preschools that allocate slots for eligible children. As in many localities, as multiple types of pre-K programs

have been developed in order to serve more, and different populations of, young children program auspice (public schools, Head Start, community programs) is a source of possible variation in program benefits. In this context, the present study examines the potential for heterogeneity in the benefits of pre-K across these three program types within a coordinated, county-wide approach to early education in the 2016-2017 school year.

As well, the quality of early education experiences offered to children in pre-K classrooms is also a potential explanation for variation in program benefits and a focus of increasing those benefits. In particular, children's experiences in classrooms, largely as a function of teacher practices and interactions such as instructional behavior, behavior management, and social support, are each elements of classroom experience related to learning gains (Auger, Farkas, Burchinal, Duncan, & Vandell, 2014; Burchinal et al., 2016; Chien et al., 2010; Keys et al., 2013). Children from low income families, DLLs, and those demonstrating problems in self-regulation also appear to benefit even more from exposure to high quality teaching interactions and practices (Pianta et al., in press), with multiple years of exposure leading to even greater benefits (Cash et al., 2018). Because these elements of classroom experience vary widely (Farkas et al., 2014) these factors are often one of the more common explanations for null, positive, or even negative effects of pre-K (Barnett et al., 2018; Keys et al, 2013; Phillips et al., 2017; Yoshikawa et al., 2013). The present study examines variation in features of pre-K classroom quality as one of several conditions that may influence variation in program benefits.

It is relevant to mention here that results from recent observations in the pre-K classrooms in which the pre-K attender group in the present study were enrolled, reveal that: (a) pre-K attenders were exposed to moderate quality pre-K classrooms (Pianta et al., 2019); and (b)

some form of instruction or learning activity for roughly a third of the time they spend in the pre-K classroom, with almost 30% of time devoted strictly to management and routine activities and another 40% devoted to non-academic or no content. These sample averages obscure considerable classroom-to-classroom variation in the level of exposure to instruction provided to the average child (Pianta et al., 2019). The present study examines fall kindergarten outcomes for this group of pre-K enrolled students compared with their non-attender peers in kindergarten.

Heterogeneity in pre-K effects by child outcome. The majority of studies of pre-K program impacts examine early literacy, language, and math skills as the primary outcomes (e.g., Barnett et al., 2018; Grindal & Lopez, 2015; Lipsey et al., 2018). In contrast, much less is known about the benefits of program participation for other dimensions of development, including children's socioemotional skills and executive functioning. This is a key gap in scientific knowledge because there is a large and growing literature indicating the foundational importance of executive functioning and socioemotional skills, not only as an indicator of competent adjustment in the classroom, but also as an underpinning of academic outcomes and long-term educational and life success (e.g., Heckman & Kautz, 2012; Jones, Greenberg, & Crowley, 2015; Masten et al., 2012; McClelland et al., 2013). Accordingly, relying on data that focus only on academic achievement greatly limits knowledge regarding the potential benefits of program participation.

The few studies of pre-K that consider both academic and non-academic outcomes have demonstrated mixed results. Some document negative associations between program participation and children's social-behavioral development (Ansari, 2018; Magnuson et al., 2007; National Institute of Child Health & Human Development [NICHD] Early Child Care Research Network, 2003), whereas others report positive or null effects (Forry, Davis & Welti,

2013; Puma et al., 2012; Weiland & Yoshikawa, 2013). As such, studies that include a wider range of school-readiness outcomes may help understand whether there is variation in program benefits as a function of domain of development.

An expanded consideration of child outcomes for understanding the conditions under which pre-K enrollment has greatest promise points to social adjustment and executive function as two areas of great interest, given indications of the importance of these skill domains to subsequent success in school (Duncan & Magnuson, 2011). Of note in this regard, among the county's pre-K programs, those classrooms located in the elementary schools and operated by the school system have had a pronounced focus on the importance of self-regulation. In fact, teacher professional development, curriculum, and assessment tools are each used systematically in an effort to bolster students' self-regulation skills. Teachers have received ongoing professional development describing the importance of self-regulation and training in a number of techniques to promote it, including mindfulness activities with children, teaching about emotions and emotion-words, and activities designed to promote impulse control, which are implemented in many classrooms. However there is not a school-division wide curriculum in self-regulation being implemented across pre-K or kindergarten classrooms. In this context, the present study may represent a specific opportunity to understand the extent to which a broader emphasis on self-regulation, without an accompanying curriculum, cascades into success for students.

The Current Study

For the purposes of understanding variation in the benefits of early learning programs as they feed into and align (or not) with the K-3 system, the pattern of skills and knowledge that children display as they enter kindergarten plays a unique role. This way of operationalizing

school readiness reflects one of the intended outcomes of public investment in preschool and is a primary goal for the educators involved in pre-K and elementary school programs. Preschoolers' skills in language, literacy, math, and social and self-regulation are the central focus of most states' early learning standards (Daily, Burkhauser, & Halle, 2010), the Federal Head Start early learning standards (U.S. Department of Health and Human Services, 2015), and a large amount of effort in the areas of curriculum, assessment, and professional development (e.g., Clements & Sarama, 2008). Therefore, these are the outcomes of interest in the present study.

The present study addresses the following research questions. 1) To what extent are there differences in school readiness skills in the fall of kindergarten between the population of pre-K attendees and a group of non-attenders (matched for pre-K eligibility and school), across academic, social, and executive function domains? Based on the extant literature we expect pre-k enrollment to be associated with significantly better skills across multiple domains of readiness. 2) To better understand the sources of variation in pre-K program benefits and the conditions influencing such variation, to what extent do the benefits of pre-K for performance across five different outcome domains vary as a function of children's poverty status and home language, along with features of the pre-K program (i.e., auspice and classroom quality)? Based on prior studies we expect that the benefits of pre-k enrollment are more likely to be present in children from lower income households and for children whose home language is not English, and we expect less-formal programs (e.g. community-based pre-K) to be associated with less benefit relative to other auspices.

Methods

The setting for the study is a culturally and linguistically diverse county, which has operated a mixed-delivery public early education system for more than a decade. The county's

average economic indicators mask a large and rapidly growing percentage of vulnerable families and children, including a very substantial immigrant population, with 18% of families in which neither parent is a U.S. citizen. Elementary school students in the district are highly diverse ethnically, with 39% white, 26% Hispanic, 19% Asian, 10% African American, and 6% other or mixed race/ethnicity. In kindergarten, 53% of children have a home language other than English, and 38% are identified as DLLs. Ten percent of students' families have no full-time wage earner and one third of children qualify as low-income (a 40% increase in the ten years prior to 2013). Thirty-eight percent of families describe themselves as having too little income to cover household needs, while 25% receive public assistance.

The county operates a large and well-funded public pre-K program that blends funding from federal, state, and local sources to target low-income children. The county governing body, the Office for Children (OFC) is the local Head Start/Early Head Start grantee and operates the state-funded pre-K program. The OFC delegates funds to be managed by the school district and local non-profit groups. Funding sources include Head Start, the state, Title I, and the county. The public schools and the county blends funds from these sources to provide low-cost or free pre-K to over 2,000 children. The vast majority (98%) of children enrolled in public pre-K attend one of two main full-day (6-6.5 hours) program types. The largest program (school-based pre-K), serving over 1,500 children, consists of pre-K classrooms within public elementary schools. The second largest program type (community-based pre-K), serving more than 400 children, consists of subsidized slots in private pre-K centers. Centers may be large or small, for profit or non-profit. Governance, policy, regulation, and funding of pre-K programs are all coordinated through the central authority of the OFC.

The county serves as a starting point for many families new to the U.S. and offers significant support at both the pre-K and elementary levels in English, Spanish, and several other languages. The OFC emphasizes support for children's home language during the pre-K years and provides professional development to child care providers. The public schools offer help lines in multiple languages, has bilingual staff members who help families with enrollment, integrates English for Speakers of Other Languages (ESOL) specialists into teaching and administrative teams, provides professional development to teachers on supporting DLLs, and runs two-way immersion programs. Children from families where a language other than English is spoken—over 50% of families—receive a language screener in kindergarten to qualify for ESOL services.

The county has made school readiness a major policy focus. The OFC works with local organizations to commit public and private funds to school readiness initiatives throughout the county. This collaborative work includes administering neighborhood school readiness teams, which bring teachers, administrators, and community leaders together to problem-solve around local neighborhood barriers to readiness and to assist in developing supports for transition into pre-K and kindergarten. The county and the school district also provide professional development to early childhood professionals, lead the regional Quality Rating and Improvement System and in putting substantial focus on self-regulation and social-emotional development in addition to academic school readiness. Of note, there is no county-wide or school-division-wide curriculum being used in the academic domains (literacy, math) or in self-regulation and social skills. Individual programs or schools may utilize specific curricula across their classrooms and teachers also draw upon their own resources and professional collaborations to identify what they consider appropriate educational activities for their students.

Recruitment of pre-K attenders

Pre-K teachers in the study were recruited from the entire population of public school and community-based pre-K program classrooms. All teachers in the public school program were eligible; in community programs teachers were eligible if they taught at a center in which more than five publicly funded pre-K children were enrolled. At the start, 156 teachers and their classrooms were initially recruited. With the assistance of program staff, researchers identified a list of community childcare centers that were either publicly funded (e.g., Head Start) or included slots for publicly funded children to attend. A flyer was sent to center directors describing the project, and staff followed up by contacting centers individually. If center directors indicated that they were interested in participating, researchers and program staff contacted teachers to describe the project in more detail and obtain teachers' consent. For the public schools, project information was distributed to teachers by the district coordinator. Teachers who opted to participate returned consent forms to the research team. Once a consent form was received, a teacher was considered to be enrolled in the study.

Of the 156 recruited teachers, 138 met eligibility requirements and enrolled in the study. A small subset of these enrolled teachers opted not to participate in teacher-level data collection (e.g., observations) but facilitated child assessments. The number of observed classrooms was 126. Lead pre-K teachers averaged 16.86 years of education and had 15.68 years of teaching experience. In terms of classroom characteristics, 51% of children were boys, 56% spoke a language other than English, and 77% were a racial/ethnic minority.

At the beginning of the school year, participating teachers sent all parents or guardians of students enrolled in their classroom a consent form and short family demographic survey. Children were eligible to participate if they were enrolled in the pre-K program, turned 4 years of

age by the start of the study, and were not receiving special education services (except for speech). Eighty percent of parents had children who were eligible to participate and consented to allow their child's participation in the study (1,498 out of 1,878 parents). Roughly 90% of these students were then successfully followed-up through the transition to kindergarten.

Recruitment of pre-K non-attenders

As all school-eligible children in the entire cohort enrolled for kindergarten entered their kindergarten classrooms, a separate pre-K non-attender sample was recruited within the elementary schools and kindergarten classrooms of the children who had attended pre-K. Pre-K non-attenders were considered eligible for recruitment if they: (1) did not attend a formal pre-K setting at the age of 4; (2) had a total family income less than 250% of the federal poverty index; and (3) attended kindergarten in the elementary school of children in the pre-K attendee sample (preferably the same kindergarten classroom). Using parent-reported data, collected by the district at the time of kindergarten enrollment, the research team determined each kindergarten enrollee's pre-K enrollment status. In elementary schools in which there were pre-K attendees enrolled in the study, if a parent or guardian indicated that a child attended family child care or had no preschool experience, they were eligible for recruitment into the non-attender group. The recruitment process for pre-K non-attenders proceeded within schools in which pre-K attendees were already enrolled, using the list of eligible non-attenders in that school. The plan was phased to prefer matching eligibility within the classroom; if there were no eligible non-pre-K matches in a classroom enrolling a pre-K sample child, recruitment then targeted within-school matches.

Similar to pre-K attender recruitment, kindergarten teachers (of the pre-K sample children) sent consent forms and family demographic surveys to eligible pre-K non-attenders'

parents or guardians. This process consented roughly 1,600 pre-K non-attenders. Using the income data that parents reported on the family demographic survey, we confirmed that about 80% of the consented children met the income eligibility criteria. If parents opted to not provide income data, children were included in the sample until income-to-needs data were obtained from the district.

All kindergarten teachers with at least one study-enrolled child (attender or non-attender) were eligible to participate in this study. Recruitment meetings with district leadership teams took place in June 2017 to maximize principal support and teacher recruitment efforts. Beginning in August 2017, district leadership personnel sent memos to principals and teachers with information about the study. A primary point of contact at each school aided in the distribution of flyers and consent forms. Of the 478 eligible teachers, more than 75% agreed to participate in all study components; 20% agreed only to allow the research team to assess participating students; and the remaining 5% of teachers refused participation or worked in a school (9) that declined participation. Of the consented kindergarten teachers, average age was 38 years six months; 77% were White, 5% African American, 1% Latina, and 17% identified with other racial or ethnic backgrounds. The kindergarten teachers averaged 9.7 years of teaching experience and 17.4 years of education.

Analytic sample of pre-K attenders and non-attenders. The analytic sample for the present study included children who were income-eligible for pre-K (attenders and non-attenders) and who were enrolled in the school division's kindergarten program. The total kindergarten sample included 2,581 children (1,247 non-attenders; 1,334 attenders), which represents roughly two-thirds of the kindergartners from low-income families in the county.

Demographic information on the pre-K attenders and non-attenders are presented in Table 1. Although we found no socioeconomic differences between pre-K attenders and non-attenders, children in the attender sample were roughly half a month older and there was a larger percentage of Hispanic students in the non-attender sample and a smaller percentage of Black students than in the pre-K attender sample. The pre-K attenders were also more likely to speak English than non-attenders, come from smaller families, have younger parents, and have parents who were less likely to be married but more likely to be living with a partner than non-attenders. Despite these differences, it is important to note that the magnitude of these differences were small, with an average standardized mean difference of less than 0.10.

Measures

Classroom type. As discussed above, the pre-K enrollees attended three types of pre-K classrooms, namely: (1) state-funded pre-K in elementary schools (72%), (2) Head Start (18%), or (3) private centers (10%). Pre-K classroom-type was classified as these three mutually exclusive groups.

The quality of teacher-child interactions in pre-K. For preschool attendees, we used the Classroom Assessment Scoring System pre-K (Pianta et al., 2008; CLASS pre-K) to measure teacher-child interactions at the classroom level with 11 dimensions on a seven-point scale; we composited these ratings across dimensions and across occasions of observation into a single overall domain of interaction quality ($\alpha = 0.85$). Each classroom was visited two or three times during the fall and spring of the pre-K year ($M = 2.60$, $SD = 0.52$). As part of these visits, observers conducted four cycles of observations (each cycle includes 15 minutes to observe, 10 minutes to score). All data collectors attended a two-day training session and were certified on the tool in order to conduct observations. Data collector reliability was maintained with

refresher training before data collection and regular calibration meetings. Twenty percent of all cycles (fall and spring) were double coded to determine inter-rater reliability (ICC =.725). For the purposes of the present investigation we used a median split to demarcate pre-K attendees who were enrolled in programs that were of higher (M = 4.79, SD = 0.22, min = 4.46, max =5.30) and lower quality (M = 4.05, SD = 0.34, min = 2.83, max =4.46).

School readiness outcomes. Children were assessed in the fall of kindergarten (September–November) by trained data collectors. Data collectors completed a one-day training prior to assessing children. Children were assessed in a quiet space, outside of the classroom when possible. All children were assessed in English with the entire battery unless their teacher indicated that they did not speak English well enough to understand simple directions. If teachers indicated that the child did not understand English well enough to follow simple directions, then Spanish-speaking children were assessed with parallel Spanish and English achievement measures and completed Spanish versions of the executive function measures. The present study utilizes the English-language achievement data for all children and the Spanish version of the executive function measures in the cases of students who completed the parallel Spanish and English achievement batteries. Because English is the language of instruction in the school division, we chose the English version of the academic achievement tests to be a common metric for outcomes of instruction. Because the executive function skills are not the focus of instruction and are conceptualized in the present study as a developmental competency shaped by a broader set of experiences, we used exact translations of the English assessments to create a common metric. Children who did not speak English or Spanish well enough to understand simple directions were not included in the study.

Academic achievement. Children's academic achievement was assessed with five subtests from the Woodcock Johnson III Psychoeducational Battery (WJ-III; Woodcock, McGrew, & Mather, 2001). Children's literacy skills were assessed with the Letter-Word Identification subtest of the WJ-III, which asked children to identify individual letters and words and is a test of early reading ($\alpha = 0.94$). Language skills were assessed with the WJ-III Picture Vocabulary subtest ($\alpha = 0.81$), which required that children identify objects that were depicted in a series of pictures. Two subscales of the WJ-III were also administered to measure children's math skills: 1) Applied Problems ($\alpha = 0.93$), which required that children perform basic math calculations in response to orally presented problems and 2) Quantitative Concepts ($\alpha = 0.91$), which required children to identify number patterns. Finally, children's general knowledge was assessed with the Academics Knowledge ($\alpha = 0.90$) subscale of the WJ-III, which assesses children's skills in the areas of science, social studies, and humanities. For these assessment batteries, we used the standard scores that were nationally normed and describe children's academic performance relative to the average performance of their same-age peers.

Executive functioning. Children's executive functioning skills were measured using three assessments. *Working memory* was measured using the Backwards Digit Span subtest (BDS; Carlson, 2005), which asked children to repeat sequences of numbers in reverse that increase in length. It has a median reliability coefficient of .88. This task has been widely used in the developmental literature as a test of working memory. Next, the Head-Toes-Knees-Shoulders assessment (HTKS; McClelland, Cameron, Connor, Farris, Jewkes, & Morrison, 2007) was used to examine a combination of children's *inhibitory control, attention, and working memory*. *Inhibitory control* was also assessed using an adapted version of a standard peg-tapping task with pencils rather than pegs (adapted from Diamond & Taylor, 1996; see

Smith-Donald, Raver, Hayes, & Richardson, 2007). This Pencil Tap assessment asks children to tap once when the assessor taps twice and vice versa. Percent of correct responses on this assessment has demonstrated good concurrent and construct validity with other measures of inhibitory control as well as predictive validity for school readiness outcomes such as phonemic awareness (Blair & Razza, 2007; Smith-Donald et al., 2007).

Socioemotional skills. Teachers rated each child on four general competencies using the Teacher-Child Rating Scale (Hightower, 1986). On a 5-point Likert scale (1 = *not at all*, 3 = *moderately well*, 5 = *very well*), teachers were directed to indicate how well a given characteristic described the child. The task orientation subscale comprised five items (e.g., completes work, well organized, functions well even with distractions, and works well without adult support; $\alpha = 0.92$). The peer social skills scale (e.g., has many friends, is friendly toward peers, and makes friends easily; $\alpha = 0.93$) and frustration tolerance scale (e.g., accepts things not going his/her way, ignores teasing, copes with failure $\alpha = 0.90$) were both also comprised of five items each. Finally, the conduct problems subscale included six items (e.g., disruptive in class, defiant, overly aggressive with their peers; $\alpha = 0.89$).

Analysis plan

Analyses of the associations between pre-K enrollment and children's school readiness outcomes at the start of kindergarten were addressed within a regression framework in Stata (StataCorp, 2009). All models accounted for the nesting of children in classrooms with clustered standard errors and, to address missing data on the covariates, moderators, and outcomes (average missing data was roughly 11%), 50 datasets were imputed using the chained equations method. Moreover, all focal continuous predictors and outcomes were standardized to have a mean of 0 and standard deviation of 1 and, thus, all coefficients can be interpreted as effect sizes.

With the above analytic framework in mind, the first set of analyses examined the associations between children's participation in pre-K at the age of 4 (vs. children who did not attend pre-K) and their academic, socioemotional, and executive functioning in the fall of kindergarten. In considering these associations, models were estimated with different specifications to ensure that findings are robust to analytic decisions. The first specification presents a simple bivariate comparison between pre-K attenders and non-attenders. To acknowledge selection bias; that is, children were not randomly assigned to attend pre-K or not, the second specification involves regression models that control for a set of child- and family-covariates that prior studies have found is associated with parents' enrollment decisions and children's early learning (Crosnoe, Purtell, Davis-Kean, Ansari, & Benner, 2016, Coley, Votruba-Drzal, Collins, & Miller, 2014). Models adjust for: child age, child gender, child race/ethnicity (White, Black, Hispanic, Asian/other), home language (English, Spanish, other), parent years of education, parent work hours, parent marital status (married, living with partner, separated or widowed, never married), income-to-needs-ratio, household size, number of children under 18 in the household, and parent age. Given that children were tested between the months of September and November, all models also control for the time between September 1st and the administration of the direct child assessments.

Although the above models address issues of selection on observable factors via covariate adjustment, concerns regarding selection bias may remain, as analytic specification is only as good as the covariates available. As a further step, the third specification added to the above regression models include classroom fixed effects (i.e., dummy variables for all classrooms in the sample). In this specification, the variance occurs within, rather than between, classrooms. That is, for the focal pre-K predictor, these models indicate the outcome differences

for pre-K graduates compared to their eligible *classmates* who did *not* attend pre-K, accounting for both unobserved and observed between-classroom variation that may exist in pre-K selection across kindergarten classrooms. The fourth and final main effects specification employed propensity score adjustment (Rosenbaum & Rubin, 1983). Although propensity scores do not change the causal identification strategy, this methodology does consider whether there is overlap in the unmatched sample and the functional form assumptions driving any findings. The nearest neighbor method was used (with up to four matches) with a caliper of .05, allowing a sufficient overlap between pre-K attenders and non-attenders on their propensity scores. This specification successfully matched over 95% of children and found that the average standardized mean difference after matching in covariates was only 0.01 and none were significantly different across conditions, suggesting balance was successfully achieved (matched descriptive analyses available from authors upon request). Regression models were re-estimated within these matched samples and, as a safeguard, included all covariates when predicting outcomes (doubly robust estimation; Funk et al., 2011).

Once the main effects of pre-K attendance were considered, attention turned to the primary aim of understanding potential variation in the benefits of pre-K as a function of child and program characteristics. When examining variation as a function of family background characteristics such as poverty (i.e., income-to-needs ratio) and DLL status, interaction terms were computed between pre-K enrollment and these demographic moderators and added to the full regression model, including the pre-K enrollment variable. When examining whether program impacts varied as a function of pre-K characteristics, including pre-K classroom type (i.e., no pre-K, Head Start, state pre-K, private center) and pre-K quality (i.e., no pre-K, low quality pre-K, and high quality pre-K), a new set of regression models were estimated

substituting these variables in place of the binary indicator for pre-K enrollment. Again, all moderation analyses were estimated with the full set of covariates, without classroom fixed effects or propensity scores. As a precaution, moderation models were then re-estimated with classroom fixed effects (both with child and classroom moderators) and propensity scores (child-level moderators only) and yielded quantitatively and qualitatively similar estimates to those reported below (results are available from the authors).

Results

Three overall patterns are evident in Table 2 with regard to the average associations between pre-K attendance and children's school readiness performance at the beginning of kindergarten. First, the associations between pre-K attendance and direct assessments of academic skills and executive functioning are moderate-to-large, on the order of 40% of a standard deviation for academics and roughly a quarter of a standard deviation for executive functioning. Second, the magnitude of the estimated associations derived from simple bivariate comparisons between pre-K attenders and non-attenders matched for income and program eligibility, did *not* change substantially when an assortment of demographic controls were included in the models as covariates, in models with classroom fixed effects, nor in propensity score models (see Table 2). A third pattern is the more modest and, in some cases, non-significant associations between pre-K attendance and kindergarten teachers' report of children's socioemotional skills. Of those measured, the largest differences were found for pre-K children's task orientation (ES = .15) and conduct problems (ES = .10), which teachers reported as being higher relative to non-pre-K children.

Having established a baseline set of associations reflecting the average benefit of pre-K enrollment for improved school readiness, the next set of analyses examined variation in these

associations as a function of children's home language and socioeconomic status (income-to-needs ratio). Results revealed that the associations between pre-K enrollment and achievement and one of the three dimensions of executive functioning (HTKS) were larger for DLLs than monolingual English speakers (see Table 3). In general, these associations were roughly 45% of a standard deviation larger for DLLs than non-DLLs. Children's language status did not moderate the association between pre-K enrollment and their socioemotional skills.

Notably, even though the sample was restricted to low-income households, the associations between pre-K and achievement and two of the three dimensions of executive functioning (PT and BDS) were larger for children at the lower end of the income distribution (see Table 3). More specifically, the academic benefits of pre-K were roughly 58%, 42%, and 26% standard deviation for children from families with an income to needs ratio of roughly 0.35 (one standard deviation below the mean on income), 1.08 (the mean of income), and 1.82 (one standard deviation above the mean on income), respectively. And although similar (albeit smaller) differences emerged across the income distribution for executive functioning, there were no differential associations between pre-K enrollment and the children's socioemotional development.

The final set of analyses examined the extent to which associations between pre-K participation and children's early learning varied as a function of classroom type and quality. In general, few differences emerged between classrooms: participation in *any* pre-K program (regardless of quality and type) was better than not attending (see Table 4). When contrasting specific pre-K classroom types, children who attended a private center at age 4 demonstrated less optimal socioemotional skills at the start of kindergarten as compared with those who attended state pre-K or Head Start, with effect sizes ranging from approximately 25 – 40% of a standard

deviation. Moreover, even though all children benefited academically from pre-K enrollment, these associations were somewhat smaller for children who participated in a private center for literacy (vs. children in Head Start [ES = 0.24] and state pre-K [ES = .20]) and academic knowledge (vs. children in state pre-K, ES = .20). And although there were few differences in programs' benefits as a function of classrooms of different quality, children who attended higher quality pre-K classrooms displayed stronger academic knowledge skills than those from lower quality pre-K classrooms (ES = .11).

Discussion

Publicly funded pre-K programs in the United States are now nearly ubiquitous. Including Head Start, in almost every school division across the country *some* form of pre-K opportunity exists for young children, particularly those from low-income households. These educational opportunities have been critiqued for underperforming relative to expectations, with questions related to lack of educational focus and the need for better curricula and more effective professional development (e.g., Ladd et al., 2014). However, a number of recent evaluations of programs operated at scale indicate that pre-K, on average, confers benefits to the children enrolled (for reviews see: Phillips et al., 2017; Yoshikawa et al., 2013). Yet in the context of acknowledging these general benefits of pre-K, programs and the populations served have changed dramatically over the last decade. The children served increasingly speak languages other than English; the growing number of children from low-income families has pressured programs to expand operations into new auspices that include private providers; and programs are under increasing pressure to have a more educational focus while at the same time we have learned more about the value of skills in executive functioning. Thus, close examination of the extent to which variations in contemporary pre-K programs and enrollees may also relate to

variation in pre-K program impacts not only deepens understanding of the overall value of pre-K for young children and communities, it also may provide a window on how to optimize such impacts. The present study provides such a lens on pre-K and its potential benefits.

Consistent with a number of state-level evaluations of public pre-K (e.g., Barnett et al., 2018), enrollment in a pre-K program was strongly associated with low-income children's school readiness (under several model specifications that adjusted for selection), regardless of whether enrollment was in community-based pre-K, Head Start, or the public schools' pre-K. At the start of kindergarten, children who spent the prior year enrolled in the county's public pre-K system, in contrast with low-income and language-diverse children not exposed to pre-K, performed significantly better in domains of achievement and executive function. These associations, particularly for academic skills, were about a quarter to half of the oft-cited achievement gap of one-standard deviation on standardized tests. Moreover, these associations reflecting the possible benefits of pre-K are not dissimilar from other studies, some of which have additional controls for selection, in which the benefits of pre-K range from roughly 0.25 – 1.15 *SD*. (e.g., Barnett et al., 2018; Phillips et al., 2017; Weiland & Yoshikawa, 2013). Although the present study did not use an experimental design, the pattern of positive associations across various methodological specifications reasonably suggests that children benefitted from attendance.

Although these results confirm that, on average, children's skills improved from exposure to pre-K, it is important to acknowledge that the educational opportunities provided to children varied considerably from classroom to classroom (Pianta et al., 2018). Prior studies with this sample characterizing the pre-K classroom experience reported: 1) extensive variation across classrooms in terms of qualities of teacher-child interaction and exposure to academic content, and 2) that these pre-K classrooms were somewhat more focused educationally and

instructionally than was typical a decade ago (Pianta et al., 2018). We speculate that the general benefits of pre-K detected here may in part reflect the strong and focused governance and experienced operations present in these programs, even if children's actual classroom experiences may vary. And, we also conjecture that such benefits might even be greater when program designs are more consistently implemented at the classroom level and more focused on academic, socioemotional, and executive function skills. Thus, initiatives focused on early education program leadership may be a promising direction for the field.

Although pre-K enrollment was, on average, beneficial for all children (perhaps as a consequence of strong operational capacity across the county system), those children attending pre-K classrooms characterized by higher quality teacher-child interactions demonstrated greater academic knowledge, while those enrolled in private child care appeared to not benefit as much. These findings are consistent with studies suggesting pre-K provided in classroom and school-based settings may be more effective than in private center-based programs (Ansari et al., 2017; Grindal & Lopez, 2015; Magnuson et al., 2007). In private or community-based child care such as those in the present sample, the likelihood of educationally-oriented experiences was observed to be somewhat lower than in pre-K classrooms operated within the public schools or in Head Start (Pianta et al., 2009; 2018). Thus, when taken together, these results affirm the potential benefits of contemporary pre-K programs provided under auspices with considerable operational capacity in early education. It may be relevant to note that the public school pre-K program required lead teachers to have a Bachelor's degree, and although most teachers across all pre-K auspices (community, Head Start, public school) had a college degree, it was possible that some teachers in the non-public-school classrooms did not. The results also support the need for attention to how operators support robust and consistent implementation of educationally-

oriented practice. Continued examination of variation in classroom-level experience as it relates to program-level designs and systems may assist efforts to understand and optimize benefits (Andrews, et al., 2012; Bernstein, et al., 2014).

Importantly, the results also indicate that associations between pre-K enrollment and children's school readiness were even larger for certain groups of children—those from lower-income households and non-English speakers. That is, pre-K enrollment helped reduce disparities in school readiness as a function of language and income. Such findings are consistent with a number of investigations, (Cannon et al., 2012; Fortuny et al., 2009; Hindman & Wasik, 2015) and demonstrate the value and potential of early educational programs for counteracting the challenges to child development posed by poverty as well as the role these programs can play in bridging home language and the language and culture of public schooling (Fortuny et al., 2009). This is particularly important when a child's home language can be a barrier to accessing educational resources, which at the start of formal school, may play a key role in reducing long-term inequality (Cannon et al., 2017; Grindal & Lopez, 2015). In considering why pre-K may have differential benefits for dual language learners, it is important to acknowledge the county's commitment and support for children's home language, resources provided through county and school system for non-English speaking families, and the provision of professional development to teachers to better understand and respond to the needs of non-English speakers.

Despite these contributions to the literature, the current study has a number of limitations. First, the design was not experimental; children were not assigned randomly to receive pre-K, and thus, the results reported herein do not support causal inference. However, the fact that the results replicate across various methodological specifications that place increasingly strict

control on selection bias lends greater confidence to our conclusions. Additionally, the results reported herein do not reflect the wide range of pre-K programs in operation across the country; it is a study of a single county's efforts and so there may be important variation in organizational and program structures and types, as well as classroom experiences that are not reflected. Consequently, the conclusions may not be widely generalizable. However, a focus on contemporary pre-K as it is implemented in the same location (e.g., Boston, Tulsa, etc.) can illuminate how certain conditions, and their combinations, may demonstrate promising options for other programs. As pointed out earlier, contemporary pre-K programs vary considerably from those of a decade ago in terms of populations served, operational auspices, programmatic focus, and awareness of the developmental importance of child outcomes such as executive functions. Finally, it should be mentioned that the outcome assessments chosen for this evaluation do not map directly onto the curricula in use or the instructional focus at the classroom level. As such, the use of these assessments may mask program effects (benefits or losses) that might be detected if the assessments used were more proximal to children's classroom experiences.

With these limitations in mind, the results of the present study confirm the promise of contemporary, scaled-up pre-K programs for promoting the early educational and developmental success of a diverse group of children from low-income backgrounds (e.g., Phillips et al., 2017; Yoshikawa et al., 2013). Importantly, the results suggest that benefits in general were consistent across program type, and for some outcomes were greater for dual language learners and when children attend a pre-K classroom with higher quality teacher-child interaction. Optimizing program benefits in the short term, and building on these early gains in the longer run have been of considerable challenge to educators and policymakers across the country, challenges that

include language diversity, expansion into private operators, and broadening of program scope and focus. Findings from this study suggest that such challenges, under certain district conditions, do not appear to override the benefits conferred by these programs and their contributions to the children, families, and communities they serve.

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Table 1.
Demographic Characteristics of the pre-K and no-pre-K samples

Variable	Non-pre-K attender		Pre-K attender		Sig. diff.
	M	SD	M	SD	
Kindergarten entry outcomes					
Academic achievement					
WJ-III Letter-Word Identification	89.86	15.52	96.09	12.30	***
WJ-III Picture Vocabulary	85.64	13.41	88.94	10.65	***
WJ-III Applied Problems	91.08	14.00	97.06	11.73	***
WJ-III Quantitative Concepts	86.97	14.97	90.69	13.61	***
WJ-III Academic Knowledge	81.55	15.41	86.92	13.16	***
Executive functioning					
Pencil Tap	0.78	0.30	0.86	0.23	***
Backward Digit Span	1.49	0.83	1.61	0.86	***
Head Toes Knees Shoulders	36.46	27.08	44.68	27.91	***
Socioemotional skills					
Frustration Tolerance	3.39	0.95	3.36	0.97	
Task Orientation	3.17	1.04	3.33	1.06	***
Peer Social Skills	3.89	0.86	3.92	0.88	
Conduct Problems	1.72	0.85	1.85	0.90	**
Child and family demographics					
Child age at kindergarten entry	5.41	0.32	5.45	0.29	**
Child male	0.48		0.50		
Child White	0.12		0.10		
Child Hispanic	0.64		0.60		*
Child Black	0.08		0.17		***
Child Asian/other	0.16		0.14		
Child home language English	0.15		0.20		***
Child home language Spanish	0.61		0.57		*
Child home language Other	0.25		0.23		
Household income-to-needs ratio	1.13	0.72	1.07	0.73	
Household size	5.07	1.54	4.84	1.42	***
Household members under 18	2.59	1.27	2.57	1.17	
Parent married	0.56		0.50		**
Parent living with partner	0.15		0.19		**
Parent separated or widowed	0.10		0.13		
Parent never married	0.19		0.19		
Parent age	33.47	7.10	34.15	7.10	*
Parent years of education	11.78	3.72	11.74	3.70	
Parent hours of employment	25.87	15.21	27.10	13.97	
Sample size	1,247		1,334		

Notes. Proportions may not sum to 1.00 due to rounding. *** $p < .001$. ** $p < .01$. * $p < .05$.

Table 2.
Associations between pre-K attendance and children's early learning and development.

Outcome	Bivariate model	Covariate adjusted model	Classroom fixed effects model	Propensity score model
Academic achievement				
WJ-III Letter-Word Identification	0.44 ***	0.53 ***	0.53 ***	0.52 ***
	(0.04)	(0.04)	(0.05)	(0.05)
WJ-III Picture Vocabulary	0.36 ***	0.33 ***	0.37 ***	0.33 ***
	(0.04)	(0.04)	(0.05)	(0.04)
WJ-III Applied Problems	0.48 ***	0.47 ***	0.52 ***	0.48 ***
	(0.04)	(0.04)	(0.05)	(0.05)
WJ-III Quantitative Concepts	0.30 ***	0.36 ***	0.36 ***	0.36 ***
	(0.04)	(0.04)	(0.05)	(0.05)
WJ-III Academic Knowledge	0.44 ***	0.40 ***	0.47 ***	0.40 ***
	(0.04)	(0.04)	(0.05)	(0.05)
Executive functioning				
Pencil Tap	0.30 ***	0.31 ***	0.35 ***	0.32 ***
	(0.04)	(0.04)	(0.06)	(0.05)
Backward Digit Span	0.14 ***	0.18 ***	0.19 ***	0.20 ***
	(0.04)	(0.04)	(0.05)	(0.05)
Head Toes Knees Shoulders	0.29 ***	0.29 ***	0.32 ***	0.31 ***
	(0.04)	(0.04)	(0.05)	(0.05)
Socioemotional skills				
Frustration Tolerance	-0.04	-0.01	-0.05	-0.00
	(0.05)	(0.05)	(0.06)	(0.06)
Task Orientation	0.14 **	0.15 **	0.12 *	0.16 **
	(0.05)	(0.05)	(0.06)	(0.06)
Peer Social Skills	0.02	0.01	-0.03	0.02
	(0.05)	(0.06)	(0.06)	(0.06)
Conduct Problems	0.15 **	0.10 *	0.15 **	0.09
	(0.05)	(0.05)	(0.06)	(0.06)
Sample size	2,581	2,581	2,581	2,482-2,531 [a]

Notes. The covariate adjusted model and classroom fixed effects model controlled for all covariates listed in Table 1. All focal continuous variables have been standardized to have a mean of 0 and standard deviation of 1, and thus, estimates correspond to effect sizes. Estimates in parentheses correspond to standard errors. [a] Sample sizes in the matched samples vary across the 50 imputed datasets.
*** $p < .001$. ** $p < .01$. * $p < .05$.

Table 3.
Heterogeneity in the associations between pre-K enrollment and children's early learning and development as a function of child characteristics.

Outcome	Pre-K X income-to-needs ratio	Pre-K X Spanish (vs. English)	Pre-K X other (vs. English)
Academic achievement			
WJ-III Letter-Word Identification	-0.15 ***	0.46 ***	0.22
	(0.04)	(0.10)	(0.12)
WJ-III Picture Vocabulary	-0.18 ***	0.57 ***	0.49 ***
	(0.04)	(0.09)	(0.11)
WJ-III Applied Problems	-0.17 ***	0.34 ***	0.34 **
	(0.04)	(0.10)	(0.12)
WJ-III Quantitative Concepts	-0.12 **	0.37 ***	0.31 *
	(0.05)	(0.10)	(0.12)
WJ-III Academic Knowledge	-0.19 ***	0.60 ***	0.56 ***
	(0.04)	(0.10)	(0.11)
Executive functioning			
Pencil Tap	-0.09 *	0.08	0.06
	(0.04)	(0.10)	(0.12)
Backward Digit Span	-0.11 *	0.12	0.23
	(0.05)	(0.12)	(0.15)
Head Toes Knees Shoulders	-0.06	0.34 **	0.41 **
	(0.04)	(0.12)	(0.13)
Socioemotional skills			
Frustration Tolerance	-0.07	0.06	0.06
	(0.05)	(0.12)	(0.14)
Task Orientation	-0.05	0.13	0.10
	(0.05)	(0.12)	(0.13)
Peer Social Skills	-0.03	0.11	0.19
	(0.05)	(0.13)	(0.14)
Conduct Problems	0.08	-0.08	-0.03
	(0.05)	(0.12)	(0.14)

Notes. All models controlled for the covariates listed in Table 1. All focal continuous variables have been standardized to have a mean of 0 and standard deviation of 1, and thus, estimates correspond to effect sizes. Estimates in parentheses correspond to standard errors. The final sample size is 2,581. *** $p < .001$. ** $p < .01$. * $p < .05$.

Table 4.
Heterogeneity in the associations between pre-K enrollment and children's early learning and development as a function of pre-K classroom type and quality.

Outcome	Variation as a function of pre-K classroom type						Variation as a function of pre-K classroom quality		
	State pre-K vs. no pre-K	Head Start vs. no pre-K	Private center vs. no pre-K	State pre-K vs. Head Start	State pre-K vs. private center	Private center vs. Head Start	Low quality pre-K vs. no pre-K	High quality pre-K vs. no pre-K	High quality pre-K vs. low quality pre-K
Academic achievement									
WJ-III Letter-Word Identification	0.55 ***	0.59 ***	0.35 ***	-0.04	0.20 *	-0.24 *	0.53 ***	0.55 ***	0.02
	(0.04)	(0.06)	(0.09)	(0.06)	(0.09)	(0.10)	(0.05)	(0.05)	(0.05)
WJ-III Picture Vocabulary	0.34 ***	0.35 ***	0.26 ***	-0.01	0.08	-0.09	0.31 ***	0.36 ***	0.05
	(0.04)	(0.06)	(0.08)	(0.06)	(0.08)	(0.09)	(0.05)	(0.05)	(0.05)
WJ-III Applied Problems	0.49 ***	0.49 ***	0.34 ***	-0.00	0.15	-0.15	0.43 ***	0.53 ***	0.10
	(0.05)	(0.07)	(0.09)	(0.07)	(0.09)	(0.11)	(0.05)	(0.05)	(0.06)
WJ-III Quantitative Concepts	0.36 ***	0.43 ***	0.24 **	-0.07	0.13	-0.20	0.34 ***	0.39 ***	0.05
	(0.04)	(0.07)	(0.09)	(0.07)	(0.09)	(0.11)	(0.05)	(0.05)	(0.06)
WJ-III Academic Knowledge	0.43 ***	0.40 ***	0.23 **	0.03	0.20 *	-0.17	0.34 ***	0.45 ***	0.11 *
	(0.04)	(0.07)	(0.08)	(0.07)	(0.08)	(0.10)	(0.05)	(0.05)	(0.05)
Executive functioning									
Pencil Tap	0.32 ***	0.32 ***	0.24 **	0.00	0.09	-0.08	0.34 ***	0.31 ***	-0.02
	(0.05)	(0.07)	(0.08)	(0.07)	(0.08)	(0.10)	(0.05)	(0.05)	(0.05)
Backward Digit Span	0.20 ***	0.17 *	0.09	0.03	0.11	-0.08	0.16 **	0.21 ***	0.06
	(0.05)	(0.07)	(0.11)	(0.07)	(0.11)	(0.12)	(0.05)	(0.05)	(0.06)
Head Toes Knees Shoulders	0.32 ***	0.25 ***	0.18	0.07	0.13	-0.07	0.30 ***	0.30 ***	0.00
	(0.04)	(0.07)	(0.10)	(0.08)	(0.11)	(0.12)	(0.05)	(0.05)	(0.06)
Socioemotional skills									
Frustration Tolerance	-0.00	0.09	-0.24 *	-0.09	0.24 *	-0.34 *	-0.04	0.01	0.05
	(0.06)	(0.09)	(0.11)	(0.09)	(0.12)	(0.14)	(0.07)	(0.06)	(0.07)

Task Orientation	0.16 **	0.28 ***	-0.14	-0.12	0.30 **	-0.42 **	0.12	0.19 ***	0.08
	(0.05)	(0.08)	(0.11)	(0.08)	(0.11)	(0.13)	(0.06)	(0.06)	(0.06)
Peer Social Skills	0.02	0.15	-0.23	-0.13	0.25 *	-0.38 *	0.02	0.01	-0.01
	(0.06)	(0.09)	(0.12)	(0.09)	(0.12)	(0.15)	(0.07)	(0.07)	(0.07)
Conduct Problems	0.10	-0.04	0.36 ***	0.14	-0.26 *	0.40 **	0.16 *	0.05	-0.11
	(0.05)	(0.09)	(0.11)	(0.08)	(0.11)	(0.14)	(0.06)	(0.06)	(0.07)

Notes. All models controlled for the covariates listed in Table 1. All focal continuous variables have been standardized to have a mean of 0 and standard deviation of 1, and thus, estimates correspond to effect sizes. Estimates in parentheses correspond to standard errors. The final sample size is 2,581. *** $p < .001$. ** $p < .01$. * $p < .05$.