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Kindergarten academic and social skills and exposure to peers with pre-kindergarten experience

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ABSTRACT

Pre-kindergarten (pre-k) is thought to have both direct and indirect effects on children's outcomes in early elementary school. Direct pre-k effectsconsistently include moderate to large gains in academic skills and sometimes include increases in problem behaviors that affect acquisition of skills in school. Indirect pre-k effects assume that having more pre-k attenders in classrooms motivates teachers to provide more challenging instruction and provide children with more academically skilled, but perhaps behaviorally challenged peers with whom they interact. To date, these indirect effects have not been carefully examined. This study used a district-wide cohort study of a pre-k program (n = 2572 children, 482 kindergarten classrooms) to examine whether the proportion of children in kindergarten classrooms with pre-k experience related to gains in children's academic, executive function, and social skills during kindergarten. Results indicated that schools with more pre-k attenders served more children from low-income families and children of color. The quality of instruction in classrooms with more pre-k attenders was rated as slightly higher in terms of instructional support and focus on abstract learning when school composition was not considered. Teachers reported less focus on teachers-parent coordination of home learning in classrooms with more pre-k attenders. Children with more classmates who attended pre-k, regardless of their own pre-k attendance histories, showed slightly larger gains in vocabulary and inhibitory control skills but also showed smaller increases in ability to manage frustration. When taken together, findings may indicate that peers influence young children's verbal and social skills, but do not support speculation that increasing pre-k exposure would improve reading or math skills overall or lead to more externalizing behavior problems.

Wide-scale attention to the benefits of formal early care and education (ECE) settings in general (Burchinal, Magnuson, Powell, & Hong, 2015) and pre-kindergarten (pre-k) programs more specifically (Phillips et al., 2017) raise questions about whether the increasing percentage of children with formal ECE experience in kindergarten classrooms changes the kindergarten experience. Both positive academic and negative social-emotional effects of exposure to peers who attended pre-k have been hypothesized due to direct and indirect peer effects (Belsky, 2001; Ladd, Muschkin, & Dodge, 2014), but few studies have examined this issue. Direct peer effects are expected through interactions with classmates and indirect peer effects through changes in instruction and teacher-student interactions (Ladd et al., 2014; Thomas, Bierman, & Powers, 2011). The purpose of this study is to examine whether the proportion of children in the kindergarten classroom with formal ECE experience contributes to gains in children's academic and social skills during the kindergarten year.

The above is of growing importance given that over 34% of children in the U.S. enter kindergarten after attending a public pre-k program (Friedman-Krauss et al., 2020). These children enter kindergarten with substantially higher academic skills and somewhat higher executive function (Phillips et al., 2017), but this advantage substantially declines during kindergarten (Early Learning Network, 2021; Phillips et al., 2017) and pre-k attenders sometimes show increasing levels of externalizing problems (Ansari, Pianta, Whittaker, Vitiello, & Rusek, 2020; Lipsey, Farran, & Durkin, 2018).

1. Hypothesized indirect pre-k effects in early elementary school

Increased pre-k enrollment raises questions about the potential impacts of having more children in a kindergarten classroom with prior pre-k experiences. For example, Ladd et al. (2014) speculated

Abbreviations: pre-k, pre-kindergarten; ECE, early care and education; ELL, English language learner; EF, executive function.

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there were larger positive impacts of the North Carolina's Pre-K program on academic skills when classrooms had proportionately more pre-k attenders. They argued that more pre-k attenders in elementary classrooms changed classroom dynamics, leading teachers to provide to more advanced instruction to match the advanced skill levels of the pre-k attenders.

In contrast, Belsky (2001) speculated that proportionately more children with formal child care experience would lead to higher levels of problem behaviors in kindergarten due to peer effects. He worries that because children who attended ECE centers enter school with higher levels of disruptive behaviors (Bassok, Gibbs, & Latham, 2019; Vandell et al., 2010 but also see Dearing & Zachrisson, 2017) that children in classrooms with more pre-k experience might negatively change the classroom environment. Interactions with peers can either positively or negatively affect children's adjustment (Fabes, Martin, & Hanish, 2003), so having more children in early elementary classrooms with slightly greater levels of disruptive behaviors could result in increased problems even for all children, even peers who did not attend formal ECE or pre-k (Belsky, 2001).

While both positive and negative impacts of having more pre-k attenders in the kindergarten classroom have been hypothesized through direct and indirect peer effects, to date discussion have not asked whether those peer effects would impact all students similar or have larger impacts for the pre-k attenders or nonattenders

2. Peer effects in preschool and early elementary school

Peer effects on language and academic skills have been reported. Children show larger gains in language skills in preschool (Foster, Burchinal, & Yazejian, 2020; Justice, Petscher, Schatschneider, & Mashburn, 2011; Mashburn, Justice, Downer, & Pianta, 2009) and academic skills in elementary school (Sacerdote, 2011) when their classmates have higher levels of language skills. The mechanism is thought to include both direct effects of interacting with more skilled peers (Foster et al., 2020) and indirect effects of prompting teachers to provide more advanced instruction (Ladd et al., 2014). Although Ladd et al. cited indirect effects on instruction to explain the larger long-term impact on academic skills through third grade for North Carolina's Pre-K program on children's academic skills in districts with proportionately more preschoolers, they were not able test this hypothesis.

Peer effects on behavior have also been shown. At the end of the school year, children in early elementary school who had more classmates with problem behaviors showed more problem behaviors (Thomas et al., 2011) as well as lower levels of cognitive skills (Neidell & Waldfogel, 2010). Preschoolers also showed lower levels of social skills at the end of the year when they had more more classmates who entered preschool with lower social skills (Aikens et al., 2010; Skibbe, Phillips, Day, Brophy-Herb, & Connor, 2012). The mechanism iappears to involve both direct effects through modeling peer behaviors and indirect effects through learning that displaying behavior problems obtains the teachers' attention (Becker, Madsen, Arnold, & Thomas, 1967) or through teachers spending more time managing problem behavior and less time instructing or teaching social skills (Bierman et al., 2008).

3. Indirect pre-k effects as a possible sustaining environment

The extent to which classmates enter kindergarten with skill sets changed by their pre-k experiences could also be a factor in the diminishing benefits of pre-k during the early elementary school years (Ladd et al., 2014). Considerable evidence indicates that publicly funded pre-k programs improve school readiness skills, with large benefits for basic reading and math skills and small to moderate benefits for language, executive functions, and social skills (Phillips et al., 2017). This pre-k advantage often diminishes and sometimes reverses during the early elementary years (Ansari, Pianta, Whittaker, Vitiello, & Rusek, 2020; Burchinal et al., 2022; Lipsey et al., 2018; McCormick et al., 2021). The transition from relatively high-quality pre-k classrooms to lower-quality elementary school classrooms has been implicated (Phillips et al., 2017). A recent meta-analysis did not find that rigor of instruction, classroom quality, and school proficiency as possible explanations (Bailey, Jenkins, & Alvarez-Vargas, 2020), but few, if any, studies have examined the possible peer effects of having more classmates who also attended pre-k in maintaining the pre-k advantage in elementary school.

4. Studies of pre-k classmates

Few studies have examined the effects of having pre-k classmates because it requires information on both the ECE experiences for the entire kindergarten classroom and child outcomes in kindergarten. One such study (Dmitrieva, Steinberg, & Belsky, 2007) used the Early Childhood Longitudinal Survey-Kindergarten 1998 Cohort that recruited a sample of kindergarteners within selected schools and therefore had multiple participants in the same kindergarten classroom. Results from this study revealed that both child- and classroom-level center exposure were related to both higher levels of academic skills and externalizing skills at entry to kindergarten and to residualized increases in the spring of kindergarten. Path analyses indicated that classroom-level center exposure was directly related to academic skills and indirectly related through fall scores to externalizing problems (Dmitrieva et al., 2007). This study, however, had child care information for less than half the children in most classrooms, thereby limiting generalizability. Furthermore, this study did not address questions about whether schools that serve proportionately more preschool attenders also differ in other ways that could account for the reported associations between the number of children with preschool attenders and acquisition of skills in kindergarten.

The Fairfax Pre-K to Third Grade Early Learning Network Project, can address these issues. The study has information about pre-k experience for almost all children in the district and information about ECE experience for all children in all kindergarten classrooms in this study. It also recorded school and classroom characteristics and observed classroom instruction and teacher-child interactions. This study can examine both the extent to which acquisition of skills in kindergarten is related to exposure to pre-k at the individual child level and at the classroom level. It can also examine the extent to which schools that serve more children who attended pre-k differ, and, if so, take those differences into account when relating gains in child outcomes to child- and classroom-level pre-k exposure. Prior reports from this project documented that pre-k attenders started kindergarten with higher levels of language, academic, and executive functioning skills, but the magnitude of the pre-K attender advantage over children without formal child care experience diminished during kindergarten by half for academic skills and by a third for language skills (Ansari, Pianta, Whittaker, Vitiello, & Rusek, 2020). The pre-K attenders had significantly more behavior problems than the children without formal child care experience in the spring of kindergarten (Ansari, Pianta, Whittaker, Vitiello, & Rusek, 2020). No evidence emerged suggesting that kindergarten classroom quality or instructional rigor sustained pre-k advantages in kindergarten (Ansari, Pianta, Whittaker, Vitiello, & Rusek, 2020). This study extends that work by addressing three related aims:

1 whether schools and classroom that serve more pre-k attenders differ from those that serve fewer.

2 whether kindergarteners acquire academic skills more rapidly and social skills more slowly when there are more pre-k attenders in their classroom.
3 whether having more pre-k attenders in the classroom sustains the advantages pre-k attenders had over nonattenders at entry to kindergarten.

5. Methods

5.1. Participants

The parent study recruited children attending the pre-k program in a large and linguistically diverse urban county in a mid-Atlantic state. This targeted program recruited children from low-income families eligible for free- or reduced-price lunch or receiving Temporary Assistance for Needy Families. The program included both public schools classrooms (80%) and slots in Head Start centers and community child care centers (20%). All classrooms were required to meet state pre-k standards.

Recruiting pre-k teachers and children. Pre-k teachers with a classroom in 2016 were recruited if they had at least five children funded by the pre-k program in their class. Center director and principals were approached, and if interested then their teachers were contacted. Of the 156 pre-K teachers contacted (100 from public schools, 56 from Head Start or community programs), 126 had five or more publicly funded pre-K children and enrolled in the study. Early in the fall, these teachers sent home a consent form and demographic survey to their children. Children were recruited if they were four-years-old and were not receiving any special education services besides speech therapy. Eighty percent of the children in these classrooms met these criteria and consented (n = 1498). The study included 76% of all country pre-k enrollees in 2016-2017 (n =1979). The next year, 92% of the sample were followed through kindergarten.

Recruiting K teachers and children. These 1402 pre-k children enrolled in 482 kindergarten classrooms in 2017–2018. All the children and 95% of their kindergarten teachers consented to participate.

In addition, a comparison group of children without center-based preschool care were recruited. As part of a partnership with the school district, the study team was provided a roster (without names) showing whether parent reported the child attended an ECE center. Teachers sent home invitations to parents who had reported at kindergarten registration that the child had not attended a center-based child care setting. Approximately 2600 packets were sent to families and roughly 1,600 nonattenders were consented (62%). Of the consented children, 80% met pre-k enrollment criteria by qualifying for free/reduced price lunch and were enrolled. Thus, the analysis data set included 1402 children with and 1171 children without pre-k experience in 482 kindergarten classrooms.

5.2. Measures

Kindergarten outcomes. Trained data collectors measured children's achievement and executive function, and teachers rated children's socio-emotional functioning in the fall and spring of kindergarten. When possible, direct assessments were conducted with children in a quiet space, outside of the classroom. In the fall, children were assessed in English unless they failed the language screener (PreLAS; Duncan & De Avila, 1998) and if they spoke Spanish they were assessed with parallel Spanish measures. In the spring, all children were assessed in English. We use only the English assessment data for the current study.

Academic achievement. The Woodcock Johnson III (WJ-III; Woodcock, McGrew, & Mather, 2001) assessed children's academic skills. Four subtests of the WJ-III measured children's literacy skills (Letter-Word Identification subtest, α = 0.94), language skills (Picture Vocabulary subtest, α = 0.81), and math knowledge (Applied Problems subtest, α = 0.93 and Quantitative Concepts subtest, α = 0.91). Analyses focused on standard scores that describe children's performance relative to the average performance of their same-age peers in the national norming sample.

Executive functioning. Two measured were collected. In hibitory control was assessed using an adapted version of a standard peg-tapping task, using pencils rather than pegs (adapted from Diamond & Taylor, 1996). This pencil tap assessment asks children to tap once when the assessor taps twice and vice versa. The number of correct responses on this assessment has demonstrated good concurrent and construct validity. The Head-Toes-Knees-Shoulders (HTKS) (McClelland et al., 2007) measured children's behavioral self-regulation. The HTKS involves 30 items that ask children to rule switch by responding to one command (e.g., touch your toes) from another section (e.g., touch your head). The items are scored as 0 (*incorrect*), 1 (*self-correct*), 2 (*correct*).

Socioemotional skills. Using the Teacher-Child Rating Scale (Hightower, 1986) teachers rated children's socioemotional skills by indicating on a 5-point Likert scale (1 = *not at all*, 3 = *moderately well*, 5 = *very well*) how well a given characteristic described the child. The rating scale measures: (a) task orientation (e.g., completes work, well organized, functions well even with distractions, and works well without adult support; α = 0.92 fall; 0.93 spring); (b) peer social skills (e.g., has many friends, is friendly toward peers, and makes friends easily; α = 0.93 fall; 0.94); (c) frustration tolerance (e.g., accepts things not going his/her way, ignores teasing, copes with failure; α = 0.90 fall; 0.92 spring); and (d) conduct problems (e.g., disruptive in class, defiant, overly aggressive with their peers; α = 0.89 fall and spring).

5.2.1. Pre-k exposure

Pre-k group. As described above, the child-level pre-k exposure included children recruited from public-pre-k classrooms (pre-k attenders) or from children who did not attend a center preschool and were in the kindergarten classrooms of the pre-k attenders (pre-k nonattenders)

Proportion of children in kindergarten classroom who attended the public pre-k or other ECE centers. The classroom-level pre-k exposure was computed in two ways. First, the proportion of the kindergarten classroom who were not part of the pre-k attender group was computed. Given 76% of all attendees were recruited, this proportion provides a good estimate of the number of pre-k attenders per classroom. The size of the class was provided by the school district for teachers have approved sharing that information (73%) and for other teachers who completed teacher interviews (7%). For 20% of classrooms, class size information was missing and a class size of 21 was assigned to these classrooms because 21 was both the mean and median and about half of the distribution was between 20 and 23. The proportion of children who had attended pre-k in each classroom was computed as the ratio of the number of pre-k attendees and class size (labeled prop pre-k).

We also computed the number of children with other center-based early childhood experience by subtracting the number of children who attended the public pre-k program from the number of children with *any* center experience for these 351 classrooms for which the district provided information.

5.2.2. Classroom measures

Interactional quality. The Classroom Assessment Scoring System (CLASS; Pianta, La Paro, & Hamre, 2008) measured the quality of teacher-child interactions at the classroom level with 11 dimensions on a seven-point scale. These 11 dimensions were collapsed

into three larger domains: *Emotional Support* (i.e., teacher sensitivity), *Classroom Organization* (i.e., the degree to which teachers manage behavior and use time and materials effectively), and *Instructional Support* (i.e., teachers' promotion of higher order thinking and language). Raters were trained to an initial level of 80% agreement (within 1-point) to be certified for collection of data in the field.

Classroom instructional dosage and content. The behavioral coding system (BCS) provides an estimate of the experience of a typical child in the classroom. The BCS was adapted from the Classroom Observation System and Observational Record of the Caregiving Environment (McCartney et al., 2007; Pianta, Mashburn, Downer, Hamre, & Justice, 2008) and Snapshot (Early et al., 2010; Ritchie, Howes, Kraft-Sayre, & Weiser, 2001). Raters iteratively observe individual children for 30 seconds and code their activity setting, instructional content, behaviors of the teacher that involve that child, and the child's behaviors. A random subset of the study children in the classroom, were observed sequentially. Their scores were aggregated across cycles and then days to create classroom-level indicators that described the proportion of intervals that target children were observed to experience activity setting, instructional content, and teacher interactions. Raters passed a video certification test with 85% or greater agreement with master codes and obtained moderate agreement in the field, $\kappa = 0.50$ (Altman, 1991).

Classroom instructional rigor. The teachers' spring survey included a series of items on literacy and math instructional content adapted from the Early Childhood Longitudinal Study – Kindergarten: 2011 Cohort (Tourangeau et al., 2015) used to describe instructional rigor was by Claessens, Engel, and Curran (2014). The survey included 29 literacy items and 26 math items. Teachers rated whether they covered the content described in that item as part of general classroom instruction. Items were scored based on ratings of grade level by experts and covered by state standards and were assigned 1-point if deemed at the kindergarten level, 2 points at first grade level and 3- points at second grade level. Instructional rigor was computed as the sum of these item score, with higher scores reflecting a classroom in which teachers reported teaching more rigorous content.

5.2.3. School characteristics

School composition. The schools district reported on the composition of each school in the study in terms of the proportion of students who were White, Black, Hispanic, Asian, English language learners (ELL), and received free- or reduced-price lunch (labeled low-income).

School administration. Teachers complete the Five Essentials survey of leadership, culture, and support (Bryk, Gomez, Grunow, & LeMahieu, 2015). Forty questions in five domains (Effective Instructional Leaders, Ambitious Instruction, Collaborative Teachers, Supportive Environments, and Involved Families) are rated for frequency or agreement. The measure shows good reliability ($\alpha = 96$ for the overall composite) and construct validity (Ehrlich, Pacchino, Luppescu, & Stein, 2016).

5.3. Data analysis

Several descriptive analyses examined univariate statistics and correlations. The classroom proportion of pre-k attenders was correlated with school and classroom characteristics. Partial correlations adjusting for school demographic characteristic followed to test whether observed associations could be due to differences in the schools serving pre-k children.

Repeated measures of child outcomes were analyzed using three-level hierarchical linear models (HLMs). The HLMs accounted for repeated assessments per child and clustering within schools. Ideally, we would have clustered at the classroom level, but estimating random classroom intercepts was almost impossible with three or fewer children in most classrooms. The main effect of child-level pre-k exposure (Pre-k Group) and classroom-level pre-k exposure (Prop Pre-k) tested whether either variable related to children's skills at entry to kindergarten. Interactions between time and the child- and classroom-level pre-k exposure variables tested whether they were rated to the acquisition of that outcome during kindergarten. By focusing on a difference score, time interactions coefficients reduce selection bias concerns (Shadish, Cook, & Campbell, 2002). Models include as covariates at the child level: the child's race/ethnicity, whether English was the home language, gender, parent education, whether parents are married, family income, household size, and number of children (<18 years) in the household. Models also include as the covariate at the school level the school's proportion of students who were: White, Hispanic, Asian, and received free/reduced price lunch. These school level covariates were included to account for the much higher proportion of Hispanic and low-income children and lower proportion of White and Asian in schools with proportionately more pre-k attenders. The model for the ith person at the jth time in the kth school is shown below.

Level 1: $Y_{ijk} = B_{ik0} + B_{ik1}Time_{ijk} + e_{ijk}$

Level 2: $B_{ik0} = \lambda_{k00} + \lambda_{k01}Child\ Covariates_{ik} + \lambda_{\kappa 02}$ Pre-k Attender$_{ik}$ $+ \lambda_{\kappa 03}$Prop Class Attend Pre-k$_{ik}$

$+ \lambda_{\kappa 04}$Prop Class Attended Pre-K x Pre-k Attender$_{ik}$ $+\varepsilon_{k00}$

$B_{ik1} = \lambda_{k10} + \lambda_{k01}Child\ Covariates_{ik} + \lambda_{\kappa 12}$ Pre-k Attender$_{ik}$ $+ \lambda_{13}$Prop Class Attend Pre-k$_{ik}$

$+ \lambda_{\kappa 14}$Prop Class Attended Pre-K x Pre-k Attender$_{ik}$

Level 3: $\lambda_{k00} = \zeta_{00} + \zeta_{01}School\ Covariates_{k} + \delta_{00}$

$\lambda_{k10} = \zeta_{10} + \zeta_{11}School\ Covariates_{k}$

All variables were standardized to have a mean of 0 and a standard deviation of 1 so the parameter estimates can be interpreted as effect sizes (Hedges, 2008).

The next analysis tested hypothesis that teachers provided more advanced instruction when there were more pre-k attenders in the classroom and whether this accounts for anticipated larger gains in academic and language skills in classroom with more pre-k attenders. Using the Sobel test approach to testing mediation (Preacher et al., 2004), indirect effects were estimated from models describing the extent that classroom quality was higher in classrooms with more pre-k attenders and models describing the extent that gains in child outcomes were larger when classroom quality was higher.

Multiple imputations accounted for missing data (Schafer, 1997). Twenty datasets were created using the MCMC algorithm in which missing values were imputed from the other variables in the dataset. HLM analyses were conducted with each of the imputed datasets and parameter estimates were combined across the analyses accounting for the variance within and between datasets.

Finally, sensitivity analyses were conducted. First, we tested the assumption of linear associations between change in child outcomes and the proportion of pre-k attenders in the classroom. The variable describing the classroom proportion of pre-k attenders was split into thirds and analyses were conducted using dummy variables representing the tercile split. Second, we ran analyses that separated the proportion of classmates without pre-k experience into the proportion with any center experience and the proportion with no center-based experiences. Substituting those two variables into the model addressed whether any classroom composition findings might be related to having peers with any center experience that was not specifically a pre-k experience. Finally, to further address concerns about selection bias as a function of unmeasured confounds, we conducted analyses that examined the extent to which omitted confounding variables could change find-

Table 1
Descriptive statistics: the kindergarten classrooms.

	N	Mean	SD	Minimum	Maximum
Class size	467	21.87	2.58	15.00	29.00
Proportion – public Pre-k	467	0.14	0.12	0.00	0.60
Proportion – center/not pre-K	351	0.61	0.24	0.00	0.96
Classroom observations					
CLASS emotional support	344	4.89	0.70	2.54	6.73
CLASS instructional support	344	2.05	0.51	1.13	4.18
CLASS classroom organization	343	5.26	0.63	2.98	6.75
BCS prop time in literacy instruction	257	0.33	0.10	0.03	0.70
BCS prop time in math instruction	257	0.18	0.07	0.00	0.37
BCS prop time-learning abstract skills	257	0.06	0.05	0.00	0.28
BCS prop time-learning basic skills	257	0.51	0.17	0.07	0.94
BCS prop time-student engaged	257	0.75	0.09	0.37	0.97
BCS prop time-disruptive behavior	257	0.02	0.03	0	0.23
Instructional rigor					
Language/literacy instruction	343	1.76	1.39	-1.03	4.67
Math instruction	341	0.98	1.81	-1.49	7.92
School administration: 5 Essentials					
Teacher professional development	343	-0.00	0.82	-2.71	1.63
Teacher collaboration	344	-0.02	0.69	-3.19	0.82
Teacher data use	344	0.09	0.65	-1.98	1.44
Teacher leadership/coherence	343	-0.06	0.71	-3.16	1.58
Teacher parent/home learning	344	-0.01	0.89	-2.06	2.42
School composition: proportion					
White students	464	0.33	0.17	0.03	0.72
Black students	464	0.11	0.08	0.01	0.37
Hispanic students	464	0.33	0.20	0.04	0.81
Asian students	464	0.17	0.11	0.02	0.66
Free/reduced price lunch	464	0.41	0.25	0.02	0.92
English language learner	464	0.32	0.18	0.05	0.71

ings. Using the Konfound IT application (Rosenberg et al., 2018), we estimated how strongly an omitted confounder would have to be related to the predictor and outcome for the observed associations to be considered not statistically significant.

6. Results

6.1. Descriptive analyses

The 482 kindergarten classrooms are described in Table 1. Overall, about three-fourths of the children in the classrooms started kindergarten with prior center-based ECE experience and about 14% of all children in the kindergarten classrooms had attended the public pre-k program.

Next whether classrooms with more pre-k attenders differed on school and classroom characteristics was tested. The proportion of pre-k attenders per classroom was correlated with school and classroom characteristics (Table 2). Results indicated large differences in school characteristics and a few modest differences in classroom instruction. Classrooms with proportionately more pre-k children were in schools with proportionately fewer White (r = -0.60), and Asian (r = -0.29) students, and more Black (r = 0,17), and Hispanic (r = 0.68) students, ELLs (r = 0.69), and low-income children (r = 0.72). Teachers in classrooms with more pre-k children also reported slightly less administrative support for teacher-parent home learning (r = -0.22). They were observed as having slightly higher instructional support according to the CLASS (r = 0.15) and slightly more time in literacy activities (r = 0.13) and learning abstract skills (r = 0.17). Follow-up analyses that included school demographics as covariates indicated partial correlations between classroom proportion of pre-k attenders and CLASS Instructional Support (r = -0.01, P> 0.05), time in literacy instruction (r = 0.07, P> 0.05), and time in abstract instruction (r = 0.06, P> 0.05) were substantially smaller and not statistically significant.

We also asked which classrooms tended to have proportionately more children who attended other types of center care. The second column in Table 2 shows the correlations between classroom proportion of the kindergarten classroom with other center experience and selected school and classroom characteristics. The associations were largely the opposite as those described above regarding proportion of pre-k attenders. Classrooms with more children who attended other center care settings were in schools with proportionately fewer Hispanic (r = -0.78) and Black (r = -0.26) students, ELLS (r = -0.77), and children receiving free-or-reduced-price lunch (r = -0.83), and more White (r = 0.70) and Asian children (r = 0.38). Teachers in classrooms with more children with other center experience reported more administrative support for home learning (r = 0.20). Finally, classrooms with proportionately more children who attended other centers were observed to have disruptive behavior less frequently (r = -0.16). This association disappeared when school demographic characteristics were also included (r = 0.03, P> 05).

The demographic characteristics of the participants are described in Table 3. Many children were ELL, from families with low-income, less than a high school education, and single parents. The proportion of classmates who attended pre-k or other center preschools was at best modestly correlated with demographic characteristics of children (Table 4).

The fall and spring assessments of the children are described in Table 5. Most measures reflect actual skill levels, not relative ranking, so higher average scores in the spring than the fall on most measures reflect acquisition of new skills during kindergarten.

6.2. HLM analyses

HLM analyses examined the final two research questions. The HLM analyses tested whether child-level and classroom-level pre-k exposure related to children's entry skills (intercept) and rate of change from fall to spring in child outcomes. The associations with initial skills reflect pre-existing differences at entry to kindergarten (K), whereas associations with rates of change reflect differences associated with classroom composition. The interaction be-

Table 2
Correlations between classroom composition and CLASS and school characteristics.

	Prop-pre-k (n = 257–467)	Prop-other center (n = 254–351)
K classroom ECE experience		
Prop pre-k		-0.78***
Prop-other center		
School administration: 5 essentials		
Teacher professional development	-0.02	0.04
Teacher collaboration	-0.01	0.05
Teacher data use	0.03	-0.01
Teacher leadership/coherence	-0.07	0.09
Teacher parent/home learning	-0.22***	0.20***
School composition: proportion		
White students	-0.60***	0.70***
Black students	0.17***	-0.26***
Hispanic students	0.68***	-0.78***
Asian students	-0.29***	0.38***
Free/reduced price lunch	0.72***	-0.83***
English language learner	0.69***	-0.77***
Classroom observations		
CLASS emotional support	0.07	-0.00
CLASS instructional support	0.15*	-0.07
CLASS classroom organization	-0.03	0.08
BCS prop time literacy instruction	0.13*	-0.10
BCS prop time math instruction	-0.10	-0.09
BCS prop time-learning abstract skills	0.17**	-0.16*
BCS prop time-learning basic skills	-0.01	-0.05
BCS prop time-student engaged	0.03	0.02
BCS prop time-disruptive behavior	0.11	-0.16*
Teacher-report instructional rigor		
Language/literacy instruction	0.04	0.05
Math instruction	0.00	0.05

*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

Table 3
Descriptive statistics – children.

	Total			Pre-k nonattender			Pre-k attender		
	N	Prop. or Mean	SD	N	Prop, or Mean	SD	N	Prop. or Mean	SD
English language learner	2561	0.82		1170	0.87		1391	0.79	
Male	2573	0.49		1171	0.47		1402	0.51	
Income-to-needs	2202	1.06	0.71	945	1.11	0.71	1257	1.02	0.71
Parent years of education	2218	11.79	3.68	1116	11.64	3.72	1102	11.95	3.63
Household size	2457	4.93	1.49	1132	5.05	1.55	1325	4.83	1.44
Race	2541			1154			1387		
White		0.11			0.11			0.11	
Black		0.13			0.08			0.16	
Hispanic		0.61			0.65			0.58	
Asian		0.12			0.13			0.11	
Other		0.01			0.01			0.01	
Multiracial		0.02			0.02			0.02	

Table 4
Correlations – classroom composition with child characteristics and K gain scores.

Child and family characteristics									
	Child male	Income /needs	Parent education	Household size	Parent-married	Child ELL	Child White	Child Black	Child Hispanic
Prop- pre-k	-0.01	-0.15***	-0.13***	-0.08***	0.05	0.11***	-0.11***	-0.01	0.12***
Prop-other center	0.01	0.15***	0.18***	0.06**	-0.06**	-0.14***	0.13****	0.02	-0.18***

Note: **$P < .01$;
***$P < .001$.

tween time and proportion pre-k ($\lambda_{\kappa 12}$) tested whether having more classmates who attended pre-k related to change in skill levels differently for children who did and did not attend pre-k.

The results from the HLM analysis relating K outcomes to the proportion of the classroom who attended the county pre-k program are presented in Table 6 with the coefficients for the full model shown in the online Supplementary Table 1. The tables list the fixed effect coefficients and standard errors for the main effects and interactions involving whether the child attended pre-k and the proportion of pre-k attenders in the kindergarten classroom. The intercept was set at fall of K, so coefficients listed under intercept describe associations at the beginning of K. The slope reflected changes in outcomes from fall to spring of K and the coefficients listed under change over time describe associations with acquisition of new skills. All analyses include both the child-level (Pre-k Group) and classroom-level (Prop. Pre-k) measures of pre-k exposure.

Table 5
Descriptive statistics – child outcomes.

	Kindergarten fall			Kindergarten spring		
	N	Mean	SD	N	Mean	SD
Woodcock Johnson w scores						
Picture vocabulary	2355	345.9	30.88	2269	390.8	29.53
Letter word identification	2354	408.9	25.58	2268	434.1	19.93
Applied problem	2352	454.4	19.39	2268	463.1	12.30
Quantitative concepts	2350	425.5	17.69	2267	445.3	13.63
Executive functioning						
Head-toes-knees-shoulders	2351	22.47	17.97	2264	30.62	18.53
Pencil Tap	2357	0.82	0.27	2269	0.92	0.18
Teacher-child rating scale						
Social skills	1812	3.51	0.84	1732	3.61	0.86
Conduct problems	1812	1.79	0.88	1731	1.77	0.89
Task orientation	1812	3.25	1.05	1732	3.39	1.09
Frustration tolerance	1812	3.37	0.96	1732	3.43	0.99

6.2.1. Skills in fall of kindergarten

The first four rows of Table 6 ask the extent to which skills at entry to kindergarten kindergarten were related to attending public pre-k or being in a classroom with more pre-k attendees. Overall, the results indicate that pre-k attenders started kindergarten with substantially higher skill levels than did nonattenders, but children in classrooms with more pre-k attenders tended to start kindergarten with slightly lower academic skills and higher social skills. The results in the row labeled pre-k group indicate that the children who had attended the county pre-k program, compared to nonattenders, tended to start kindergarten with higher levels of skills in language (WJ PV B = 0.44), literacy (WJ LW B = 0.24), math (WJ AP B = 0.39 & QC B = 0.22), behavioral self-regulation (HTKS B = 0.23) and inhibitory control (Pencil Tap B = 0.27), but also higher levels of conduct problems (TCRS CP B = 0.10).

The focus of this study, proportion of classmates with pre-k experience, was examined in relation to entry skills in the next two rows. The results in the row labeled Prop. Pre-K indicate that in classrooms with proportionately more pre-k attenders, children started kindergarten with lower levels of skills in language (WJ PV B = -0.10), literacy (WJ LW B = -0.06), math (WJ AP B = -0.08), inhibitory control (Pencil Tap B = -0.12), but also higher levels of social skills (TCRS SS B = 0.08), and frustration tolerance (TCRS TO B = 0.15) and lower levels of conduct problems (TCRS CP B = -0.08). The row labeled Prop. Pre-k x Pre-k Group indicates the pre-k nonattenders, but not the pre-k attenders, had lower academic skills at entry to kindergarten among children in classrooms with more pre-k attenders. This interaction suggests the negative association between proportion pre-k attenders in the classroom and children's fall academic scores was somewhat negated for the pre-k attenders in language (WJ PV B =0.11), literacy (WJ LW B = 0.08), math (WJ AP B = 0.09), and inhibitory control (Pencil Tap B = 0.09). Combining the effect-coded coefficients for the main effect and interaction, these results suggest the proportion of pre-k attenders in the classroom was modestly and negatively associated with skills for pre-k attenders (e.g., language B = -0.10 + 0.50 × 0.11 = -0.045) and more negatively associated with skills for pre-k nonattenders (e.g., language B = -0.10 – (0.50 × 0.11) = -0.155) at kindergarten entry. This pattern of results might be because kindergarten classrooms with more pre-k attenders tended to serve more low-income children and those children started school with lower skills if they did not attend the public pre-k.

6.2.2. Acquisition of skills during kindergarten

The next rows in Table 6 describe the acquisition of skills during K overall and in relation to whether the child attended pre-k and the proportion of classmates who attended pre-k. Overall, children showed large gains in K in their language (WJ PV B = 0.64), literacy (WJ LW B = 1.28), math (WJ AP B = 0.94 & WJ QC B = 1.10), and behavioral self-regulation (HTKS B = 0.63) and moderate gains in inhibitory control (Pencil Tap B = 0.50), social skills (TCRS SS B = 0.29), and task orientation skills (TCRS TO B = 0.30). Shown in the row labeled Pre-k group x time, results indicate the advantage the pre-k attenders had over the nonattenders diminished between fall and spring for language (WJ PV B = -0.35), literacy (WJ LW B = -0.18), and one of the math assessments (WJ AP B = -0.24).

The proportion of classmates with pre-k experience was examined in relation to acquisition of skills during kindergarten in next two rows (research question 2). Children in classrooms with proportionately more classmates who attended the county pre-k program showed modestly larger gains in language (WJPV B = 0.13) and inhibitory control (Pencil Tap B = 0.12), but also smaller gains in frustration tolerance (TCRS FT B = -0.16).

The interactions among time, proportion pre-k and Pre-k group asked whether rates of skill acquisition were faster for pre-k attenders than nonattenders when they had more pre-k attenders in their kindergarten classroom (research question 3). No evidence emerged suggesting that pre-k attenders in classrooms with proportionately more pre-k attenders showed smaller or larger gains than nonattenders on these two skills, or any other outcomes (see row labeled Prop. Pre-k × Pre-k group × time). Put another way, having proportionately more classmates with pre-k experience did not sustain (or erase) the pre-k advantage.

Sensitivity analyses. Follow-up analyses supported the findings described above. First, these analyses allowed for nonlinear associations by categorizing the classroom proportion of pre-k attenders into terciles (see Supplementary Table S2 in the online supplement). No additional associations emerged. Second, analyses divided the proportion of the classroom with center care into two groups, proportion with pre-k experiences and proportion with other center care experiences. Results shown in Supplementary Table S3 were largely simlar to findings reported in Table 6. Children showed smaller gains in frustration tolerance in classrooms with proportionately more PK attenders than children with home care experience (B = -0.19, se = .08, P < .05). Similar coefficients, albeit not statistically significant, describing associations between the proportion of pre-k attenders compared to children with home care in rates of change over time in vocabulary (B = 0.11, se = .07) and inhibitory control (B =-0.11, se = .08). No evidence of differences in rates of change over time on any outcome related to proportion of the classroom experienced other center care compared to home care prior to kindergarten.

Table 6
HLM analyses: relating proportion of K classroom who attended county pre-k to level (fall K) and change (spring – fall K) in child outcomes.

Effect	Picture vocabulary	Letter-word ID	Applied problems	Quantitative concepts	HTKS	Pencil Tap	Social skills	Conduct problems	Frustration tolerance	Task orientation
Intercept	-0.03 (0.05)	-0.58*** (0.05)	-0.39*** (0.05)	-0.40*** (0.05)	-0.18** (0.06)	-0.17** (0.05)	-0.18** (0.07)	0.10 (0.06)	-0.11 (0.07)	-0.26*** (0.06)
Pre-k group	0.44*** (0.03)	0.24*** (0.03)	0.39*** (0.03)	0.22*** (0.03)	0.23*** (0.03)	0.27*** (0.04)	-0.01 (0.04)	0.10** (0.04)	-0.05 (0.04)	0.08* (0.04)
Prop. Pre-k	-0.10*** (0.03)	-0.06* (0.03)	-0.08** (0.03)	-0.05 (0.03)	-0.01 (0.03)	-0.12*** (0.03)	0.10* (0.04)	-0.08* (0.04)	0.15*** (0.04)	0.03 (0.04)
Prop-Pre-K x Pre-k group	0.11*** (0.03)	0.08** (0.03)	0.09** (0.03)	0.06 (0.03)	0.03 (0.03)	0.09** (0.04)	-0.05 (0.04)	0.07 (0.04)	-0.07 (0.04)	-0.03 (0.04)
Change over time	0.64*** (0.09)	1.28*** (0.09)	0.94*** (0.09)	1.10*** (0.09)	0.63*** (0.10)	0.50*** (0.1)	0.29** (0.11)	-0.07 (0.11)	0.15 (0.11)	0.30** (0.11)
Pre-k group x time	-0.35*** (0.06)	-0.18** (0.06)	-0.24*** (0.06)	-0.10 (0.06)	0.01 (0.07)	-0.14 (0.07)	0.07 (0.08)	-0.09 (0.07)	0.05 (0.08)	0.04 (0.07)
Prop. Pre-k x time	0.13* (0.06)	0.07 (0.05)	0.10 (0.05)	0.04 (0.05)	0.00 (0.06)	0.12* (0.06)	-0.13 (0.07)	0.01 (0.07)	-0.16* (0.07)	-0.07 (0.06)
Prop. Pre-k x Pre-k group x time	-0.09 (0.06)	-0.08 (0.06)	-0.10 (0.06)	0.00 (0.06)	0.01 (0.07)	-0.07 (0.07)	0.06 (0.08)	0.01 (0.08)	0.10 (0.08)	0.03 (0.07)

HLM models – account for clustering in schools and repeated assessments per child. Models include as covariates: race/ethnicity, ELL, gender, parent ed, parent married, income, household size, number of children (<18 years) in HH, school proportion: white, Hispanic, Asian, free/reduced price lunch, and interactions between each of these characteristics and age. Pre-k group is the measure of pre-k exposure at the individual child level and Prop. Pre-k is the measure of pre-k exposure at the classroom level.
*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

Analyses were conducted using the data from classrooms for which class size and number of children with center experience were reported. These analyses were conducted using the data for which the district provided the number of children with center care. Reanalysis of the model reported in Table 6 shown in Table S3 reported almost identical coefficients for gains in frustration tolerance (B = -0.18. se = 0.08, $P<$ 0.05) and similar but somewhat smaller coefficients for gains in language (B = 0.11. se = 07, $P<$ 0.10) and inhibitory control (B = 0.11. se = 08, $P <$ 0.10).

Next, we tested the extent to which the classroom quality indices correlated with the classroom proportion of public pre-k attenders mediated associations between classroom proportion of public pre-k attenders and gains in child outcomes. Using the Sobel test approach described by Preacher (Preacher et al., 2004), an additional set of analyses were conducted that tested the indirect path from proportion class who attended public pre-k through CLASS Instructional Support, BCS time in literacy instruction, and BCS Time in abstract instruction in relation to gains in WJ PV, Pencil Tap, and Frustration Tolerance. Models did not support paths from classroom pre-k exposure to classroom quality indices when school characteristics were considered or from the classroom quality indices to gains in child outcomes. Thus, it is not surprising that results provided no evidence of mediation for either CLASS Instructional Support (WJ PV z = 0.05; Pencil Tap z = -0.05; Frustration Tolerance z = 0.05), BCS proportion time observed in literacy activities (WJ PV z = -0.23; Pencil Tap z = -0.33; Frustration Tolerance z = 0.71), or BCS proportion of time observed in abstract or inferential learning (WJ PV z = -0.15; Pencil Tap z = 0.54; Frustration Tolerance z = 1.19).

Finally, we examined the extent to which omitted confounding variables could change findings regarding classroom-level exposure to pre-k peers and children's acquisition of skills in K. The Konfound IT application (Rosenbach et al., 2018) indicated very modest confounders could invalidate inferences regarding classroom-level center exposure and children's language, inhibitory control, and frustration tolerance. More specifically, controlling for an unobserved confound would negate our findings if the unobserved confound correlated with both the predictor and outcome at a minimum of r = 0.03 for language and inhibitory control and r = 0.06 for frustration tolerance, suggesting that findings were fragile and could eaily become nonsigificant if omitted variables related to both the proportion of pre-k attenders in the classroom and child outcomes..

7. Discussion

This study examined the extent to which having more kindergarten classroom peers with pre-k experience related to school characteristics, classroom experiences, and acquisition of skills during kindergarten. We found relatively large differences in the schools that serve more pre-k attenders and some mixed evidence of differences in the classrooms and in child outcomes. Results provided some support for hypotheses that having more pre-k attendees as peers was related positively to acquisition of verbal and inhibitory control skills, but also negatively to frustration tolerance. No evidence emerged suggesting that the proportion of pre-k attenders moderated differences between pre-k attenders and nonattenders.

7.1. Schools and classrooms serving more children with public pre-k experience

This study provides further documentation that schools that serve proportionately more children who attended public pre-k programs have proportionately more Black and Brown children, ELLs, and low-income students. The reverse was observed in

schools serving proportionately more children with other types of center-based care. Teachers reported less focus by school administration on teacher-parent communication regarding home learning in classrooms serving more public pre-k attenders and more focus in classrooms serving more private preschool attenders. These findings are consistent with the literature on schools with a high density of low-income children (Reardon, 2013). They are not surprising given the county pre-k program targeted children from low-income families for enrollment whereas children with private, center-based preschool experience tend to be from more affluent families with parents working full-time and who speak English at home (Cui & Natske, 2021).

In contrast, there was far more limited evidence that within-classroom experiences varied as a function of proportion of classmates with formal ECE experience of various types. There was some evidence that teachers with more public pre-k attenders spent more time on literacy instruction and provided higher quality instruction according to the CLASS and instructional time spent teaching more abstract skills. These findings are consistent with claims that having more public pre-k attenders in the classroom may improve the level of instruction because they enter K with higher levels of academic skills (Dodge, Bai, Ladd, & Muschkin, 2017; Ladd et al., 2014). However, adjusting for the demographics of the school, these correlations became much smaller and statistically nonsignificant, suggesting that the differences in classroom experiences were *not* attributed to the enrollment of more pre-k children. Furthermore, mediation analyses did not suggest that higher levels of CLASS Instructional Support or time observed in literacy activities or abstract instruction accounted for associations between class level pre-k exposure and larger gains in vocabulary or inhibitory control skills or smaller gains in frustration tolerance.

7.2. Child skills at entry to K in classrooms serving more children with pre-k experience

This study reported pre-k attendance related to children's skills in the fall of kindergarten in terms of both child-level and classroom-level indices of pre-k experience. Child-level pre-k exposure involved comparing pre-k attenders and nonattenders. As previously reported (Ansari, Pianta, Whittaker, Vitiello, & Rusek, 2020), children who attended pre-k began K with higher levels of language, reading, math, and EF skills, but also higher levels of conduct problems. These child-level findings are consistent with other pre-k follow-up studies (Burchinal et al., 2022; Lipsey et al., 2018; McCormick et al., 2021) and a nationally representative report from the ECLS-K (Bassok et al., 2019).

Classroom-level exposure involved relating the proportion of the classroom with pre-k exposure to kindergarten entry skills. Children with more classmates who attended pre-k started kindergarten with higher levels of social skills and frustration tolerance and lower levels of conduct problems for both children who did and did not attend pre-k, but also lower levels of academic skills and inhibitory control for children who did not attend pre-k. These findings are not consistent with the one prior study that looked at classroom-level exposure to children with center experience. Dmitrieva et al. (2007) reported that children in the ECLS-K who had more classmates with center experience started kindergarten with higher academic skills and more externalizing problems. The two studies differ in terms of whether they examined child- and classroom-level exposure to public pre-k specifically or center care more generally and the number of children in the kindergarten classroom for whom prior care experience was known. It is likely that school entry skills of children in classrooms with proportionately more children who attended ECE centers differ from those in classrooms with proportionately more children with pre-k experience due largely to the differences in family and school demographics as described above.

7.3. Acquisition of child skills during K in classrooms serving more children with pre-k experience

This study also tested the extent to which child-level and classroom-level indices of pre-k experience related to the acquisition of skills during K. As previously reported for this sample, the child-level pre-k advantage diminished during kindergarten. Pre-k nonattenders showed larger gains in language and academic skills and smaller gains in conduct problems than pre-k attenders (Ansari, Pianta, Whittaker, Vitiello, & Rusek, 2020), a finding consistent with a substantial literature on pre-k convergence or catch-up (Abenavoli, 2019; Phillips et al., 2017).

One of the research questions motivating this study asked whether children in K classrooms with more pre-k attenders showed larger gains in academic skills or problem behaviors. This study may be among the first to ask whether classroom-level pre-k exposure in kindergarten relates to acquisition of skills during the school year. Prior studies indicated that peer language skills related to gains in language and academic skills (Foster et al., 2020; Justice et al., 2011; Mashburn et al., 2009; Sacerdote, 2011) and peer problem behaviors related to gains in problem behaviors (Thomas et al., 2011). One study suggested larger gains in both academic skills and externalizing problems associated with classroom center experience (Dmitrieva et al., 2007). Thus, it was speculated that pre-k attendance could have more child- and classroom-level impacts during the school year (Dodge et al., 2017) because pre-k attendees tended to enter kindergarten with substantially higher levels of academic skills and moderately to modestly higher levels of problem behaviors (Abenavoli, 2019; Phillips et al., 2017).

This study provided some support for these hypotheses. Findings suggested that both pre-k attenders and nonattenders showed modestly larger gains in language and inhibitory skills when more of their classmates attended pre-k. These findings are similar, but not completely consistent with the ECLS-K study looking at classroom-level center exposure (Dmitrieva et al., 2007). Both studies found some evidence of classroom-level indices of ECE experience positively predicting cognitive skills and negatively predicting social skills, but this study did not find associations with the same outcomes as did the ECLS-K study. This difference could be due to a focus on pre-k exposure in this study and center exposure in the prior study or differences in when and where the studies were conducted.

Consistent with studies that directly measured peer skills (Foster et al., 2020; Justice et al., 2011; Mashburn et al., 2009), the results of this study could suggest that higher language skills among pre-k attenders related to gains in language skills through peer effects. It is likely that having more classmates with stronger language skills provided children with the kinds of language exchanges involving responsive multi-turn conversations that are most likely to strengthen language skills (Bond & Wasik, 2009; Justice, Jiang, & Strasser, 2018), especially for ELLs (Foster et al., 2020). It is also possible that these gains were due to teachers adapting their instruction as an indirect peer effect. Instructional practices such as higher quality instruction and more inferential learning was observed in classrooms with more pre-k attenders and have been shown to promote language and academic learning (Claessens et al., 2014; Mashburn et al., 2009). Nevertheless, associations between classroom proportion pre-k attenders and both language and non-academic skills are more likely related to direct peer effects than indirect effects through the teacher because language skills are more likely to be learned in individual or small group conversations than in group instruction (Bond & Wasik, 2009; Justice et al., 2018). In contrast, it is likely that pro-

viding a rich learning environment can improve inhibitory control (Pianta et al., 2020; Schmitt, McClelland, Tominey, & Acock, 2015)

This study also suggested that having more classmates who attended pre-k was related to modestly smaller gains in frustration tolerance during kindergarten. Prior studies also suggested that having more peers who display problem behaviors, related to students themselves developing more problems (Neidell & Waldfogel, 2010; Thomas et al., 2011). This study found that teacher report of conduct problems at entry to kindergarten was higher for pre-k attenders than nonattenders and lower for children in classrooms with more pre-k attenders, but did not report changes in conduct problems during kindergarten associated either with being a pre-k attender or in a classroom with more pre-k attenders. In contrast, we found higher levels of frustration tolerance at entry to kindergarten but larger reduction in frustration tolerance during kindergarten among children in classrooms with more pre-k attenders. These findings are difficult to explain aside from consistent findings that children with pre-k or center-based experience tend to start kindergarten with higher levels of teacher reported behavior problems (NICHD ECCRN, 2006).

The final research questions motivating this study asked whether having more classmates who attended pre-k moderated differences in gains in outcomes among children who did and did not attend pre-k. Asking whether having more classmates who attended pre-k could serve to buffer children from pre-k fade-out in kindergarten, this study might be the first to examine this index of classroom composition as a factor that might help sustain a pre-k advantage in kindergarten. As in the meta-analysis of other hypothesized sustaining environment factors (Bailey et al., 2020), results provided no evidence that having more pre-k attenders as classmates was more strongly related to gains in kindergarten for pre-k attenders or nonattenders. Thus, the advantages conferred by having more pre-k peers in kindergarten classrooms were the same for both pre-k attenders and nonattenders.

The findings of this study, coupled with the long-term negative findings from the Tennessee pre-k program (Durkin, Lipsey, Farran, & Wiesen, 2022), strong evidence of fade-out/catch-up in many recent studies (Ansari, Pianta, Whittaker, Vitiello, & Rusek, 2020; Burchinal et al., 2022; McCormick et al., 2021; Phillips et al., 2017), and rather convincing evidence that subsequent sustaining environments do not prevent catch-up (Bailey et al., 2020), provide additional evidence that further examination is needed to ensure pre-k programs are preparing children to succeed in school.

7.4. Limitations

Several limitations need to be acknowledged. First, these results do not representcausal associations. We attempted to limit selection bias in two ways. First, we focused on fall to spring gain scores because they reduce bias in a similar manner as individual fixed effects, albeit less effectively (Shadish et al., 2002). Second, we estimated how strongly a confounder would have to relate to both gains in outcomes and the proportion of center or pre-k attenders to negate findings. Not surprisingly given the modest associations, these associations are quite fragile. We included as covariates most of the demographic characteristics that would clearly bias findings such maternal education and race to address, in part, deep systemic racism than many of the study children likely faced. Nevertheless, we acknowledge selection bias is a major concern for causal inference.

Second, we identified children as pre-k attenders based on enrollment into this study during the pre-k year. Over 75% of all pre-k attenders in the district enrolled in the study, so we have relatively good coverage. Nevertheless, there were some pre-k attenders who would have been counted as attending centers but not pre-k. The prior studies in this area relied on the center-care experience of up to feight classmates (Dmitrieva et al., 2007) so 76% coverage is clearly an improvement over this study. Nevertheless, it is likely our proportion of pre-k attenders is undercounted, and we hope pre-k attenders not enrolled in this study were distributed relatively randomly across classrooms. It is possible that combining state pre-k enrollment and state educational data bases might address this question more accurately, at least for the outcomes in those state data bases such as disciplinary actions and state achievement tests.

Third, we estimate class size for about 15% of the children because their teachers did not consent to having the district share that information with us. We felt comfortable assigning these classrooms with the median class size because of the relatively tight distribution for class size due to district regulations. Sensitivity analyses that excluded these classrooms yielded very similar results in terms of effect sizes, suggesting our findings were not biased by this decision.

Fourth, we relied on parent report on center-based experience prior to kindergarten. Parent report has been demonstrated to be inaccurate when parents are asked to describe the type of center-based care their child received but is more reliable when parents are asked whether their child received care at their home, someone's home, or an ECE classroom that could be located in a center or school (NICHD ECCRN, 2006).

Fifth, this study describes the classroom composition regarding pre-k experiences and acquisition of skills in a large suburban district in the Southeast. This limits generalization, because considerable evidence has shown that both school quality and outcomes may be higher in suburban than in rural than more urban areas (Miller et al., 2019). It is reassuring that little or no evidence that associations among quality/school characteristics and outcomes differ in urban and rural areas (Burchinal et al., 2015), but it is not clear whether results generalize to other areas of the country.

8. Conclusions

This study reports some, albeit limited, evidence that having more classmates with pre-k experience is related to gains in cognitive skills and lower levels of behavioral skills during kindergarten. These findings suggest that these indirect effects on child outcomes likely were due to having peers with more advanced language skills and perhaps less frustration tolerance rather than changes in teacher instruction or classroom management. In addition, the results suggest there are large differences in the schools and small differences in classroom quality and the skills of classmates related to having more peers who attended ECE centers in general or pre-k in specific. Thus, this evidence for such "selection effects" and more limited evidence from the more robust analyses of change over time than of skills at a given time-point (Shadish et al., 2002) suggests that increasing the number of classmates with pre-k experience is unlikely to substantially change children's learning in early elementary school. Further examination, however, is warranted since this may be the first study to directly study the extent to which increased numbers of pre-k attenders impacts teaching or child outcomes of the pre-k attenders and their kindergarten classmates.

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Supplementary materials

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