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Abstract

Numerous studies have demonstrated a strong link between participation in pre-K programs and both short-term student achievement and positive later-life outcomes. Existing evidence primarily stems from experimental studies of small-scale, high-quality programs conducted in the 1960s and 1970s and analyses of the federal Head Start program. Meanwhile, evidence on state-funded pre-K programs, with no income restrictions, is scant and inconclusive. Using enrollment lotteries for over-subscribed school-based sites in Georgia's universal pre-K program, we analyze the impact of participation on elementary school outcomes. Lottery winners enter kindergarten more prepared in both math and reading than non-winning peers. Gains fade by the end of kindergarten, and some negative achievement effects emerge by grade 4. Free-and-reduced-price meal (FRPM) students benefit more compared to non-FRPM students in later grades, suggesting greater benefits from attendance for disadvantaged students. Although we find no effects for discipline, lottery winners had one fewer absence each grade after kindergarten.

Keywords: early childhood education, educational economics, education policy, pre-kindergarten
JEL Classification: I21, I28, H40

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Introduction

It is well established that there is a strong link between K-12 performance and later adult outcomes, such as post-secondary education attainment, teenage pregnancy, criminal activity, and adult employment and earnings (Cunha & Heckman, 2007, 2009; Goldhaber & Özek, 2019; Heckman et al., 2010a, 2010b; Heckman et al., 2013; Watts, 2020). Given that differences in educational performance appear early in life and the fact that it is increasingly difficult to remediate disparities in education as children age, many have suggested prioritizing early educational interventions as a means of improving performance both in childhood and later in life (Carneiro & Heckman, 2003; Cunha et al., 2006; Heckman, 2000, 2008). This view has its theoretical foundations in the child psychology literature (Justice et al., 2009; Stipek, 2006) and is supported by early studies of high quality but small-scale Pre-K programs such as the Perry Pre-School Program (Heckman et al., 2010a, 2010b) and the Carolina Abecedarian Project (Garcia et al., 2020), which find substantial benefits to participants in both the short-run and long-run. Fueled in part by evidence from these small-scale experiments like Perry Preschool and Abecedarian, some states initiated or significantly expanded pre-K education programs in the 1980s and 1990s (Mitchel, 2001). While most of these state-funded pre-K programs have income thresholds, as of 2017, 11 state programs (including Georgia's) are "universal" programs that have no income restriction for participation (Friedman-Krauss et al., 2022).

Georgia's Pre-K Program is a state-funded early education program for four-year-old children in Georgia that is administered by Bright from the Start: Georgia Department of Early Care and Learning (DECAL). The program began in 1993 and its goal is to prepare children for success in Kindergarten and in later school years. Currently, there are approximately 84,000 available slots in Georgia's Pre-K Program spread over roughly 4,000 sites that are located

throughout the state (Goldring, 2020). Some programs are located at public elementary schools and are operated by public school districts (school-based pre-K sites, or for the purposes of this paper, SBPK), while others are operated by private child development centers, independent of local school systems (non-school-based pre-K sites, hereafter, non-SBPK).

Currently, little is known about the effects of participating in SBPK programs in Georgia on later educational outcomes. In this paper we estimate the impacts of winning an enrollment lottery and attending a school-based site in Georgia's Pre-K Program on a student's academic achievement, attendance, and discipline in later grades using data from a large school district in the metro Atlanta area (hereafter, the District). Our comparison group are students with similar characteristics who sought admission to an over-subscribed SBPK in the District but did not win the enrollment lottery and did not end up enrolling in any (school-based or non-school-based) site in Georgia's Pre-K Program. Thus, we are not comparing the efficacy of attending a SBPK program relative to a non-SBPK program. Rather, we are comparing outcomes for students in school-based sites in Georgia's Pre-K Program to students whose families sought admission to a SBPK program, but were not granted admission and ended up either attending an early learning program (e.g., a Montessori or private school) outside of Georgia's Pre-K Program or no formal early-learning program at all. This approach enables us to evaluate SBPK against a hypothetical scenario where no GA Pre-K is available, in other words, against a scenario of "business as usual" without GA Pre-K.

In addition to average outcomes, we also show how the effects of enrolling in a SBPK vary based on the sociodemographic characteristics of children, like free or reduced-price meals (FRPM) eligibility, a crude measure of poverty. Finally, we characterize the early childhood education decisions made by families of children who enter lotteries for over-subscribed SBPK

sites but do not win the lottery and thus are not offered admission. More specifically, using data from a metro-Atlanta school district, we address the following questions:

1. What is the effect of enrolling in a school-based site in Georgia's Pre-K Program (SBPK) for students who would otherwise not attend Georgia's Pre-K Program on future test scores, attendance, and behavior in K-12?
2. How does the effect of enrolling in a school-based site in Georgia's Pre-K Program (SBPK) vary by families' economic status?
3. How do the enrollment decisions of lottery non-winners vary by a student's demographic subgroup?

Using Pre-K enrollment data from GA Pre-K and admission lottery and roster data from the District, we find that lottery winners enter kindergarten significantly better prepared, scoring around six national percentiles higher on the Measures of Academic Progress (MAP) math and reading tests. However, these gains fade by the end of kindergarten, and some negative effects on achievement emerge by grade 4. The negative effects in later grades may be driven by students in the control group who attend options outside of Georgia's Pre-K Program. We find that free-and reduced-price-meal (FRPM) students benefit more from Pre-K compared to non FRPM students in grades 1, 2 and 4, suggesting that attending pre-K may be more beneficial for disadvantaged students, a common finding in the early education literature (Currie, 2001; Lee et al., 1990). Winners were no less likely than non-winners to commit a disciplinary infraction in any grade. however, they did miss about one fewer day of instruction in each grade after kindergarten. FRPM status does not moderate the effect of Pre-K on attendance and discipline.

1.1 *Background on Georgia's Pre-K Program*

Early education providers in Georgia may apply to become a Georgia's Pre-K Program Provider; upon approval, they receive reimbursement conditional on meeting DECAL guidelines. The level of and requirements for reimbursement are almost identical between the SBPK and non-SBPK sites. For example, conditional on a teacher's level of education and certification, DECAL grants equal funding for teacher salaries at both types of sites, and only slight differences exist between the two in the amount of funding given for non-wage benefits and classroom operating expenses. However, the District studied supplements the DECAL-provided salaries of teachers in school-based sites to match the District's pay scale for K-12 teachers. In short, DECAL guidelines are unlikely to create differences in teacher quality, but differential pay from additional District funding might. It is not clear whether non-school-based sites also supplement teacher funding or the extent to which differences in salary translate to differences in teacher quality. In addition, both SBPK and non-SBPK sites are required to choose from a set of DECAL-approved curricula for instruction. It is doubtful, then, that students in non-SBPK sites will learn significantly different content than those in SBPK sites.

Families whose children are enrolled in either a SBPK or non-SBPK site in Georgia's Pre-K Program face no out-of-pocket costs for regular instruction. Providers in Georgia's Pre-K Program are prohibited from charging fees for the 6.5-hour instructional day, and additional funding is granted to providers for assisting low-income students. To this end, providers are required to classify enrolled students into two categories based on their income: a child is eligible for Category One if they or their family participate in the Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI), Medicaid, Temporary Assistance for Needy Families (TANF), or the Childcare and Parent Services (CAPS) program and are classified

as Category Two otherwise. Providers are prohibited from charging fees for meals or transportation for Category One students.

Despite the nearly identical provisions for SBPK and non-SBPK providers, a few practical differences exist that may influence parental choice. In addition to SBPK sites requiring applicants to reside in the school district, families may be limited in the number of school-based sites to which they can apply. In the metro-Atlanta area school district we study (henceforth "the District"), parents may only apply for a single school-based site. Meanwhile, there is no limit on the number of non-SBPK sites to which families can apply. In practice, families may apply to both.

The rate at which transportation is provided is another key difference between SBPK and non-SBPK sites. While providers cannot charge fees for transportation to Category One students, offering transportation is optional. According to DECAL's public data on providers, almost all school-based sites (98.7%) in the District provide transportation to and from school. Meanwhile, only a handful (5.5%) of non-school-based sites in the District do the same, a difference likely arising from the availability of existing busing infrastructure at school-based sites. DECAL compensates providers for transportation at a rate of $16.50 per month per eligible child. This rate may be commensurate for a larger-scale, efficient busing system, but implementing transportation could be economically infeasible for sites where few children would use or need transportation.

The stark difference in the rate at which school-based and non-school-based providers implement transportation raises some concerns about the equity of access to universal pre-K. Transportation bears direct costs in the form of fuel, vehicle maintenance, or public transportation fees. It also presents indirect costs; time spent taking children to school is time that could have been spent working or engaging in some other activity. The fact that some families may have one or no vehicles or no ready access to public transportation exacerbates the problem. Assuming the

extent to which these costs are relevant varies based on income, low-income families could effectively have fewer choices even among programs with no out-of-pocket costs.

The number of children seeking entrance to SBPK programs frequently exceeds the number of seats available. DECAL does not dictate how programs allocate these seats in over-subscribed programs, leaving room for variation in enrollment processes. For example, Peisner-Feinberg et al. (2013) surveyed programs across the state during the 2012–13 year and found that, while most (77%) use a first-come-first-served system, the remaining 23%, including the District, use a lottery to determine assignment. In the District, enrollment lotteries for attendance during the next academic year occur each spring. To participate, a child must be four years old by September 1st of the calendar year in which they apply and reside within the District's attendance boundaries.

Prior Evidence

Past research shows ample benefits from high-quality early childhood education programs. Evidence suggests that interventions early in life are more effective at producing equitable outcomes than those that occur in adulthood (Currie, 2001). Randomized experiments, like the High/Scope Perry Preschool Program in the 1960s and the Carolina Abecedarian Project (CAP) in the 1970s, demonstrated extraordinary value for participating children from low-income families.

Attendees of these programs enjoyed benefits that lasted well beyond their years in school. Being selected to participate in the Perry Program raised children's lifetime earnings by about $200,000 (Belfield et al., 2006). Male CAP participants earned $20,000 more at age 30 and female CAP participants were more likely to be employed at 30 (Garcia et al., 2020). Children who were selected to participate in the Perry Preschool Program spent significantly less time in prison or

probation, received about $3,000 less in government assistance, and earned around $200,000 more over their lifetime (Belfield et al., 2006). Meanwhile, children who received services from the CAP had greater earnings, were more likely to be employed, and were less likely to be arrested in adulthood (Garcia et al., 2020). Benefits extended beyond the children; parents of CAP participants saw increases in earnings between $7,000 and $14,000. Indeed, the Perry Preschool Program and Carolina Abecedarian Project respectively generated $12.90 and $7.30 of public benefit for every dollar invested (Belfield et al., 2006; Garcia et al., 2020).

Among the earliest of the public interventions in early childhood care is Head Start, which began in the 1960s and sought to provide education and health support to poor children between ages three and five, as well as providing support to their parents. Children who attend Head Start have greater achievement in early elementary school (Deming, 2009) and are more likely to graduate from high school (Ludwig & Miller, 2007). The benefits seem to be greatest for children of below-average initial ability (Deming, 2009). Participants are also more likely to be immunized (Currie & Thomas, 1995) and less likely to die from preventable causes (Ludwig & Miller, 2007).

The large benefits exhibited by the experiments in the second half of the 20th century focusing on families with low incomes, and to a lesser extent Head Start, have generated widespread advocacy for public implementation of early childhood education and care. However, the benefits of universal (no income basis for admission) pre-K programs, like Georgia's, are less clear. Reviewing thirty studies on universal early childhood education conducted between 2005 and 2017, Huizen and Plantenga (2018) find that only one in three studies show positive effects while one in six show negative effects. Even among studies observing the same type of outcome, results can be mixed. For example, Durkin et al. (2022) find evidence that attendees of the Tennessee Voluntary Pre-K Program may later have worse behavior than non-attendees, while

studies of other programs show behavioral improvements (Belfield, 2006; Chor et al., 2016). Belfield (2006) even finds that non-attendees benefit from the presence of attendees in a kindergarten classroom.

The common result is that children who participate in any type of pre-K tend to perform better on achievement tests or cognitive measures shortly after the pre-K year (Chor et al., 2016; Currie & Thomas, 1995; Lee et al., 1990; Lipsey et al., 2018). However, these effects are commonly shown to diminish and perhaps disappear completely over time[1]. Creating long-term changes in children's cognitive ability is difficult in the first place (Currie, 2001), and elementary schools might not be taking advantage of the greater preparation of pre-K attendees (Lipsey et al., 2018). Fading quickly, the academic benefits of pre-K can disappear by first or second grade (Lee et al., 1990; Lipsey et al., 2018). One study found that the rate of decay varies based on the characteristics of students. For example, Currie & Thomas (1995) observe Black students seeing the greatest decreases in impact over time—suggesting differences in program delivery or in the types of schools attended by students of different races after early learning.

The uneven findings from research on universal pre-K lies in stark contrast to the preponderance of evidence supporting targeted, high-quality ("model") programs like the Carolina Abecedarian Project and the Perry Preschool Program. Cost-benefit analyses of these programs illustrate the disparity. The benefit of universal pre-K is generally found to be in the range of $2 to $4 for each dollar invested (Bartik et al., 2012; Karoly, 2016). This clearly departs from estimated benefits as high as $17 for model programs (Karoly, 2016). Previous explanations of this discrepancy have noted differences in the funding and intensity of model and public pre-K programs (Currie, 2001; Huizen & Plantenga, 2018). The Carolina Abecedarian Project, for

[1] One dissenter is Huizen & Plantenga (2018), whose meta-analysis of universal early childhood education studies suggests no fade out.

example, spent more than $20,000 per child each year adjusted for inflation (Arnold Ventures, 2017), about four times as much as the Georgia Pre-K Program[2]. It also involved children from eight weeks old to five years old, had no more than six children to a teacher, and operated year-round (Arnold Ventures, 2017). Meanwhile, the Georgia Pre-K program, like other state-funded universal pre-K programs, includes only four-year-olds and permits no more than eleven children per teacher.

Even if programs today had the same funding and intensity, it is possible that their measured benefits would still pale in comparison to those of past programs. The effect estimated depends on the counterfactual—the education a child would have received had they not attended pre-K—and some argue that this comparison is changing. Lipsey et al. (2018) makes this argument, contending that children today have more educational resources, like the internet, at home. Furthermore, Karoly et al. (2016) notes that children in the past were less likely to attend any pre-K program. Students from low-income families, who may have less ability to learn at home, tend to benefit the most from universal pre-K (Huizen & Plantenga, 2018).

Another difference between the early model interventions and universal pre-K that may contribute to the overwhelming positive effect of the former is that the model interventions were targeted to disadvantaged children only. The Perry Preschool Program was targeted to disadvantaged African American students living in Ypsilanti, Michigan (Heckman et al., 2010a, 2010b) while the Carolina Abecedarian Project targeted disadvantaged and predominantly African American students in Chapel Hill, North Carolina (Garcia et al., 2020). There is no such restriction in universal pre-K programs.

[2] National Institute for Early Education Research, 2018

Data

This study centers around admission lotteries that took place in the District between 2012 and 2018. As stated above, in the District, enrollment lotteries for attendance during the next academic year occur each spring. Site rosters and waitlists help identify winners and non-winners respectively. GA Pre-K sites submit rosters of all enrolled students four times a year to DECAL. Likewise, those sites also send an updated list of students who are actively waiting for spots in the site four times a year. In other words, providers are responsible for maintaining the waitlist by identifying students who no longer wait. While these waitlists do not explicitly identify lottery non-winners, it does record when students enter the waitlist for each site. In the District, full sites accept late applications until August 31; however, these sites only process the applications after exhausting the waitlist. While the ideal strategy would be to identify students who entered the waitlist just after the lottery in spring (since they are the most likely to be lottery non-winners and not late applicants), the earliest date of entry sites can select when adding students to the waitlist is July 1. Therefore, we assume that students lost a lottery if they entered the waitlist on that date.

Students who participate in a lottery and lose may later appear on the roster of another GA Pre-K site. In addition, a student could be removed from the waitlist if a spot opens at their preferred site and causes them to leave the waitlist. Otherwise, they can enroll in another school-based or non-school-based site. In some cases, both happen: a student enters a non-school-based site in Georgia's Pre-K Program, but later enrolls in the site for which they were waitlisted. With that in mind, for questions (1) and (2), We compare students who won the lottery to those who did not win the lottery and never enrolled in any site in Georgia's Pre-K Program. We define lottery sites as sites that had at least one non-winner in a given year. A student is defined as a lottery winner if they appear on a roster for a lottery site but never appear on that site's waitlist.

Since our control group consists of lottery non-winners who don't go to any GA pre-K site, SBPK or non-SBPK, it is important to explore the choices made by them. Table 1 shows the number and percentage of lottery non-winners who attend each type of pre-K site. The most common outcome for children who lose a lottery is to not attend any GA pre-K site, accounting for nearly half of all non-winners (49.59%). For the other half of students who remain in a GA pre-K site, the typical choice (28.38%) is to enroll in a non-SBPK; this constitutes more than half (56.30%) of non-winners who attend GA pre-K sites. Some non-winners (18.94%) do later attend an SBPK, with the majority (11.62%) attending the SBPK for which they originally lost a lottery. Finally, a small number of students attend multiple sites. The most frequent (2.42%) situation in which this occurs is when a child attends both a non-SBPK and their preferred SBPK over the course of a year. One takeaway from Table 1 is that losing an enrollment lottery doesn't necessarily preclude attendance of a pre-K in Georgia's Pre-K Program, both for school-based and non-school-based sites. Considering this, Appendix Table A1 examines the intensive margin of school attendance, comparing students who did not win the lottery with all GA Pre-K attendees, even in non-lottery sites, who were never on a waitlist.

Table 1: Non-winner decisions

	# non-winners	% non-winners
No Pre-K Observed	3,285	49.59
Non-SBPK	1,880	28.38
Preferred SBPK	770	11.62
Other SBPK	485	7.32
Non-SBPK & Preferred SBPK	160	2.42
Non-SBPK & Other SBPK	25	0.38
Preferred SBPK & Other SBPK	19	0.29

Note: If a student loses a lottery for an SBPK, that SBPK is considered "preferred" by that student

To measure the effects of attending SBPK on K-12 outcomes, we use administrative panel data on students who attended public school in the District. In addition to demographic information like gender, race/ethnicity, English learner status, and free or reduced-price meals eligibility, we also observe key outcomes: absences, disciplinary infractions, and performance on the Measures of Academic Progress (MAP) formative assessments in math and reading. Using these data, we follow students for several years after exiting pre-K and entering the District.

Methods

A challenge to estimating the impacts of school-based sites in Georgia's Pre-K Program is that families decide both (i) whether or not to seek admission into a specific program for their child and, (ii) conditional on whether they are offered admission to the desired program, what early learning program (if any) they choose to enroll their child into. Figure 1 illustrates the many choices parents face with respect to their child's early education. If parental choice over programs is influenced by factors that also drive student outcomes (e.g., family income), then a simple comparison of outcomes for students who attend a SBPK program with those who do not attend any Georgia Pre-K Program site would conflate the true impacts of the program with the characteristics of the children and their families.

To mitigate potential bias from parental decisions to apply for admission to a SBPK program, we limit our analyses to students whose parents applied for admission to an over-subscribed SBPK program in the District and were thus participants in an enrollment lottery. Given that admission offers are randomly assigned to lottery participants, the characteristics of lottery winners (who are offered admission) and the characteristics of non-winners (who are not initially admitted) should be equal on average and thus eliminate any bias from unobserved family

characteristics associated with the decision to apply for a slot in a SBPK program. Figure 1 highlights these groups in green and yellow respectively.

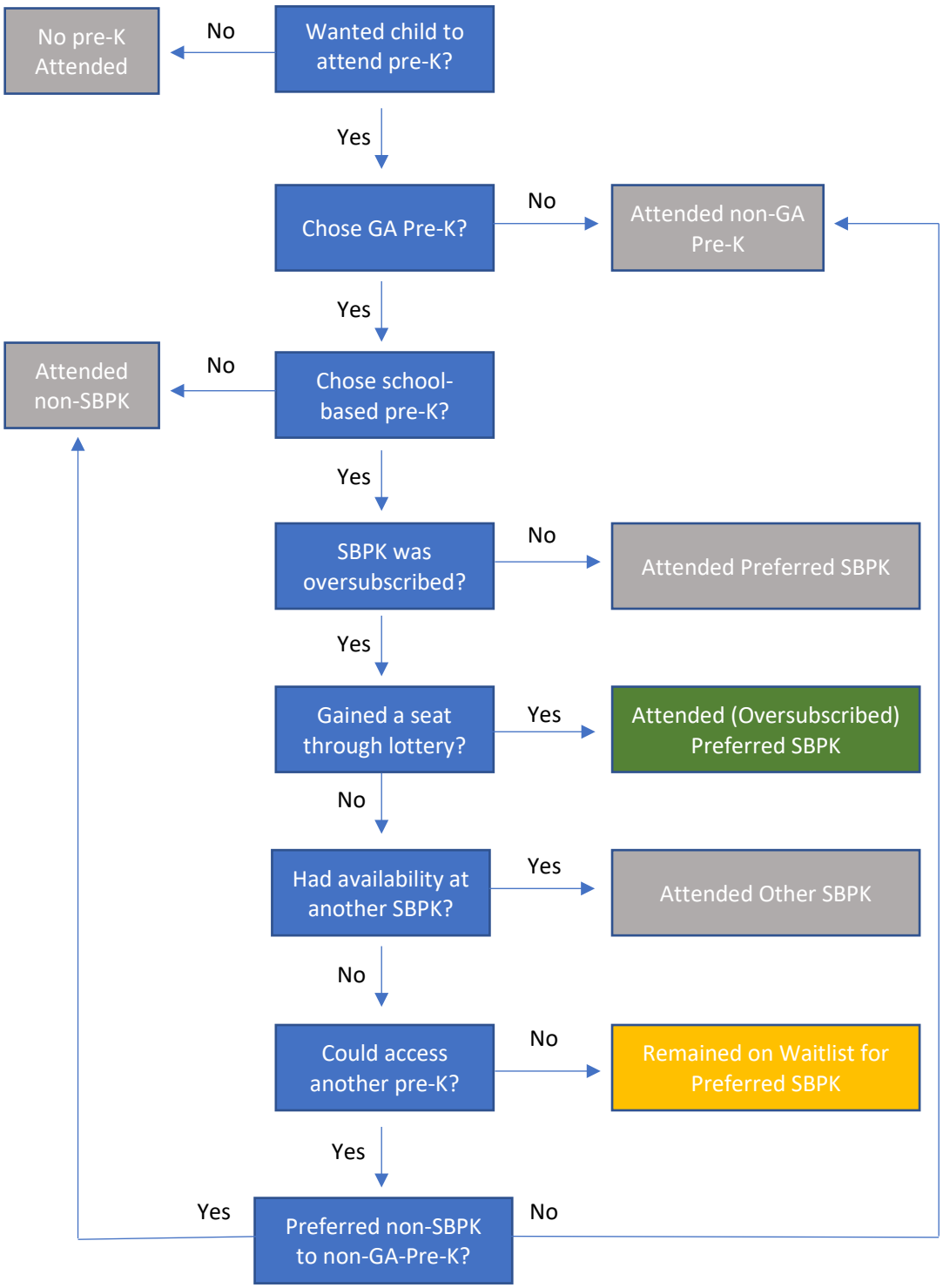
We use equation 1 to estimate the effect of SBPK. While the characteristics of students should be balanced in winners and non-winners within a lottery, the characteristics of students may not be balanced between lotteries. In other words, while the winners and non-winners in the same lottery may be similar on average, they may be different across different lotteries. To this end, we use lottery fixed-effects which enables comparison of students within lotteries, controlling for systematic differences between students across lotteries.[3] We also use a year fixed-effect for the year in which an outcome was measured. In doing so, we account for potential variation over time in outcomes for all students that is unrelated to attendance of a SBPK.

While including student characteristics in the model would be unnecessary in a fully randomized lottery, our sample is only partially randomized. For it to be fully randomized, among the lottery participants, the decision to go to a SBPK site would need to be unrelated with student characteristics. This is an untenable assumption because the lottery non-winners have a choice to go to a different GA Pre-K program, e.g., a non-SBPK. We control for student demographic characteristics which helps mitigate bias arising from selection into the control group.

$$(1): \quad Y_{ip,g=g^0} = \beta_0 + \beta_1 win_{ip} + \beta_2 X_i + \delta_{t_i(g^0)} + \lambda_p + \epsilon_{ipg}$$

[3] The lottery fixed effect is defined as a site-year combination. If a school was observed having a lottery five years in a row, it would generate five different lottery fixed effects.

Figure 1: Example Decision Tree for Parents



Equation 1 shows the model to be estimated. $Y_{ip,g=g^0}$ is the outcome in selected grade $g = g_0$ for student i who participated in lottery p. win_{ip} is the treatment indicator and equals one if student i won enrollment lottery p. X_i is a vector of control variables including race, gender, FRPM status, and ESL status. $\delta_{t_i(g^0)}$ is a fixed-effect for the year t_i in which student i had an outcome for grade g^0, while λ_p is a lottery fixed-effect. The estimated coefficient of interest β_1 is the effect of winning the lottery and attending an oversubscribed SBPK on our outcome of interest.

To assess heterogeneity of the benefits from pre-K by family income, we estimate a version of equation (1) which includes an interaction of the treatment indicator with an indicator for a student having ever qualified for FRPM. In equation (2), $win_{ip} \times FRPM_i$ is the interaction term between the treatment indicator and FRPM status. The average marginal effect of winning a lottery and attending for FRPM-qualifying students can be calculated by adding the coefficient on the treatment indicator and the interaction term (i.e., $\gamma_1 + \gamma_2$). On the other hand, the coefficient to the interaction (γ_2) is the difference in marginal effect of an FRPM student winning the lottery and attending an SBPK compared to a non-FRPM student winning the lottery and attending the same. A large and significant interaction coefficient would suggest that attending a SBPK is more important for one group than the other. Because a common finding in the pre-K literature is that disadvantaged students tend to benefit more from pre-K attendance, one might expect the interaction to be positive.

(2): $$Y_{ip,g=g^0} = \gamma_0 + \gamma_1 win_{ip} + \gamma_2 win_{ip} \times FRPM_i + \gamma_3 X_i + \delta_{t_i(g^0)} + \lambda_p + \epsilon_{ipg}$$

Limitations

Restricting the analysis to participants in enrollment lotteries does not eliminate potential group differences from subsequent family decisions about where to enroll their child. Students who win a SBPK lottery are eligible to attend but may choose not to. If the attendance decision is

correlated with factors that drive student outcomes, it could lead to biased estimates of the impact of SBPK attendance. For example, suppose that more affluent families frequently decide to send their child to a private early-learning program outside of Georgia's Pre-K Program, even when they win the school-based admission lottery, whereas lower-income families cannot afford non-subsidized private alternatives and almost always enroll their child in a SBPK site if they win the lottery. Assuming that more affluent families can also provide additional educational support that raises student outcomes, this would make it look like the SBPK is less effective than it truly is. Similarly, our control group consists of lottery non-winners who do not attend any GA Pre-K. If more affluent families who lose the school-based lottery are more likely to find a non-SBPK site for their child (rather than no formal child care at all), they would be underrepresented in our control group, which could depress outcomes for the control group and overstate the efficacy of attending SBPK.

A second concern is that we do not observe the early childhood educational choices of students that do not attend any site in Georgia's Pre-K Program. While our data covers all public and private sites that are part of the system overseen by DECAL, families have a variety of options (of varying quality) outside of Georgia's Pre-K Program. For example, some early-learning centers in the District that are generally perceived as high-quality, like Montessori schools, are not administered by DECAL. Students who attend these schools could raise the average readiness for the control group. This, in turn, would lower the size of the effect we estimate. On the other hand, children who do not win the SBPK lottery and do not attend any site in Georgia's Pre-K Program could end up in informal childcare settings, such as staying with a neighbor or relative, that may or may not provide strong early-learning opportunities.

Our later analyses attempt to discern the effect of gaining a seat in an oversubscribed SBPK for students who qualify for free or reduced-price lunch, a rough measure of poverty. While this is an important analysis from an equity perspective, it also partially addresses the concern raised previously. Namely, if we assume that higher income families have greater access to other high-quality sites outside Georgia's Pre-K Program than lower income families, children in the latter group would be more likely to have no formal early education. In this case, FRPM-qualifying non-winners would be less likely to attend such a site, and the effect measured among FRPM students should better capture the effect of attending a SBPK versus attending no GA Pre-K.

Third, our analytical strategy relies on comparing winners and non-winners within oversubscribed schools. Our estimates measure the effect of attending an SBPK relative to no attendance of any site in Georgia's Pre-K Program. The extent to which our findings apply to pre-K sites that are not over-subscribed is not clear. The level of oversubscription at pre-K sites is highly likely to be nonrandom. Demand for "good" schools could cause effective pre-K sites to be oversubscribed. Thus, one cannot necessarily extend our findings to school-based sites that are not over-subscribed. In the same vein, our results come from only one school district, and may not be generalizable to other school districts in Georgia or elsewhere.

The fourth issue pertains to the likelihood that a student enrolls in the District in later years and whether winning a lottery affects that likelihood. Our data on elementary school outcomes only covers students who were enrolled in the District, and some students may be more likely to leave than others. This may be a problem if the types of students who are more likely to leave also tend to get a different level of benefit from attending pre-K.

Results

Effect of SBPK attendance on academic achievement in elementary school

We begin by estimating the effect on academic achievement in Kindergarten and beyond from winning an enrollment lottery and attending an oversubscribed SBPK program. Academic performance is measured using national percentile ranks in math and reading from the Measures of Academic Progress (MAP) exam. Students in the District take the exam at each grade level during early fall, winter, and late spring. This structure permits evaluating how well prepared a student enters a grade and how their performance evolves over that school year. The MAP exam taken during the fall of kindergarten is of particular interest. Such timing permits little instruction prior to testing, meaning that experiences before kindergarten should drive differences in this score.

Table 2: Effects of pre-K attendance on MAP national percentile scores, by grade, subject, and test timing

	Reading			Math		
	Fall	Winter	Spring	Fall	Winter	Spring
Kindergarten	5.676***	3.559**	1.962	5.779***	3.346*	2.233
	(1.050)	(1.240)	(1.315)	(1.099)	(1.309)	(1.350)
N	2613	2575	2536	2632	2574	2531
Grade 1	-0.086	0.929	0.074	0.646	-0.479	-0.319
	(1.006)	(1.005)	(1.034)	(1.064)	(1.021)	(1.049)
N	4072	3994	3901	4079	3998	3907
Grade 2	-0.222	-0.427	-1.013	-0.243	-0.453	-0.773
	(0.792)	(0.841)	(0.914)	(0.885)	(0.939)	(1.076)
N	5565	5445	4641	5584	5439	4638
Grade 3	-0.739	-0.390	-1.285	-1.266	-1.566*	-0.855
	(0.885)	(0.854)	(1.010)	(0.818)	(0.797)	(0.921)
N	5890	5814	4418	5916	5811	4412

Grade 4	-1.181 (0.925)	-1.861* (0.930)	-0.789 (1.148)	-2.018* (0.866)	-1.279 (0.839)	-2.631* (1.065)
N	4877	4790	3395	4903	4795	3396

Note: *, **, and *** represent significance at the .05, .01, and .001 levels.

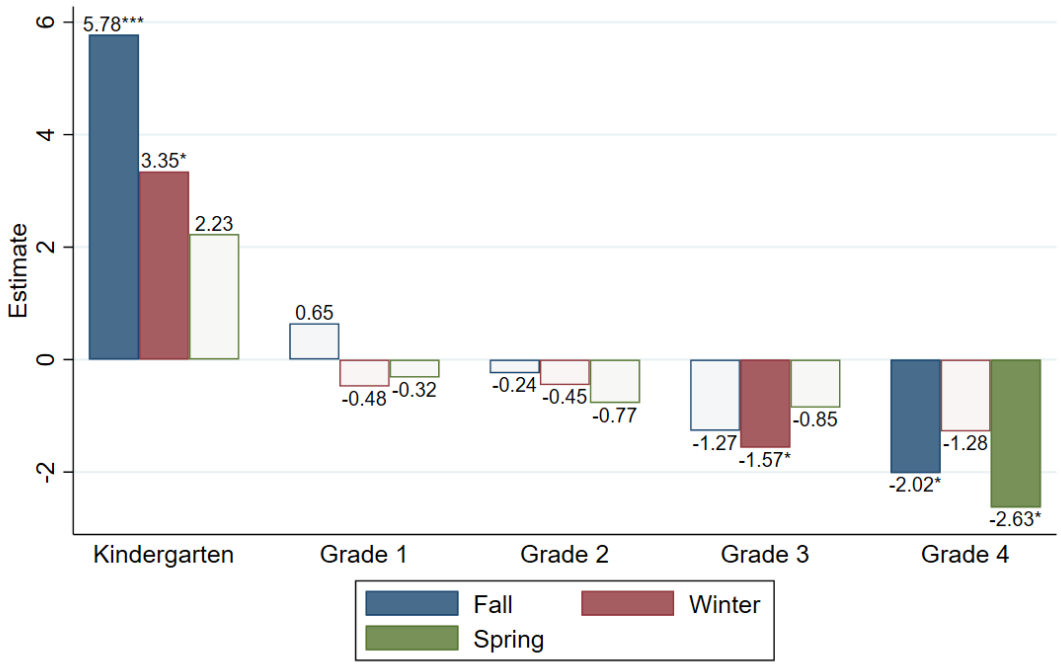
Table 2 depicts the estimated effect of attending an oversubscribed SBPK on national reading and math percentiles by grade and test timing following equation (1). In short, it answers the following question: If the average student who lost a lottery (and then never attended any GA Pre-K site) had instead won their lottery and attended, how would we expect their national percentile to change?

Pre-K attendees entering kindergarten score 5.68 and 5.78 percentiles higher on the fall reading and math exams, respectively, than non-attending peers who lost an attendance lottery and did not go to any GA Pre-K. A near six percentile difference is quite large, suggesting that attendees tend to be much better prepared for kindergarten. However, this effect is cut almost in half after a semester of instruction in kindergarten: SBPK attendees score just 3.35 percentiles higher in math and 3.56 percentiles higher in reading on the winter test than non-winners who did not attend any GA Pre-K. By the test at the end of the spring, point estimates have been cut nearly in half once more, and are marginally insignificant (at the 5% level). The downward trend of the effects which began in kindergarten continue through first grade, where negative, but insignificant, point estimates emerge. By second grade, all point estimates are negative, a situation which never reverses in further grades. For the 3rd grade winter math test, the 4th grade winter reading test, and the 4th grade fall and spring math tests, estimates are negative and significant, which may suggest detrimental effects from attendance of a school-based pre-K.

The gradual decrease in the positive effect of SBPK can also be observed in Figures 2 and 3 for math and reading respectively. The height of the bar represents the expected difference in

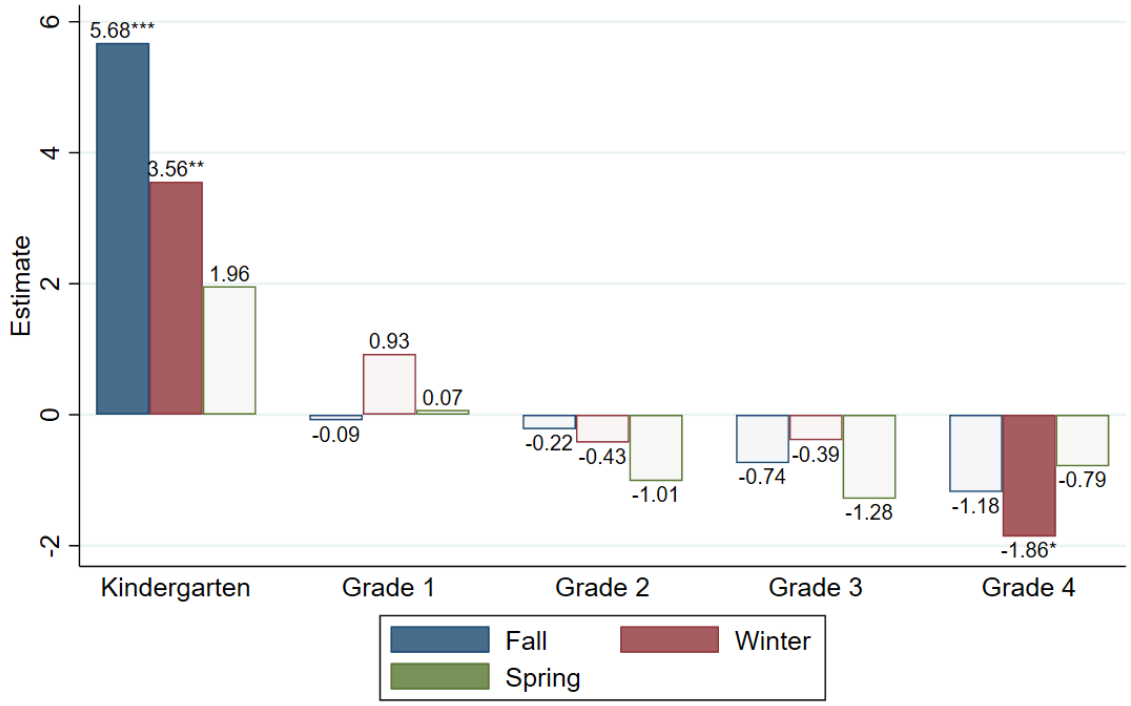
math percentile rank between students who win an enrollment lottery and attend a SBPK site and students who do not win a lottery at the same site and end up at a non-GA Pre-K early learning center or in no formal pre-K. Shaded bars represent estimated differences in outcomes that we can be 95% confident are not zero.

Figure 2: Effect of School-Based Pre-K Attendance on MAP Percentile in Math
(Relative to not attending Georgia's Pre-K Program)



Note: shaded bars indicate significant estimates – estimates which are at least 95% likely to be different from zero.

Figure 3: Effect of School-Based Pre-K Attendance on MAP Percentile in Reading
(Relative to not attending Georgia's Pre-K Program)



Note: shaded bars indicate significant estimates – estimates which are at least 95% likely to be different from zero.

At first glance, the emergence of statistically significant negative impacts of SBPK attendance on test scores in 4th grade is surprising. However, significant negative effects from attending universal pre-K are not unheard of. Durkin et al. (2022) find some negative effects in later grades when evaluating Tennessee's Voluntary Pre-K Program, and Huizen and Plantenga (2018) indicate that one in six evaluations of universal pre-K programs show significant negative effects. However, our results may also suffer from the sources of bias discussed in the limitations section. In particular, some students who lost a lottery and never attended a site in the GA Pre-K program could go to a high-quality, non-GA-Pre-K private program instead. Because the data covers only GA Pre-K sites, such students appear to have never attended pre-K and therefore enter the control group. Likewise, students who attend high-quality non-GA-Pre-K options may perform better academically regardless of pre-K. If the effect of attending pre-K fades for both groups, a

difference in later grades could reflect only the differences in group characteristics. While this issue may be affecting the level of our estimates, it is unlikely to be changing their pattern. Overall, it seems that attendance of an oversubscribed SBPK confers a significant boost to students when they enter kindergarten that fades rapidly as non-winning peers catch up.

Differential effects of pre-K attendance for low-income students

Evidence suggests that early childhood education can play a significant role in the development of children from disadvantaged backgrounds, namely those from low-income families (Currie, 2001). Universal pre-K is in part organized around the belief that an early intervention can have large effects for that group by reducing the disparity in resources available to children from different economic backgrounds. To better understand the role of early childhood education for low-income students, we repeat the previous estimation while including an interaction of the treatment indicator with FRPM eligibility following equation (2). Table 3 presents the results of that estimation.

Table 3: Effects of pre-K attendance on MAP reading national percentile scores, by grade and test timing

		Reading			Math		
		Fall	Winter	Spring	Fall	Winter	Spring
Kindergarten	*Win*	3.722*	1.016	-0.833	3.542	1.065	0.953
		(1.784)	(2.187)	(2.176)	(1.957)	(2.200)	(2.024)
	Win x FRPM	3.071	3.984	4.383	3.513	3.578	2.006
		(2.139)	(2.609)	(2.681)	(2.297)	(2.661)	(2.618)
N		2613	2575	2536	2632	2574	2531
Grade 1	*Win*	-3.330*	-2.493	-3.360*	-1.800	-3.814*	-2.562
		(1.584)	(1.610)	(1.577)	(1.693)	(1.567)	(1.596)
	Win x FRPM	5.151**	5.429**	5.461**	3.884	5.282**	3.559
		(1.983)	(2.007)	(2.040)	(2.118)	(1.987)	(2.055)
N		4072	3994	3901	4079	3998	3907

	Win	-2.103	-2.804*	-1.546	-2.197	-1.764	-2.348
		(1.267)	(1.323)	(1.435)	(1.302)	(1.316)	(1.415)
Grade 2	*Win x FRPM*	2.765	3.474*	0.767	2.869	1.917	2.264
		(1.593)	(1.674)	(1.803)	(1.705)	(1.760)	(1.964)
N		5565	5445	4641	5584	5439	4638
	Win	-2.318	-2.029	-2.122	-2.775*	-3.344*	-2.668
		(1.425)	(1.372)	(1.549)	(1.321)	(1.341)	(1.465)
Grade 3	*Win x FRPM*	2.149	2.611	1.776	1.873	1.792	2.116
		(1.710)	(1.664)	(1.886)	(1.580)	(1.590)	(1.763)
N		5890	5814	4418	5916	5811	4412
	Win	-4.048**	-4.902***	-3.506*	-4.735***	-4.337***	-5.101***
		(1.287)	(1.330)	(1.591)	(1.261)	(1.282)	(1.482)
Grade 4	*Win x FRPM*	3.959*	3.819*	2.570	3.460*	3.944*	3.113
		(1.614)	(1.667)	(1.970)	(1.553)	(1.556)	(1.831)
N		4877	4790	3395	4903	4795	3396

Note: *, **, and *** represent significance at the .05, .01, and .001 levels.

The coefficient for win is the marginal effect of SBPK attendance for non-FRPM qualifying students. A positive significant effect for this group only emerges for the fall reading test in kindergarten, showing a 3.72 percentile higher score for SBPK students compared to students who applied but were not granted admission. Point estimates are positive, but insignificant, for four out of the other five kindergarten tests. However, in grade 1 onwards, we often see a statistically significant negative effect of SBPK on non-FRPM students.

The coefficient on $win\ x\ FRPM$ is the difference in the marginal effect of winning between FRPM and non-FRPM students. Coefficients to this interaction term are always positive and often significant. This indicates that the marginal effect of SBPK attendance on test percentiles for students who ever qualified for FRPM is measurably greater than those students who never qualified for FRPM. Taking the results from Tables 2 and 3 together, the large, positive aggregate

effects shown in Table 2 seem to be driven by FRPM students.

Two explanations are plausible for the pattern of results exhibited by both subject tests. Recall that, because of the limitations of our data, we are unable to distinguish between going to a non-GA-Pre-K site (like many Montessori schools) and not going to any pre-K site. Our control group, then, contains both children who don't attend any pre-K and those who attend a non-GA-Pre-K program. We can expect that non-FRPM students are more likely to be able to afford non-GA-Pre-K options and hence are less often classified correctly as not having attended any pre-K, implying that the "true" effect is being captured less frequently among non-FRPM students. Second, early interventions for students from low-income backgrounds could benefit those students beyond direct education. Entering education at age four rather than age five may help remedy resource disparities between high and low-income children, for instance by providing nutritious meals or by giving parents, especially mothers, greater flexibility in employment.

Effects of SBPK attendance on absences and disciplinary infractions in elementary school

In the previous section, we showed that attending an oversubscribed SBPK yields large gains in math and reading percentiles at the start of kindergarten which decay as students entered later grades. Prior research has shown that high-quality pre-K programs can yield benefits beyond just helping students score higher on tests, however. School-based Pre-K in the District seeks to promote social-emotional well-being for students in addition to enhancing their educational achievement. We don't have any direct measures for social-emotional well-being. However, given prior literature's findings about non-test score effects, we broaden our analysis to examine two other measures: later attendance and disciplinary conduct. We generate estimates once again by comparing the outcomes of winners and non-winners within lotteries.

Table 4 shows the effect of oversubscribed SBPK attendance on attendance and the number of disciplinary infractions in each grade. We estimate equation (2) to separately identify the effect on FRPM and non-FRPM students. When it comes to disciplinary infractions, we find a positive interaction term for discipline in grade 2 implying a positive marginal effect of SBPK attendance on disciplinary infractions for FRPM-qualifying students. This, however, is the lone significant result for discipline. In general, we do not find a relationship between attending a SBPK and disciplinary infractions. Because a student's number of disciplinary infractions is only a loose measure of their overall social and emotional competency, these results are not necessarily indicative of the ineffectiveness of SBPK in the District for nurturing social-emotional learning.

Table 4: Effects of pre-K attendance on disciplinary infractions and attendance, by grade

	Kindergarten		Grade 1	
	# Disciplinary Infractions	Days Absent	# Disciplinary Infractions	Days Absent
Win	-0.003	-0.256	0.002	-0.485*
	(0.005)	(0.224)	(0.004)	(0.214)
Win x FRPM	-0.004	-0.150	-0.018	-0.236
	(0.010)	(0.289)	(0.013)	(0.302)
Constant	0.044***	4.853***	0.022	4.404***
N	9802	9675	9163	7957

	Grade 2		Grade 3	
	# Disciplinary Infractions	Days Absent	# Disciplinary Infractions	Days Absent
Win	-0.002	-0.300	-0.011	-0.737*
	(0.004)	(0.249)	(0.006)	(0.309)
Win x FRPM	0.021*	-0.444	0.031	0.347
	(0.009)	(0.360)	(0.020)	(0.436)
Constant	0.035**	4.096***	0.050***	4.802***
N	8828	5835	7774	3912

	Grade 4	
	# Disciplinary Infractions	Days Absent
Win	0.003	-1.022**
	(0.003)	(0.391)
Win x FRPM	0.002	0.282
	(0.009)	(0.659)
Constant	0.021**	4.416***
N	5928	1974

Note: *, **, and *** represent significance at the .05, .01, and .001 levels.

On the other hand, winning a lottery for and attending an SBPK does appear to significantly decrease the number of days for which a student is marked absent in first grade, third grade, and fourth grade. Point estimates are negative but insignificant for kindergarten and second grade. FRPM status does not appear to moderate this effect. Taken as a whole, the relationship here is modest, with the average winner attending roughly three more days of school between kindergarten and fourth grade.

Student characteristics and pre-K enrollment behavior for lottery non-winners

Certain characteristics of students are predictive of whether and where a student goes to pre-K. We use a multinomial logit model to estimate the marginal effect of membership in various subgroups on the relative likelihoods for different types of pre-K attendance among children who enter lotteries for over-subscribed SBPK sites but do not win the lottery and thus are not offered admission. Table 5 provides the coefficients from that model, which should be interpreted as the marginal effect of the given subgroup on the log-odds of attending SBPK, Non-SBPK, or both, relative to not attending any pre-K. Further discussion below interprets the coefficients as odds rather than log-odds, which one can obtain by exponentiating the coefficient. These exponentiated log-odds are also listed in the table as the odds-ratio.

Table 5: Marginal effect of subgroup membership of nonwinners on odds of pre-K attendance type

	SBPK	Non-SBPK	Both
	Odds ratio [Log odds] (Standard error)	Odds ratio [Log odds] (Standard error)	Odds ratio [Log odds] (Standard error)
Female	1.162* [0.150*] (0.07)	1.113 [0.107] (0.06)	1.195 [0.178] (0.15)
Black	1.937** [0.661**] (0.20)	2.140*** [0.761***] (0.21)	2.160 [0.770] (0.62)
White	0.730 [-0.315] (0.19)	0.394*** [-0.932***] (0.20)	0.254* [-1.371*] (0.60)
Asian	0.982 [-0.018] (0.21)	1.234 [0.210] (0.21)	1.078 [0.075] (0.62)
ELL	0.537*** [-0.621***] (0.11)	0.838 [-0.177] (0.09)	0.319*** [-1.142***] (0.31)
FRPM	1.487*** [0.397***] (0.09)	1.602*** [0.471***] (0.08)	2.237*** [0.805***] (0.19)
Constant	0.386*** [-0.951***] (0.21)	0.522** [-0.651**] (0.22)	0.055*** [-2.906***] (0.64)
N = 6208			

Note: These are multinomial logit model estimates of the marginal effect of membership in various subgroups on the relative likelihoods for different types of pre-K attendance. The first number for each student characteristic is the odds of attending the program indicated in the column relative to not attending pre-K, the second number is the log odds and the third number is the standard error of the log odds calculated in the multinomial logit model. Subtracting one from the odds ratio allows interpretation as a percentage more or less likely.

English language learners who lose an enrollment lottery are 46.3% less likely to attend a SBPK and 16.2% less likely to attend a non-SBPK relative to not attending GA Pre-K at all. In contrast, FRPM-qualifying students who lose an enrollment lottery are 48.7% more likely to attend a SBPK and 60.2% more likely to attend a non-SBPK than not attending GA Pre-K. White non-

winning students are slightly less likely to attend a SBPK and significantly less likely to attend a non-SBPK than no site in Georgia's Pre-K Program, whereas Black non-winner-students are almost twice as likely to attend either a SBPK or non-SBPK than not attending Georgia's Pre-K Program. Because our data cannot distinguish students who attend a pre-K unaffiliated with the GA Pre-K Program from those who truly do not attend any pre-K at all, it is difficult to interpret these results. White children being less likely to be observed in any pre-K might reflect the use of options outside Georgia's Pre-K Program. In contrast, the finding that English learners who lose a SBPK lottery are more likely to not attend GA Pre-K, rather than attend a SBPK or non-SBPK, may be explained by limited access to ELL services in non-SBPKs and difficulty in obtaining transportation for their children, which could result in staying at home or participating in informal pre-K settings. The choices of FRPM-qualifying students are more difficult to rationalize. Given that few non-SBPK programs offer transportation, it is surprising that FRPM non-winners are relatively more likely to attend a non-SBPK than not attending GA Pre-K at all. The reader should note that these explanations are merely conjecture, as this study does not have data on options outside of Georgia's Pre-K Program. Further research on pre-K in Georgia would greatly benefit from data with more detail on the choices of students who do not attend any pre-K affiliated with Georgia's Pre-K Program, but gathering quality data from a variety of independent early childhood education centers presents a significant challenge.

Conclusion & Policy Implications

In this paper, we estimated the effects of attending an oversubscribed school-based Georgia's Pre-K Program on achievement, attendance, and discipline in elementary school. Using the results of lotteries for oversubscribed school-based pre-K sites in a metro-Atlanta school

district, we compared students who gained a seat through an enrollment lottery and attended a school-based site in Georgia's Pre-K Program to students who did not gain a seat through a lottery and did not go to site in Georgia's Pre-K Program. We find that lottery winners enter kindergarten significantly more prepared, around six percentiles, than their non-winning peers as measured by national percentile rankings on the Measures of Academic Progress (MAP) math and reading tests. However, these gains fade by the end of kindergarten, and some negative effects on achievement emerge by grade 4. The negative effects in later grades may be driven by students in the control group who attend options outside of Georgia's Pre-K Program. Measured effects are always statistically significantly greater in grades 1, 2, and 4 for students who qualify for free or reduced-price meals (FRPM) as compared to their non-qualifying peers, suggesting that attending pre-K may be more beneficial for disadvantaged students, a common finding in the early education literature (Lee et al., 1990; Currie, 2001). While winners were no less likely than non-winners to commit a disciplinary infraction in any grade, they did miss about one fewer day of instruction in each grade after Kindergarten.

Importantly, we find that students who qualify for free or reduced-price meals almost always benefit more from winning a lottery for a school-based pre-K and attending. Disadvantaged students who are not in a formal setting may have more limited access to educational resources than their peers, a disparity that pre-K attendance alleviates. Another factor that may be relevant for low-income families is the difference in transportation provision between school-based and non-school-based sites in Georgia's Pre-K Program. While almost all school-based sites offer transportation (which is free for low-income students), almost no non-school-based sites do, and the effects of losing a lottery could be more acutely realized for low-income families who have limited transportation availability.

The limitations of our analysis make us cautious in providing policy recommendations. However, due to the disparities in transportation access across sites, offering transportation-limited students priority at sites which offer transportation could be impactful. In the long-term, additional funding could help non-school-based sites overcome the cost of providing transportation, as they don't have the economies of scale like elementary schools do. Finally, providing additional information to parents could be a relatively inexpensive and potentially impactful way to increase the number of students served. In particular, informing non-winning parents of next steps and other options within Georgia's Pre-K Program reduces the chance that their child does not attend any formal pre-K. Our results give suggestive evidence that this type of intervention could be particularly beneficial if aimed at families with limited language proficiency, as they have a greater barrier to accessing information.

It is possible that providers in Georgia's Pre-K Program are preparing students in ways that we are not measuring. For instance, pre-K may develop its attendees' social-emotional skills. Our null results for impacts on discipline do not support this notion, but they do not necessarily rule it out. Little variation exists in the number of infractions per student, meaning that our model might not be well-suited to detecting a relationship. On the other hand, we do find a consistent, positive relationship of pre-K with later elementary school attendance. This is encouraging insofar as it indicates that attending a school-based pre-K can have a persistent effect on a student, but it is unclear what mechanism drives this decrease in absenteeism. It could also be possible that students who attend pre-K generate positive effects for non-attendees in their classrooms, as Belfield (2006) suggests. For instance, pre-K attendees may be more prepared, or easier to teach, allowing teachers to perform their job more effectively. In theory, these spillovers would raise the readiness of the control group and diminish the estimated effect of attending a school-based pre-K on later

outcomes. We cannot conclusively explain the mechanisms driving the patterns shown in this paper.

The broad patterns we find are consistent with previous studies of the efficacy of universal pre-K programs elsewhere: attending a school-based pre-K does prepare students well academically for kindergarten, but these measured benefits do not appear to persist for long. It is not clear why this is the case. One study has suggested that elementary schools might fail to capitalize on the greater academic preparedness of pre-K attendees (Currie & Thomas, 1995). More research is needed to understand the pathways that connect early educational outcomes to those later in childhood.

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Appendix A – Further discussion of non-winner decisions

Table A1 illustrates the fact that students who lose an enrollment lottery spend about half as many days enrolled in GA Pre-K compared to the average student who was never on any waitlist. Students who were never on a waitlist spend 85.9% of days between August 15th and May 31st enrolled in GA Pre-K, whereas students who do not win the lottery spend only 44.2% of the same time period enrolled in GA Pre-K. For non-winners, we fail to observe them in any GA Pre-K program for 55.8% of days in that span, indicating that they were either not attending any pre-K, or attending a pre-K program not administered by GA Pre-K. Children who do not win the lottery but attend GA Pre-K tend to spend the most time enrolled in non-SBPK sites, followed by SBPK sites other than their lottery school.

Table A1: Average number of days spent in each type of pre-k site between August 15th and May 31st

	Non-winners		Never on Waitlist	
	Mean	% of Days	Mean	% of Days
Days Not Enrolled in Pre-K	160.22	55.8	40.51	14.1
Days Enrolled in GA Pre-K	126.63	44.2	246.23	85.9
Days in Non-SBPK	73.96	25.6	140.85	48.7
Days in Any SBPK	52.67	18.2	105.37	36.5
Days in Preferred SBPK	32.52	11.3	-	-
Days in Other SBPK	20.15	7.0	-	-

Note: If a student loses a lottery for an SBPK, that SBPK is considered "preferred" by that student. The time period is 289 days between August 15th and May 31st.