RUNNING HEADER: Pre-K and college

Universal Pre-K and College Enrollment: Is there a Link?

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Abstract

In this study, we use data from a cohort of 4,033 Tulsa kindergarten students to investigate the relationship between pre-K enrollment and later college enrollment. Specifically, we test whether participation in the Tulsa Public Schools universal pre-K program and the Tulsa CAP Head Start program predict enrollment in two-year or four-year colleges. We use propensity score weighting with multiply imputed data sets to estimate these associations. We find that college enrollment is 12 percentage points higher for Tulsa pre-K alumni compared with children who did not attend Tulsa pre-K or Head Start. College enrollment is 7.5% higher for Head Start alumni compared to children who did not attend Head Start or Tulsa pre-K, although this difference is only marginally significant. Although Tulsa pre-K attendance is associated with two-year college enrollment among children from all racial and ethnic backgrounds, only among Black and Hispanic students does it predict four-year college enrollment.

Universal pre-K and college enrollment: Is there a link?

Developmental science has demonstrated the importance of early childhood experiences in creating a strong foundation for later learning (Shonkoff & Phillips, 2000). Given the importance of the early years, and the high cost of early childhood education to parents, many state and local governments have created public pre-kindergarten (pre-K) programs. By increasing access to early childhood education (ECE) which provides developmentally appropriate learning opportunities, pre-K programs are intended to improve three- and four-year-old's school readiness. The short-term efficacy of these programs has been demonstrated by many studies, using a variety of research designs (Yoshikawa et al., 2013). Yet, there have been few longitudinal studies of pre-K program's lasting impacts beyond the elementary school years. In particular, there is scant evidence on whether at-scale public programs increase later educational attainment, including post-secondary education.

In this paper, we investigate whether attending a well-established, high-quality universal pre-K (UPK) program in Tulsa, OK predicts college enrollment. We ask two key questions: First, are students who participated in Tulsa's public ECE programs (school-based pre-K, Head Start) more likely to attend college compared with similar students who did not attend an these ECE programs? Second, if Tulsa's ECE programs have long-run with college enrollment, are these associations found among socioeconomically disadvantaged students and students of differing racial and ethnic backgrounds? We answer these questions by using data for students who attended kindergarten in Tulsa Public Schools in the fall of 2006, including both ECE alumni and non-alumni.

Background

The economic value of higher education is clear. In the U.S., adults with a bachelor's degree earn twice as much as those with only a high school degree, while those with an associate's degree earn one and one half times as much (Schanzenbach et al., 2017). Even completing college credits without finishing a degree yields economic benefits (Hershbein & Kearney, 2014), and today's college "wage premium" is the highest it has ever been (Carnevale, 2020). The strong connection between a college degree and positive adult outcomes, has motivated both researchers and policymakers to find ways to encourage students to apply to, enroll in, and finish college. Current strategies tend to focus on helping students overcome proximal barriers to college by reducing costs and supporting students through completing college admission and financial aid applications (Castleman & Page, 2016; McKinney & Novak, 2012). However, programs and interventions that are less proximal to college entry may also be effective in boosting college enrollment and completion.

One intervention with the potential to increase college enrollment is ECE. Both developmental psychology and human capital theory point to the importance of early development, suggesting that investments in young children's cognitive and behavioral skills sets the stage for later academic success (e.g., Blair, 2016; Duncan et al., 2007). Early childhood education programs offer children enriched, but developmentally appropriate learning environments, where children learn through self-directed inquiry as well as planned activities, such as joint book reading. A significant body of evidence finds that ECE experiences have immediate and meaningful impacts on constrained skills such as letter and number knowledge and often on unconstrained skills such as vocabulary and executive functioning. This boost in early academic and behavior skills that children experience as a function of ECE programs, has the potential to improve children's later schooling trajectories. If children enter the formal school

system with greater early skills, they may learn more over the course of schooling and ultimately pursue more education than those who did not attend ECE programs. In Heckman's (2000: 50) words, "learning begets learning."

The long-term effects of ECE programs are not simply about persisting knowledge. Educational attainment is a cumulative process that results from ongoing engagement in learning institutions. As a result, educational attainment reflects the successful mastery of academic skills, such as reading and mathematics, as well as behavioral skills, such as developing positive relationships with teachers and fellow classmates (Alexander, Entwisle & Olson, 2014; Pungello, Kuperschmidt, Burchinal, & Patterson, 1996). As noted by Dupéré and colleagues (2015), much of the empirical research on educational attainment does not theoretically integrate long-term factors that may contribute to disengagement with specific short-term precipitating events. Dupéré et al. argue for a developmental life course approach, which recognizes the developmental underpinning of educational trajectories that begin earlier in life and seeks to better explain how these interact with later-occurring proximal factors.

Theories of language development have differentiated between constrained and unconstrained skills (Snow & Matthews, 2016), and recently scholars have broadened this approach to include math skills (Rittle-Johnson & Schneider, 2015; McCormick et al., 2021). Put simply, constrained skills are those that are limited and can be fully mastered, such as learning the letters of alphabet, sounds of letters, or how to count. These are skills that are directly teachable and easily assessed, and as such much of the elementary school curricula focus on these constrained skills and thus, they are fundamental to academic progression. In contrast, unconstrained skills refer to a broader set of competencies that develop, that are complex and difficult to assess, because they can never be fully mastered (Snow & McCormick, 2016). This

includes skills such as reading comprehension or geometric abstractions. In both cases, the skills are not about knowing the right answer, but about a process of problem-solving and critical thinking approaches that can be flexibly applied to reach an answer. Scholars suggest that while there are conceptual differences that differentiate constrained and unconstrained skills, they can be complementary, and that instruction should support both types of skills acquisition. Yet, ECE program impacts on constrained skills may be more fleeting as the children who do not attend such programs may be able to quickly learn the skills when they are taught in the early school years. In contrast, if ECE affects unconstrained skills and related problem solving and critical thinking skills, this helps students to learn new material. Under these circumstances, what is being "sustained" may not be the ability to recall facts and formulas but rather cognitive and behavioral patterns that enable successful adaptation to new circumstances and situations. If pre-K attendance results in higher levels of unconstrained skills and behavioral engagement in schools (and this may vary as a function of ECE programs and classes), then it might eventually have impacts on students' overall educational attainment.

Finally, whether ECE programs do have a lasting impact on academic trajectories likely depends on whether subsequent school environments build on and extend that early learning advantage. These "sustaining environments" enable young people to build on prior knowledge, intellectual curiosity, and ambition (D. Bailey et al., 2017). As in dominoes, a positive chain reaction depends on a series of interlocking experiences where one positive experience leads to another. Conditions in school can support or impede that progression. Public schools in the U.S. often lack the resources (Jackson, Johnson & Persico, 2015) or the practices (Neal, 2018) to help students maintain positive educational trajectories. Thus, early skills may not beget later skills in subsequent environments that are under-resourced or instructionally weak.

Empirical experimental studies of two ECE programs highlight the considerable potential of ECE. The Perry Preschool Program, which served low-income Black children in Ypsilanti, MI in the 1960s, yielded higher high school graduation rates and approximately one more year of schooling (Schweinhart et al., 2005). The Abecedarian Project, which served disadvantaged children in Chapel Hill, N.C. in the 1970s, also yielded approximately one more year of schooling and a much greater likelihood of graduating from college, despite no difference in high school graduation rates (Campbell et al., 2002). However, these programs were quite small, and they took place at a time when children who were not enrolled in these programs had very little access to alternative ECE programs. Much has changed since the 1960s, including much greater access to ECE programs and various social services for all children, which means that the effects of a contemporary program are likely to be smaller (Feller et al., 2016).

Research on long term effects of scaled-up ECE programs has focused primarily on Head Start, the federal government's ECE program for low-income children. Using sibling-based comparisons, Garces et al. (2002) found a link between Head Start attendance, higher high school graduation rates, and higher college attendance rates; Deming (2009), also comparing siblings, found a positive relationship between Head Start participation and high school graduation rates and college attendance rates. Using a similar research design and a more recent cohort, Schanzenbach and Bauer (2016) found that Head Start is associated with higher rates of high school graduation, college attendance, and the receipt of a postsecondary degree, license, or certificate. However, a subsequent analysis using Deming's methodology and a combination of early and late cohorts found generally null or mixed impacts of Head Start on adult earnings and other adult outcomes (Pages et al., 2020).

Beyond Head Start, a small number of large-scale public pre-K programs have been studied over an extended period of time. Usually, however, these studies have only reported high school graduation outcomes, if that, because the research is still in progress. In a review of 22 high-quality empirical studies conducted between 1960 and 2016, McCoy et al. (2017) found a statistically significant positive association between ECE programs and high school graduation rates, with a Cohen's *d* of 0.24. The meta-analysis was unable to look at college enrollment because of a shortage of studies.

In an ongoing study of the Chicago Child-Parent Centers program, operated by the Chicago Public Schools and financed by the federal government's Title I program, Reynolds et al. (2018) found that ECE attendance was linked to higher rates of receiving an associate's degree and higher rates of receiving a bachelor's degree. Even more substantial benefits flowed from an extended program that combined preschool with continuing parental training and support through elementary school. A recent study of Boston's universal pre-K program, using admission lotteries to mimic random assignment, found that students who attended a Boston preschool between 1997 and 2003 were 5.5 percentage points more likely to attend a four-year college in the fall after graduating from high school (Gray-Lobe, Pathak, & Walters, 2021).

Universal pre-K programs, although increasingly common (Friedman-Kraus et al., 2021), have thus far generated less long-term research than targeted programs like Perry, Chicago, and Head Start. This is in part because they have not been in existence long enough to follow students who initially attended the program through to college enrollment or graduation. However, the longitudinal study of a cohort of students in the Tulsa pre-K program has just reached the point where they are old enough to start attending college. Tulsa is a particularly interesting context for ECE programs, because it enables us simultaneously to evaluate both a

universal pre-K program and a targeted ECE program (Head Start). Its racially and ethnically diverse student body—35 percent Black, 33 percent white, 21 percent Hispanic, and 9 percent Native American—also permits exploration of whether there are heterogeneous associations across racial and ethnic groups. Unfortunately, the Asian population in Tulsa is too small to be examined separately in this study.

Garcia Coll's and colleagues' (1996) integrative model for examining developmental differences for minority and non-minority children provides a useful tool for considering how marginalized racial and ethnic groups school trajectories may be affected by ECE programs. Children of color experience both "inhibiting and promoting environments" (Garcia Coll et al., 1996: 1896). In Tulsa, inhibiting environments include historical and current systemic racism and discrimination that result in economic and social stratification as well as segregated communities. In contrast, white children in Tulsa face numerous economic and social privileges that further their positions of educational advantage. These divergent circumstances have the potential to yield different educational outcomes for white students compared with students of color.

Black, Native American, and Hispanic children typically begin preschool or kindergarten with lower levels of school readiness than white children, as measured by standardized test scores and other indicators. One consequence of this is that children of color typically have more to gain from a high-quality pre-K program and K-12 educational settings. Economic and racial segregation of neighborhoods and communities results in children of color being less likely to attend high-quality schools than white children (Boschma & Brownstein, 2016). The fact that later schooling environments may not be as enriching for children of color compared to white children could mean that any substantial and positive short-term impacts of ECE on early skills

do not persist (D. Bailey et al., 2017). Yet in Tulsa, magnet schools, including lottery-admissions magnets and magnets that take both academic achievement and residential neighborhood into account, make it possible for highly-motivated disadvantaged students to attend relatively good schools. Prior evidence suggests that Tulsa's magnet schools help students to sustain the positive benefits associated with pre-K enrollment (Kitchens, Gormley, & Anderson, 2020). If patterns of enrollment in magnet schools equalize access to quality education across racial groups, then magnet schools may give a sustained boost to students who have historically suffered from racial discrimination and attended weaker public schools.

The evidence to date suggests that Hispanic students, and especially those from Spanish-speaking households, benefit from high-quality preschool as much and maybe more than white students at program completion. Evidence on short-term effects from rigorous studies in Tulsa (Gormley, 2008), Boston (Weiland & Yoshikawa, 2013), New Mexico (Hustedt et al., 2021), North Carolina (Peisner-Feinberg, 2014), and elsewhere (Yoshikawa et al., 2013) supports this proposition.

Studies of the TPS pre-K program, like other ECE studies, have sometimes found bigger positive effects for students from low-income households than for students from middle-class households (Gormley, Phillips & Anderson, 2018; Yoshikawa et al., 2013). Unlike studies of the Perry Preschool Program and the Abecedarian Project (Anderson, 2008), which found greater long-term benefits for girls than for boys, studies of the TPS pre-K program and studies generally have seldom found systematic differences by gender (Corrington, 2008; Gormley et al., 2018; Amadon et al., 2022; Magnuson et al., 2016). Based on that literature, we expect that students from low-income households will benefit at least as much from Tulsa's ECE programs as students from middle-class households, but we expect no differences by gender.

Tulsa's Educational Landscape

In 1998, Oklahoma enacted a law providing school districts with funding to establish public, universal, school-based pre-K. Although the program is universal, it is not mandatory, and parents choose whether to enroll their four-year-old children in pre-K. Pre-K teachers are paid on the same scale as other public school teachers, student/teacher ratios are 10/1, and teachers are required to have a bachelor's degree and an early childhood certificate. Pre-K classrooms are located within elementary schools or in separate pre-K-only buildings. School districts receive funding for these programs through the state aid formula. This differs from the multiple service providers model that one finds in many other states, effectively privileging school-based pre-K. However, state law also permits local Head Start programs to receive state pre-K dollars if they form a partnership with a local school district, which happened in Tulsa well before our study began. Thus, both TPS pre-K classrooms and CAP Head Start classrooms receive state funds from Oklahoma's UPK program.

In Tulsa, as elsewhere, parents with low-incomes and parents of children with disabilities can enroll their children in Head Start, provided that space is available. Proximity is a factor in parent's ECE decisions: parents who lived close to a pre-K program were more likely to enroll there, whereas parents who lived close to a Head Start program were more likely to enroll there (unpublished results, available on request). Because the number of school-based pre-K sites substantially exceeded the number of Head Start sites in Tulsa, proximity tended to favor pre-K. More recent evidence, using a cohort of Tulsa children who attended kindergarten in the fall of 2018, supports this assertion. When asked why they enrolled their child in one program rather than the other, 34 percent of TPS pre-K parents (but only 9 percent of Head Start parents) said it

was “most conveniently located.” In contrast, 45 percent of Head Start parents (but only 17 percent of TPS pre-K parents) said their chosen program “offered the strongest support for my child’s social development and learning.” (Castle, Phillips, Hutchison, Shochet, & and Johnson, 2019). Parents also reported other reasons for making the choice of pre-K or Head Start such as the presence of wrap-around services (a plus for CAP Head Start); the presence of siblings in TPS elementary schools (a plus for TPS); and continuity going forward with later TPS school settings (a plus for TPS).

Data from Tulsa’s pre-K program present an unusual research opportunity because Tulsa’s program is school-based and universal. It also was one of the first contemporary pre-K programs to be studied, rendering it more comparable to current state pre-K programs than earlier generations of ECE studies, including the Perry Preschool and Abecedarian research projects. The reach of universal programs (i.e., the penetration rate) is almost always higher than that of targeted programs. This means that K-12 teachers in UPK communities or states typically have a larger proportion of students who enter kindergarten ready for school, as research in Tulsa has shown (e.g., Gormley & Gayer, 2005), and teachers might therefore shift the pace and content of their instruction to match the students’ higher levels of skills.

Research suggests that a strong K-3 curriculum is a great way to help sustain pre-K effects over time (Claessens, Engel & Curran, 2014). Indeed, it is also advantageous to students who did not attend pre-K. We do not have data on the TPS’ K-3 pedagogy during this time or how it evolved as the school district’s pre-K penetration rate increased. However, TPS staff members clearly recall that TPS elementary school principals and the TPS central administration were increasingly concerned about early elementary school learning during the difficult No Child Left Behind (NCLB) implementation years (2002-2008), as pressure from the federal

government and the state of Oklahoma mounted to improve disappointing test scores (McKenzie & McKenzie, 2022). During this time, TPS launched a summer workshop for principals aimed at raising their consciousness about ECE and its implications for curriculum alignment and adjustment. Thus, the stage was possibly set for TPS elementary school principals and teachers to increase the effectiveness of their pedagogy during this time period. On the other hand, as would be expected this push to improve test scores played out differently in different elementary schools (McKenzie & McKenzie, 2022), with some schools focusing on the learning needs of children in a flexible way, while others focused on increasing time spent on whole group instruction, particularly in reading and math and reducing time spent on other academic content and on non-academic activities.

Another contextual feature of Tulsa's public policy setting that is important for studying post-secondary outcomes is free community college. Established in 2007, the Tulsa Achieves program offers free tuition for local high school seniors who wish to enroll in Tulsa Community College (TCC) (Brookey, 2017). The preconditions are that the student must: a) be a Tulsa County resident who attends a public or private high school or is home schooled; b) be a U.S. citizen or a legal resident of the U.S.; and c) have an overall high school GPA of 2.0 or better. Students must also volunteer for a nonprofit organization in Tulsa County for 40 hours per academic year while attending college. Unlike some other free community college programs, Tulsa Achieves applies to only one community college, TCC, and is a last-dollar financial aid program (Bell, 2021), meaning that Tulsa's tuition support kicks in after federal and state aid have been awarded. We mention this factor because a free community college program clearly makes it more feasible for students, especially low-income students, to afford college

To sum up, prior literature suggests important short-term impacts of ECE programs, including public programs, on children's early skills. Theoretically, there are good reasons to think that positive impacts on early elementary school skills, particularly if they are unconstrained skills or behavioral patterns, may predict greater overall educational attainment. Yet, the existing evidence is thin. To date, only a handful of studies have demonstrated that public pre-K programs are linked to increased enrollment in college. In this study we use data from Tulsa to test whether two public ECE programs predict subsequent college enrollment. our research questions include:

1. Is Tulsa pre-K attendance (compared with not attending a public ECE program) associated with a higher likelihood of attending a 2-year college, 4-year college, or enrolling in any higher education?
2. Is Tulsa CAP Head Start attendance (compared with not attending a public ECE program) associated with a higher likelihood of attending a 2-year college, 4-year college, or enrolling in any higher education?
3. Do associations vary by subgroups, including race/ethnicity, free/reduced lunch, and gender?

Methods

Our original sample consists of 4,033 students who entered the Tulsa Public Schools (TPS) kindergarten program in the fall of 2006. Some of these students (approximately 40 percent) attended the TPS pre-K program the previous year; others (approximately 11 percent) attended the CAP of Tulsa County Head Start program the previous year; the rest (approximately 49 percent) attended neither program, though it is possible that they attended some other type of private preschool or child care center.

Measures

Our measures come from four different data sources: (1) Administrative data from TPS on student characteristics and student progress; (2) An August 2006 survey of parents of incoming kindergarten students at TPS; (3) Census Bureau's American Community Survey data on the neighborhood in which each student lived (as recorded in TPS school district 2006 administrative data); and (4) The National Student Clearinghouse (NSC) data on college enrollment for 2019-20 or 2020-21. The data directly from TPS and the August 2006 parent survey come from a research agreement with the district and were matched via TPS-assigned student ID numbers.

Treatment

We define ECE participation based on enrollment in pre-K or Head Start in 2005-06 and on attendance using TPS administrative records. To be included in our treatment group, students must have attended pre-K or Head Start for at least 50 percent of the academic year (90 days or more). The comparison group therefore were students who were not in pre-K or Head Start or attended these programs for less than 50 percent of the school days. The 50 percent threshold is analytically conservative; the inclusion of very low attendance students as part of the control group may actually *underestimate* any beneficial impact of the ECE program. About 10% of students who attended some pre-K or Head Start were placed into the comparison group because they attended for less than 50% of the academic school year.

Covariates

TPS provided administrative data for each child enrolled in TPS kindergarten during the 2006-07 academic year. From administrative records, information was available on: school attended, date of birth, race/ethnicity, gender, and school lunch eligibility. The parent survey

administered in August 2006 collected the following information: the child's previous preschool experience, parental marital status, whether the child currently lived with his or her biological father, the highest level of education attained by the mother, and the availability of internet access at home. The overall response rate was approximately 64 percent. As described in more detail below, we use multiple imputation methods to handle missing data.

Outcomes

We obtained data on college enrollment (two-year and four-year institutions of higher education) from the NSC, in March 2021, to encompass students who enrolled in college during the 2019-20 or 2020-21 school year. To identify these records, we supplied the NSC with the name and date of birth of all 4,033 students. If a student's name changed in our official records over time, we supplied different versions of the student's name, to ensure accurate matches across data sources. We generated three variables from these data: whether a student attended a 2-year institution, a 4-year institution, or any type of college or university. If a student enrolled in both a 2-year institution and a 4-year institution, we counted that student as enrolling in a 4-year institution.

When dealing with college enrollment, we face relatively minor attrition concerns, because the NSC now possesses and disseminates data for approximately 98 percent of all college-enrolled students. Thus, for our sample (N=4,033), a reasonable estimate is that about only 80 students attended college but were not in the NSC data. We have no way of tracking these students and we have no basis for distinguishing them from non-enrolled students. Therefore, as is standard in research projects using NSC data (Dynarski, Hemelt, & Hyman, 2015), we assume that they are not enrolled in college. We have no reason to believe that ECE alumni are disproportionately represented in this group.

Overall, 39 percent of the kindergarten entrants in our original sample are listed by the NSC as attending a college or university in 2018-19 or 2019-20 – slightly lower than the national average of 41 percent of 18- to 24-year-olds (National Center for Education Statistics, 2020, 2021). Among all students, 19 percent were enrolled in a four-year-college, 25 percent were enrolled in a two-year college, and 6 percent were enrolled in both types during this time period (e.g., students who switched from a community college to a four-year university or vice versa).

Analytic Strategy

Students were not randomly assigned to attend pre-K or Head Start. However, we have a set of measures that may capture important differences between children who attended pre-K or Head Start and those who did not. We used these measures in propensity score modeling to generate weights for analysis to ensure that on observable background factors the groups of children being compared were very similar. Propensity scores were calculated using the full sample, and regressions were done comparing pre-K to non-pre-K (excluding Head Start) and Head Start to non-Head Start (excluding pre-K).

To facilitate comparison with earlier work, we modeled our analytic strategy on prior analyses of this sample in middle school and high school (Gormley et al., 2018; Amadon et al., 2022). First, we calculated the probability that a given child would have attended pre-K (or Head Start), given observable kindergarten characteristics. As recommended by Stuart (2010), we used a comprehensive set of covariates to predict whether a student attended pre-K and used students' observed covariate values to obtain a predicted probability of attending pre-K. In practice, this meant that we included many variables in generating propensity scores (see Table 1). In contrast, we were more selective and parsimonious in choosing variables to include as covariates for our final weighted regression models.

We estimated the ATT (average treatment effect on the treated) rather than the ATE (average treatment effect) because pre-K is universally available but not mandatory in OK. We used boosted logistic regression modeling techniques, which utilize a machine learning approach, to estimate the propensity scores (specifically, the TWANG package: McCaffrey, Ridgeway, & Morral, 2004). We selected iterations, non-linearities, and interactions to optimize the model and minimize the absolute standardized difference (ASD) between the treatment and control cases (the difference in means for each covariate divided by the pooled standard deviation). As Appendix A indicates, the ASD statistics following propensity score weighting are much lower than before weighting.

Estimating the ATT with propensity scores involves assigning the treated participants a weight of one and the control participants a weight equal to the predicted odds of being in a treatment case (Hirano, Imbens & Ridder, 2003). This weighting strategy up-weights the comparison participants whose observed covariate values best match those of treatment participants and down-weights participants whose observed covariate values are *unlike* those of treated participants. Other algorithms for propensity score analysis exist (e.g., matching), and there is not a consensus on the single best approach (Guo & Fraser, 2010; Stuart, 2010). Our approach focuses on achieving the best covariate balance (Harder, Stuart & Anthony, 2010), and weighting by the odds produced well-balanced groups (see Appendix A).

After propensity score weights were generated, we conducted weighted multiple regression with covariates, using the more limited set of covariates mentioned above: race/ethnicity, maternal marital status and education, free lunch status, gender, internet access at home, neighborhood median income, and living with biological father, all as measured at kindergarten entry. We primarily ran multinomial logistic regressions with no college, 2-year

college, and 4-year college enrollments as mutually exclusive categories; multinomial regression results in two sets of associations (one for 2-year and one for 4-year enrollments), presenting a more nuanced picture of the relationship between the three mutually-exclusive categories. However, in some contexts, the distinction between 2-year and 4-year enrollment is secondary to the overall question of increased college enrollment, in part because both types of enrollments are associated with improved outcomes later in life. Since we are only examining college enrollment in the year or two after high school graduation, we also do not know how many students at 2-year institutions will eventually transfer to 4-year institutions. For these reasons, we also ran binomial regressions with any enrollment compared to no enrollment. Additionally, as a secondary analysis, we ran binomial regressions with any 4-year enrollment vs 2-year or no enrollment and 2-year enrollment vs no enrollment (excluding 4-year enrollments). We also ran the same regressions using subgroups by race/ethnicity, gender, and free lunch status.

Missing data were minimal for our outcome and school administrative variables; however, not all parents completed the parent survey in the fall of 2006, resulting in missing data on some covariates. Per prior work (e.g., Gormley, Phillips, & Anderson, 2018), we generated 40 multiply imputed datasets using Stata's *mi impute chained* command prior to estimating propensity scores and conducting multiple regression analyses. For 13 students, too many covariates were missing to properly impute missingness, so these students were dropped from the regression analysis, leaving a sample of 4,020 students. We also investigated whether the data were appropriate for multiple imputation given expectations for data being MAR (Little & Rubin, 2014), and analyses indeed suggested that the missing data were MAR. As recommended by Granger et al (2019), we implemented a *within* dataset approach to apply propensity weights to multiply-imputed data; each observation had an imputation-specific propensity weight that

was directly used to regress that imputation, rather than averaging an observation's weights across imputations and applying that single mean weight to all imputed datasets.

Results

Our first question asks whether attending Tulsa pre-K is associated with college enrollment (2-year, 4-year, or at all) compared to those who did not attend either Tulsa pre-K or Head Start. Bivariate statistics suggest that both TPS pre-K and CAP Head Start are associated with college enrollment. Overall, 44 percent of pre-K alumni and 37 percent of Head Start alumni enrolled in a college or university, as opposed to 33 percent of students in the comparison group (Table 2).

We turn to propensity score weighted regressions to determine whether pre-K attendance is associated with college enrollment, after holding constant differences in the kindergarten characteristics of children and their families. We ran multinomial logistic regressions, where 4-year college, 2-year college, and no college are mutually exclusive categorical outcomes (no college is the referent category). We found that pre-K attendance is significantly associated with increased likelihood of both 2-year enrollment ($p < .001$) and 4-year enrollment ($p < .001$), relative to not enrolling in college (Table 3). Binomial logistic regressions were similar to the multinomial models (Table 4); attending pre-K was associated with an increased likelihood of enrollment in any higher education ($p < .001$), in 4-year institutions ($p = .025$), and in 2-year institutions ($p < .001$). Because odds ratios are difficult to interpret, we translate results into marginal percentage points. Our calculations indicate that the likelihood of enrolling in any college or university is 12 percentage points higher for an average TPS pre-K student than for an average student in the control group who attended neither TPS pre-K nor Head Start. In addition, 7.3 percent (or 117/1601) attended a two-year college years later who otherwise would not have

done so had they not attended pre-K. Likewise, an additional 2.9 percent (or 46/1601) attended a four-year college who otherwise would have attended a two-year college or no college at all.

The results for Head Start attendees were mixed. In multinomial logistic regression, we find that Head Start attendance was marginally associated with an increased likelihood of 4-year college enrollment ($p = .054$), but not with an increased likelihood of 2-year college enrollment ($p = .185$). The likelihood of enrolling in any college or university is 7 percentage points higher for an average CAP Head Start student than for an average student in the control group, though we caution that the relationship is marginally significant. Binomial logistic model results confirmed these results. It is worth noting that the Head Start sample was about $1/4^{th}$ the size of the pre-K sample, so it is not clear whether the lack of statistical significance is due to the small sample size or small magnitude of the associations between Head Start and college.

We applied Benjamini-Hochberg (1995) false discovery adjustments to our results to account for the number of analyses conducted. Even under a strict false discovery rate of 5%, all statistically significant pre-K results remain statistically significant. Under a less strict false discovery rate of 15%, the marginally statistically significant Head Start results remain marginally statistically significant, but under a false discovery rate of 10% or lower, the results are no longer statistically significant.

Subgroup Results

The subgroup findings for multinomial regressions for race and ethnicity are reported in Table 5. In general, we find that students of all ethnic and racial backgrounds are more likely to attend college if they attended pre-K. Among white and Native American students (separately), those who attended pre-K were more likely than their control group counterparts to enroll in 2-year institutions (white: $p < .001$; Native American: $p = .041$). On the other hand, among Black

students, those who attended pre-K were more likely than those who did not to enroll in 2-year institutions ($p = .003$) and 4-year institutions ($p = .005$). Among Hispanic students, attending pre-K was associated with an increased likelihood of enrollment in 4-year institutions ($p = .034$) and marginally associated with an increased likelihood of enrollment in 2-year institutions ($p = .094$).

For both full-price lunch students and students eligible for a free lunch, those who attended pre-K were more likely to enroll in 2-year institutions (full: $p < .001$; free: $p < .001$) and in 4-year institutions (full: $p = .016$; free: $p = .003$), each relative to no enrollment when compared to control group students (Appendix B). Both the male and the female subgroups were more likely to enroll in a 2-year (male: $p = .010$; female: $p < .001$) or 4-year college (male: $p = .003$; female: $p = .011$) compared to no enrollment if they attended pre-K, relative to those who did not attend pre-K or Head Start (Appendix C).

Subgroup analyses for Head Start resulted in a few interesting findings. Most notably, in multinomial logistic regressions, among Native American students, attending Head Start was associated with large increases in the likelihood of 2-year college enrollment ($p = .019$) and marginally associated with an increased likelihood of 4-year college enrollment ($p = .052$), relative to their non-Head Start, non-pre-K counterparts. Among white students, those who attended Head Start were more likely than those who did not to enroll in 2-year colleges ($p = .020$), but not 4-year colleges ($p = .631$). Among Black students, those who attended Head Start were not more likely to enroll in 2-year colleges ($p = .325$) but *were* more likely to enroll in 4-year colleges, compared to Black students who attended neither pre-K nor Head Start ($p = .018$).

In subgroup analyses by gender, we found that for female students, relative to those who attended neither pre-K nor Head Start, those who attended Head Start were more likely to enroll in 2-year college (p = .044) and in 4-year college (p = .072), compared with no enrollment. Among free lunch students, those who attended Head Start were more likely to enroll in 4-year colleges (p = .043), but not more likely to enroll in 2-year colleges (p = .359), compared with students who did not attend Head Start or pre-K.

In summary, attending pre-K seemed to influence college enrollment for nearly all subgroups, while attending Head Start appeared to influence college enrollment for some racial, gender, or lunch status subgroups but not others. It is difficult to determine whether these mixed results stem from true differences in the impact of Head Start or are the result of sample size limitations.

Discussion

The results from our analyses suggest that participating in Tulsa's public ECE programs is associated with an increased likelihood of enrolling in a post-secondary educational institution within two years of completing high school. The impact of the TPS pre-K program was particularly strong—an increase of nearly 12 percentage points of enrolling in any college compared to a comparable sample of students who did not attend TPS pre-K or Head Start. The largest increases were found for 2-year college enrollment, predominantly at Tulsa Community College. Among students who enrolled in 2-year colleges, 81% of the TPS pre-K alumni enrolled in TCC, compared to 71% of the control group students. In considering these findings, it is important to keep in mind that this program is one of the oldest universal pre-K programs in the country operating in an urban setting. Both the school-based pre-K program and the Head Start

program employed college-educated teachers who were early childhood certified, and both were paid wages commensurate with public school teachers.

If college enrollment is an important societal goal, then this study's findings suggest that ECE may be one way to promote that goal. But how does Tulsa's UPK program compare to other distal interventions that focus on ECE or early elementary education? M. Bailey et al (2021) estimated that Head Start (from 1965 to 1980), yielded an 8.5 percentage point increase in college enrollment. Similarly, Gray-Lobe et al. (2021) concluded that Boston's UPK program (from 1997 to 2003) yielded an 8 percentage point increase in college enrollment within six months after high school graduation. Dynarski, Hyman & Schanzenbach (2013) found that smaller class sizes in early elementary school in Tennessee (1985, 1986) increased the rate of postsecondary attendance by 2.7 percentage points. Comparing estimates across studies is complicated by differing contexts and populations and sometimes wide confidence intervals. Nevertheless, Tulsa's UPK program seems to be at least as effective as some other powerful educational interventions focusing on children's early years.

In fact, the estimated magnitude of Tulsa's UPK program's association with college enrollment is comparable to those of more proximal interventions, such as programs targeting understanding and access to college financial aid. A meta-analysis of multiple studies of college financial aid reforms found that they yielded, on average, a 12 percentage point increase (Harvill et al., 2012) A free tuition offer to most colleges or universities within the state of Michigan to graduates of a Kalamazoo high school yielded a 14 percentage point boost in college enrollment (Bartik et al., 2021), and the Pittsburgh Promise program, which offers substantial financial aid to attend a Pennsylvania college or university, resulted in a 5 percentage point boost in college enrollment (Page, Iriti, Lowry & Anthony, 2019). Potential differences in costs, implementation,

and beneficiaries prevent any direct comparison of which approach is more efficient, but it is noteworthy that Tulsa's ECE program yielded such effects.

What might generate a link between pre-K and college enrollment? Previous research in both Chicago and Tulsa suggests that magnet schools might play a role. In a study of the Chicago Child Parent Centers Program, focusing on students who enrolled in the 1980s, Reynolds and Ou (2011) found a link between pre-K enrollment, magnet school enrollment, and positive outcomes as young adults. In a study of the Tulsa pre-K program, Kitchens et al. (2020) found a positive link between pre-K enrollment and magnet school attendance in both middle and high school. They also reported a positive relationship between magnet school attendance and standardized test scores and between magnet school attendance and PSAT test scores—a good indicator of students' ability actively to consider college as an option. By most indicators, Tulsa's magnet high schools are more successful in laying the groundwork for college enrollment than Tulsa's traditional high schools. The Oklahoma Department of Education's letter grade ratings for Tulsa's magnet high schools range from A+ to C-, while the ratings for traditional high schools range from D to F (Kitchens et al., 2020: 11). AP enrollment, one sign of college aspirations, ranges from 70% to 31% at Tulsa's magnet high schools, from 29% to 5% at traditional schools (numbers calculated by authors from niche.com statistics).

Magnet schools in Tulsa originated in the early 1970s as a strategy for coping with the legacy of racial discrimination in public education. In response to a federal court order, the Tulsa Public Schools established magnet schools that would attract both Black and white children. In the absence of such magnet schools (accessible, abundant, superior), Black, Hispanic, or Native American students who attend an ECE program in Tulsa might get a sudden positive boost in test scores or other outcomes, followed by a gradual decline, as these students

would be likely to attend lower quality public schools. In the presence of magnet schools, there are better opportunities for favorable long-term outcomes for students generally and for students of color in particular (see also Kitchens & Brodnax, 2021). Magnet schools might lead to fewer course failures and more advanced coursework, which in turn might lead to increased college enrollment. In Tulsa, Amadon et al. (2022) do find differences in advanced course taking in high school between pre-K attendees and those who did not attend as well as decreases in course failures in high school among pre-K attendees. In short, Tulsa's K-12 environment has the potential to reduce the number of "struggling learners" and to increase the number of "excelling learners" among Black, Hispanic, and Native American students (Iruka et al., 2020).

In contrast to our evidence on magnet schools as potential mediators between Tulsa's UPK program and positive outcomes in adolescence and early adulthood, we can only speculate about the K-3 curriculum as a mediating variable. Although the pre-K penetration rate was high at the time and might have encouraged elementary schools to accelerate or advance K-3 course content, we cannot confirm that they did so, and indeed there is some evidence that elementary schools responded differently to the new realities wrought by UPK. Moreover, this was an exceptionally challenging time period for TPS and for schools nationwide due to many ambitious education reforms, including NCLB and the Common Core (adopted by Oklahoma, then later abandoned). There are three different ways to think about this. From one perspective, the increased focus on school accountability and test scores created stressful times for teachers, school administrators, and students. It is remarkable that pre-K alumni were able to maintain their initial momentum during this challenging period. From another perspective, one advantage of ambitious education reforms is that they invited teachers and school administrators to take a fresh look at what they were doing and to try to figure out ways to do it better. Across the

nation, kindergarten generally became more challenging between 1998 and 2010. As Bassok, Latham, & Rorem (2016) have put it, kindergarten became "the new first grade." From a third perspective, considerable variety in school practices within the same school district created opportunities for students who experienced a big bounce from pre-K to seek out more challenging and more stimulating school environments which may have influenced their unconstrained skills. If change and micromanagement made average progress difficult, variety made differential progress more likely.

Findings from earlier work suggest that TPS pre-K can lead students to attend better schools (Kitchens et al., 2020) and to take more advanced courses and fail fewer courses (Gormley et al., 2018; Amadon et al., 2022). Our latest research suggests a positive, statistically significant relationship between TPS pre-K attendance and on-time high school graduation rates (Amadon et al., n.d.). Prior work by other scholars has also found positive associations between ECE attendance and high school graduation rates (McCoy et al., 2017). Indeed, studies such as Lobe-Gray et al (2021) show that even in the absence of pre-K impacts on test scores in high school, college enrollment is increased through other aspects of school engagement. While the mechanisms connecting ECE to increased college attendance are still poorly understood, our study adds to the growing literature showing a strong connection between ECE programs and later life outcomes.

Limitations

While the results are promising, our study is not without its limitations. Although our treatment and control group students have strikingly similar demographic characteristics, the possibility of differences on unobserved characteristics, such as motivation, remains. We also worry about the possibility that the COVID-19 pandemic could have affected some of our

students. Luckily, most of our college-bound students enrolled in the fall of 2019, prior to COVID-19. However, about 23 percent of our students were not in a position to enroll in college at that time because they were retained in grade for one year. Although prior work and conventions in research methods recommend retaining grade retained students in the sample (as grade retention could be a mediator between pre-K and college enrollment), we checked the robustness of our results by excluding grade-retained students. Results suggest that the associations between TPS pre-K and college enrollment for on-time students are of greater magnitude than the results reported here. Full results are available upon request.

Our primary results define college enrollment as any enrollment in a college after graduation, regardless of whether that enrollment occurred in the fall following high school graduation. As an additional robustness check, we reran our main regressions using the definition of on-time enrollment which Gray-Lobe et al. (2021) used in studying Boston's UPK, which meant only enrollment in the fall semester following an on-time graduation. Using this definition, the magnitude of the association of pre-K or Head Start attendance with college enrollment was just as large as that found in our original definition of enrollment (Appendix D).

The context of community college aid in Tulsa County might make our findings less likely to generalize to other communities. The students in our study who graduated from high school and met the minimum GPA requirements had access to free community college. Undoubtedly, the presence of this program makes it easier for students—especially disadvantaged students—to attend college. While this might be part of the reason we see a robust and large impact on two-year college enrollment, it does not account for the four-year college enrollment effect for pre-K graduates. Thus, it seems unlikely that our findings are entirely due to the Tulsa Achieves (free community college) program.

Conclusion

The case for ECE programs is strengthened by evidence that ECE programs have lasting positive effects on important life outcomes. College attendance is one of the most important milestones indicating upward mobility and is an excellent predictor of adult earnings. We find that Tulsa's school-based universal pre-K program is indeed linked to higher college enrollments. We also find that Tulsa's Head Start program is linked to higher college enrollments for certain subgroups.

The circumstances are favorable in Tulsa: high-quality early childhood education programs with relatively high levels of instructional support; a high pre-K participation rate that enables elementary school teachers to upgrade their pedagogy if they choose to do so; opportunities for students to convert a preschool bounce into subsequent academic progress by attending relatively strong magnet middle schools and high schools; and a free community college program that enables high school graduates to attend the local community college without paying tuition.

Not every community has these practices and opportunities that contribute to educational success in the short and long run, which suggests that a strong pre-K program alone may not be sufficient for replication elsewhere. On the other hand, we found a positive link between pre-K and four-year college enrollment, so the presence of free community college, though important for the overall picture, is not a sine qua non for long-term educational success.

Our findings for Head Start are more equivocal than our findings for Tulsa's school-based pre-K program, possibly because of noticeably smaller sample sizes. Nevertheless, we see statistically significant positive associations between both types of ECE programs and college enrollment for students of color and for white students. The bottom line is that Tulsa's early

childhood education programs are helping students from diverse racial and ethnic backgrounds to face the challenges of a rapidly changing economy with the confidence that flows from having attended college. In this respect, early childhood education is indeed the gift that keeps on giving.

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Table 1. Descriptive Statistics for Independent Variables by Treatment Status

Baseline Characteristic	TPS PreK		Head Start		Control		Full sample	
	n	%	*n*	%	*n*	%	*n*	%
Gender[a]								
Female	753	47	212	50	942	47	1,907	47
Male	848	53	216	50	1,049	53	2,113	53
Race[a]								
White	532	33	44	10	823	41	1,399	35
Black	562	35	173	40	505	25	1,240	31
Hispanic	342	21	182	43	404	20	928	23
Asian	19	1	3	1	28	1	50	1
Native American	146	9	26	6	231	12	403	10
Lunch-status[a]								
Free	1,050	66	379	89	1,322	66	2,751	68
Reduced-Price	187	12	27	6	180	9	394	10
Full-Price	364	23	22	5	489	25	875	22
Marital status[b]								
Never married	256	16	72	17	269	14	597	15
Married	606	38	125	29	557	28	1,288	32
Remarried	25	2	5	1	29	1	59	1
Separated	47	3	20	5	71	4	138	3
Divorced	93	6	14	3	137	7	244	6
Widowed	11	1	5	1	14	1	30	1
No response/missing	563	35	187	44	914	46	1,664	41
Education of mother[b]								
Less than High school	167	10	59	14	180	9	406	10
High school or GED	241	15	74	17	233	12	548	14
Some college	367	23	73	17	377	19	817	20
College Degree	139	9	19	4	175	9	333	8
No response/missing	687	43	203	47	1,026	52	1,916	48
Internet access at home[b]								
No	470	29	165	39	538	27	1,173	29
Yes	567	35	79	18	547	27	1,193	30
No response/missing	564	35	184	43	906	46	1,654	41
Biological father lives at home[b]								
No	389	24	98	23	473	24	960	24
Yes	638	40	144	34	606	30	1,388	35
No response/missing	574	36	186	43	912	46	1,672	42
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Median Neighborhood Income (in $1000s)[c]	3.74	1.69	3.47	1.39	3.94	2.03	3.81	1.85

Note. 13 students had too much missingness to impute covariates; They are omitted above.
[a] From TPS data. [b] From 2006 Parent Survey. [c] From the Census Bureau

Table 2. Unweighted Descriptive Statistics for Dependent Variables by Treatment Status

Outcome	TPS PreK		Head Start		Control		Full sample	
	N	%	*n*	%	*N*	%	*N*	%
Any higher ed	704	44	160	37	664	33	1,528	38
2-year[a]	431	27	104	24	389	20	924	23
TCC	351	22	80	19	276	14	707	18
non-TCC	80	5	24	6	113	6	217	5
4-year[a]	273	17	56	13	275	14	604	15
No higher ed	897	56	268	63	1,327	67	2,492	62

[a] Students who had both 2-year and 4-year enrollments were counted as 4-year enrollments.

Table 3. Multinomial Logistic Regression Results

Outcome	TPS Pre-K (n = 3,591)			Head Start (n = 2,418)		
	Estimate	*SE*	*p*	Estimate	*SE*	*P*
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.70***	0.16	< .001	1.28	0.24	.185
4-year	1.52***	0.17	< .001	1.54*	0.34	.054

Note. All coefficient estimates are presented as relative risk ratios relative to no higher ed.
*p < .10, **p < .05, ***p < .01

Table 4. Binomial Logistic Regression Results

Outcome	Estimate	*SE*	*P*	Marginal Change[a]	*N*
TPS Pre-K					
Any Higher Ed (vs none)	1.63***	0.13	< .001	12.1%	3,591
Any 4-year (vs 2-year or none)	1.27**	0.14	.025	3.2%	3,591
2-year vs none	1.70***	0.16	< .001	11.9%	3,043
Head Start					
Any Higher Ed (vs none)	1.36*	0.22	.056	7.5%	2,418
Any 4-year (vs 2-year or none)	1.43*	0.31	.096	4.1%	2,418
2-year vs none	1.27	0.24	.213	4.6%	2,087

Note. All coefficient estimates are presented as odds ratios.
[a] Marginal Change presented as percentage point increase in absolute probability seen for an average student with the treatment compared to the same student without treatment.
*$p < .10$, **$p < .05$, ***$p < .01$

Table 5. Multinomial Logistic Regression Results by Race and Ethnicity

	TPS Pre-K			Head Start		
Outcome	Estimate	*SE*	*P*	Estimate	*SE*	*P*
White	*n* = 1,354			*n* = 866		
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.78***	0.28	< .001	2.72**	1.17	0.020
4-year	1.37	0.24	.116	1.31	0.73	0.631
Black	*n* = 1,067			*n* = 678		
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.69***	0.30	.003	1.33	0.39	0.325
4-year	1.74***	0.34	.005	2.05**	0.62	0.018
Hispanic	(*n* = 746)			(*n* = 586)		
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.37*	0.26	.094	0.95	0.30	0.860
4-year	2.17**	0.80	.034	0.81	0.43	0.691
Native American	(*n* = 377)			(*n* = 257)		
No Higher Ed	(base outcome)			(base outcome)		
2-year	2.04**	0.71	.041	7.92**	6.91	0.019
4-year	1.41	0.53	.358	5.93**	5.40	0.052

Note. All coefficient estimates are presented as relative risk ratios relative to no higher ed.
*$p < .10$, **$p < .05$, ***$p < .01$

Appendix A
Balance Statistics Pre- and Post-Propensity Score Weighting

Figure A1. Pre-K Balance Statistics Balance Statistics Pre- and Post-Propensity Weighting

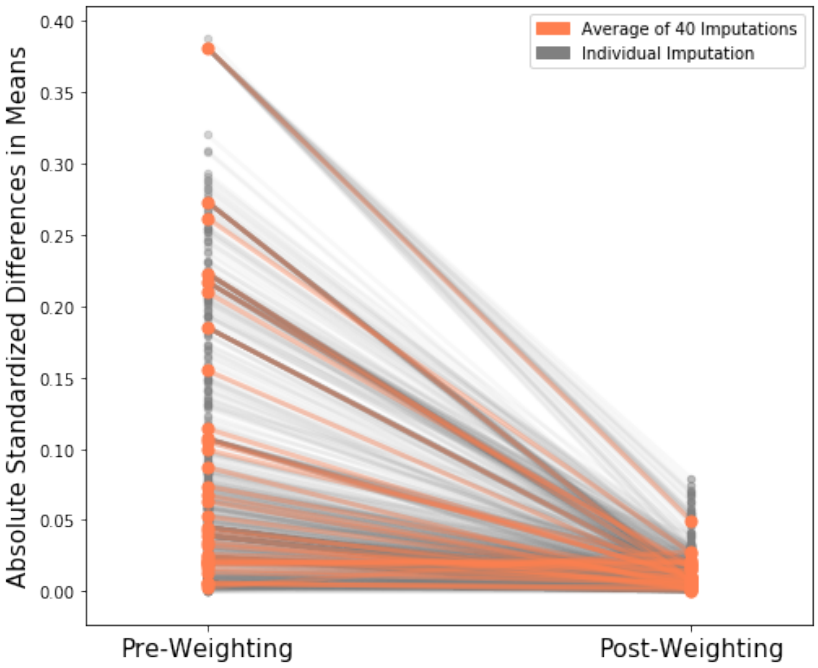
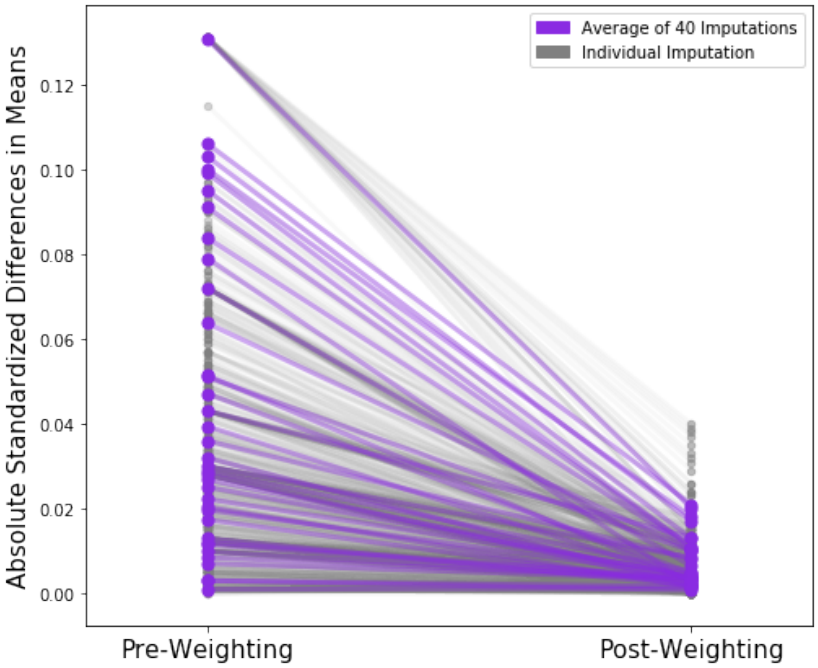


Figure A2. Head Start Balance Statistics Pre- and Post-Propensity Weighting



Appendix B
Multinomial Logistic Regression Results by Lunch Status

	TPS Pre-K			Head Start		
Outcome	Estimate	*SE*	*p*	Estimate	*SE*	*p*
Free Lunch	*n* = 2,371			*n* =1,700		
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.61***	0.19	< .001	1.21	0.25	.359
4-year	1.58***	0.24	.003	1.68**	0.43	.043
Reduced-Price	*n* = 367			*n* = 207		
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.51	0.41	0.135	1.02	0.79	.978
4-year	1.32	0.48	.448	1.27	1.43	.835
Full-Price	*n* = 853			*n* = 511		
No Higher Ed	(base outcome)			(base outcome)		
2-year[a]	2.04***	0.40	< .001	10.43***	8.59	.005
4-year[a]	1.62**	0.33	.016	1.02	0.68	.976

Note. All coefficient estimates are presented as relative risk ratios relative to no higher ed.
*p < .10, **p < .05, *** p < .01

Appendix C
Multinomial Logistic Regression Results by Gender

	TPS Pre-K			Head Start		
Outcome	Estimate	*SE*	*p*	Estimate	*SE*	*p*
Male	*n* = 1,896			*n* = 1,264		
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.43**	0.20	.010	0.96	0.30	.901
4-year	1.65***	0.28	.003	1.68	0.66	.187
Female	*n* = 1,695			*n* = 1,154		
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.97***	0.25	< .001	1.58**	0.36	.044
4-year	1.48**	0.23	.011	1.69*	0.49	.072

Note. All coefficient estimates are presented as relative risk ratios relative to no higher ed.
*p < .10, **p < .05, *** p < .01

Appendix D
Multinomial Logistic Regression Results using Boston Paper's Definition of "On-Time Enrollment"

	TPS Pre-K (n = 3,591)			Head Start (n = 2,418)		
Outcome	Estimate	*SE*	*p*	Estimate	*SE*	*p*
No Higher Ed	(base outcome)			(base outcome)		
2-year	1.84***	0.19	< .001	1.21	0.26	.367
4-year	1.63***	0.18	< .001	1.57**	0.36	.046

Note. All coefficient estimates are presented as relative risk ratios relative to no higher ed.
*p < .10, **p < .05, *** p < .01