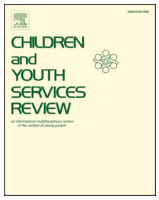
Children and Youth Services Review 164 (2024) 107832

Contents lists available at ScienceDirect

Children and Youth Services Review

journal homepage: www.elsevier.com/locate/childyouth



Pre-K enrollments and teaching environments in North Carolina elementary schools

Clara G. Muschkin [a,*], Helen F. Ladd [a], Maria Sauval [b]

[a] Duke University, USA
[b] University of California, Irvine, USA

ARTICLE INFO

Keywords:
Pre-kindergarten programs
Elementary schools
Teacher satisfaction
Teacher retention
Principal retention
School environment

ABSTRACT

Prior research finds that some high-quality preschool programs are successful in generating significant initial academic gains and long-term benefits for students as they progress through school. This study examines one of the mechanisms through which North Carolina's statewide pre-K program (NC Pre-K) may generate such benefits: improvements in the teaching environments of the elementary schools in which NC Pre-K graduates enroll. We find that an increased presence of former NC Pre-K students in elementary schools over the period 2004–2018 was associated with better teachers' perceptions of different dimensions of their teaching environment, as well as increased teacher and principal retention. Our findings suggest that pre-K expansion policies may benefit the entire school community.

1. Introduction

In recent decades, many states have invested in pre-kindergarten programs (pre-K) with the goal of enhancing school readiness, particularly for economically disadvantaged children (Friedman-Krauss et al., 2020). Such programs typically generate short-term academic gains and, according to some studies, can have positive effects on the long-term socio-economic outcomes of the enrolled children (e.g., Yoshikawa et al, 2013; Gray-Lobe et al., 2023). Some Pre-K researchers have thought about the dynamics between pre-K participation and elementary school experiences. For instance, some have hypothesized that the elementary school years might play a role in the persistence of pre-K effects. These studies suggest a positive relationship between initial academic gains for pre-K children and longer-term gains when the elementary school environment builds on and complements the pre-school program (e.g., Bailey et al., 2020). Yet, few researchers have looked at the other direction in the relationship between pre-K and elementary school environments, by asking how the expansion of pre-K programs might in turn alter the elementary school learning environment to the benefit of the entire school community. That is the focus of the current study.

Specifically, the current study examines the association between increasing proportions of students who previously participated in the North Carolina Pre-K program (NC Pre-K) and teaching environments in the elementary schools in which the students subsequently enroll. NC Pre-K is a high-quality publicly funded statewide program started in 2001 for low-income four-year old children. By enhancing the academic and social readiness at school entry of pre-K eligible children, the expansion of this high-quality pre-K program could well improve the learning environment within elementary schools, and consequently, the teaching environment and teachers' work satisfaction (Horng, 2009; Johnson, Kraft, & Papay, 2012; Ladd, 2011).

Importantly, our focus on how the NC Pre-K program affects teachers reflects the long-recognized fact that teachers are a key contributor to the well-being and outcomes of students within a school. The starting hypothesis is that an increase in the proportion of former NC pre-K-attenders, most of whom are from low-income families by program design, will create a more favorable teaching environment within an elementary school. Moreover, because schools serving high proportions of disadvantaged students often find it difficult to attract and retain high quality teachers, more positive perceptions of the teaching environment might also have positive effects on teacher retention, principal retention, and the mix of teachers in the school (Borman & Dowling, 2008; Ladd, 2011; Loeb, Kalogrides, & Horng, 2010).

As we describe in detail below, we use responses to biennial surveys of teachers to measure teachers' perceptions of their working environment. In addition, we use administrative data to measure changes at the school level in the rates of teacher retention and proportions of experienced teachers, as well as changes in principal turnover.

* Corresponding author.
E-mail address: muschkin@duke.edu (C.G. Muschkin).

https://doi.org/10.1016/j.childyouth.2024.107832
Received 23 February 2024; Received in revised form 19 July 2024; Accepted 29 July 2024
Available online 7 August 2024

Our findings show that over time a rising share of former NC pre-K children within individual elementary schools is associated with improvements in teachers' perceptions of the school environment and a small decrease in their probability of leaving the school. In the following sections, we first provide background information and prior research on the NC pre-K program, followed by a description of our three main research questions, methods and data, main results and robustness checks, and conclusions and implications.

2. North Carolina's Pre-Kindergarten program

North Carolina established its public preschool program in the early 2000s. Initially called the More at Four program, it was renamed the NC Pre-K program in 2011. It is a statewide program targeted primarily at four-year-old children from low-income families, with the goal of enhancing the school readiness of eligible children. Children are eligible if their families have an annual income at or below 75 percent of the state's median income. In addition, up to 20 percent of children may be eligible if the child is in a military family or has identified "risk factors" such as being an English language learner, having an identified disability, a chronic illness, a developmental need, or the child is homeless. The program provides funding for pre-K slots rather than for classrooms but requires that any organization accepting funded slots for some or all of the children they serve – including public schools, head start centers or private for profit or non-profit organizations –meet high quality standards. In order to qualify for NC Pre-K slots, classrooms have to meet state-standardized criteria regarding curricula, training and education levels for teachers and administrators, class size, and additional program services (Peisner-Feinberg et al., 2019). As noted by Watts et al. (2023), between 2002 and 2021, the NC program met an average of 9.3 of the 10 quality benchmark standards set by the National Institute for Early Education Research (NIEER). As the quality of pre-K in North Carolina increased over time, funding levels for the program and the proportion of four-year-olds attending pre-K also increased.

A series of quasi-experimental studies have exploited the variation in funding across the state's counties and over time to evaluate the NC Pre-K program. These studies have documented that the program generated positive outcomes for children. Measured at the level of individual students, more NC Pre-K funding allocated to a county was associated with higher test scores in reading and math in grades 3 through 8, particularly for students from more disadvantaged backgrounds (Bai, Ladd, Muschkin, & Dodge, 2020; Dodge, Bai, Ladd, & Muschkin, 2017; Ladd, Muschkin, & Dodge, 2014; Muschkin, Ladd, & Dodge, 2015; Watts et al., 2023).[1] As highlighted in the first of these studies (Ladd, Muschkin, & Dodge, 2014), the relatively large magnitudes of the estimated test score impacts suggest that in addition to providing benefits for students in funded pre-school slots, NC pre-K may also generate positive spillovers for all age-appropriate children.

Positive spillovers might arise because any non-funded children enrolled in pre-K classrooms or centers in which some of the children were funded would have benefitted from the high-quality standards required for the classroom to receive funding for NC Pre-K slots. A second type of positive spillover could occur once the funded pre-K children enter elementary school and would arise if the presence of children who had been funded by the NC Pre-K improved the teaching and learning environments in the elementary schools they attend.

This second form of spillover is the focus of this paper. We ask whether an increasing share of former NC Pre-K children in elementary schools is associated with better teacher outcomes in elementary schools. Given that most of the children who participate in NC Pre-K are from low-income families (based on program eligibility), we focus on the share of former NC Pre-K students among the economically disadvantaged students in each school. High quality programs such as NC Pre-K aim to enhance both academic and social readiness of low-income children at school entry (Peisner-Feinberg & Schaaf, 2011; Peisner-Feinberg et al., 2019). Increased proportions of children exposed to high-quality pre-k experiences can result in improved elementary school environments. These improvements could generate benefits to all children in those schools, not just the former NC Pre-K students, by easing the challenges of teaching. In particular, we test the hypotheses that the enrollment of former NC Pre-K students is associated with better teacher satisfaction, reduced rates of teacher turnover, and a lower proportion of inexperienced teachers. Increased proportions of children who are ready for kindergarten also may ease challenges for school administrators, potentially reducing rates of principal turnover. This outcome can in turn contribute to improved teacher satisfaction and consequently a better environment for student learning.

3. Conceptual framework

Our study investigates the extent to which higher proportions of students who participated in the NC Pre-K program when they were four years old is associated with: (1) teachers' perceptions of their teaching environment, (2) employment and mobility of teachers in the elementary schools in which these students subsequently enroll, and (3) mobility of principals in these schools. In this section, we motivate our hypotheses in these three domains.

3.1. Teachers' perceptions of their working environment

The concept of "working conditions" for teachers has many dimensions including, for example, the salaries teachers are paid, the quality of the physical environments in which they teach, their contractual responsibilities, and their opportunities for advancement. Importantly, teachers' satisfaction with their working environment also include other cultural and social elements such as aspects of the school's culture, the quality of the school leadership, and the relationships among colleagues (Johnson et al., 2012; Boyd et al., 2011). As highlighted in various studies (Johnson et al., 2012; Steinberg and Garrett, 2006; Yesil-Dagli, 2012), these can best be measured by teacher surveys designed to elicit teachers' own perceptions of their work environments. Studies based on North Carolina survey data also confirm that teachers care about the quality of school leadership and other factors such as time for planning and collaboration; these factors contribute to the planned or actual departure rates of teachers from a school (Ladd, 2011) and also to the achievement levels of its students.

In the present study, we test the hypothesis that rising proportions of elementary school students who had formerly enrolled in a high-quality state-funded pre-K will improve the teaching and learning environment in schools, as measured by teachers' own perceptions. This outcome would occur if the prior participation of pre-K eligible children in high quality preschool enhanced their school readiness, influencing their experiences in subsequent elementary school years. For instance, if more students participated in NC Pre-K, we could expect a reduction in the variation in the skills of children in the classroom. Moreover, students might enter schools feeling more prepared and better supported to meet the demands and expectations of the elementary school grades. In turn, this would allow teachers to optimize the time allocated to teach the required content, as well as facilitate the planning and collaboration between teachers.

3.2. Teacher retention and experience

Research has long shown that teachers often leave schools serving

[1] In addition to higher test scores, Muschkin, Ladd, & Dodge (2015), Dodge, Bai, Ladd, & Muschkin (2017), and Bai, Ladd, Muschkin, & Dodge (2020) found that NC Pre-K was associated with lower rates of special education placement and lower retention rates in elementary school years. These findings were not replicated by Watts et al. (2023), in which the analysis included several additional cohorts of data and a different specification of the cohort fixed effects.

high proportions of low-achieving, low-income, and racially minoritized students for more economically and educationally advantaged schools at higher rates than teachers at other schools (Hanushek et al., 2004; Loeb et al., 2005). While this is not a direct consequence of student socio-demographic characteristics (Johnson et al., 2012), it reflects how working conditions differ across schools. This pattern also reflects the pressures placed on all schools to assure that students perform well on standardized tests, despite unequal and inadequate staffing support in forms such as teacher assistants, mental health workers, and psychologists to help both students and teachers. As a result, schools serving low-income children often find it difficult to attract and retain teachers (Hanushek et al., 2004; Horng, 2009; Yesil-Dagli, 2012). As discussed in the previous section, by improving students' skills prior to entering elementary school, NC Pre-K may ease the work of elementary school teachers, in particular in those schools with more NC Pre-K eligible population (i.e., those serving low-income children). An improvement in teachers' perceptions of the school environment might induce more teachers to remain in the school rather than to move to other schools or to leave the profession (Horng, 2009). If so, it would reduce the rate of teacher turnover. High teacher turnover has been shown to be harmful to student learning in part because it is disruptive to the continuity of instructional programs and has potentially adverse effects on collegiality, continuity and trust (Henry & Redding, 2018; Ronfeldt, Loeb, & Wyckoff, 2013; Sorensen & Ladd, 2020). In addition, one of the hidden costs of teacher turnover is that when teachers depart, schools often must replace them with inexperienced teachers or teachers with otherwise weak credentials (Sorensen & Ladd, 2020). Thus, to the extent that a rising share of NC Pre-K students within a school reduces the turnover of teachers, it may have the additional benefit of reducing the school's share of teachers with weak credentials.

One commonly used measure is years of teaching experience. Multiple studies indicate that teachers with limited experience, often defined as three years or less, are less effective in generating students' learning gains than those with more experience (Adnot et al., 2017; Boyd et al., 2008; Papay & Kraft, 2015).[2] Moreover, studies indicate that schools serving large proportions of low-income students typically have higher proportions of teachers with limited experience than other schools as well as higher rates of teacher turnover. Those patterns reflect the fact that within a given teacher labor market, the schools serving more advantaged students are more attractive to experienced teachers, thereby leaving the inexperienced teachers for the schools serving lower-income students (Sorensen & Ladd, 2020). Further, inexperienced teachers have incentives to try to move to more advantaged schools as they gain experience. We thus hypothesize that an increased presence of students in a school who attended pre-K, through their increased school readiness, contributes to increased rates of teacher retention and consequently to an increased presence of more experienced teachers.

3.3. Principal retention

While this study focuses primarily on teachers' work environments and retention rates, we include principal retention rates as a separate outcome because this characteristic of schools has important implications for their teachers and students. Recent studies document the high rates of principal turnover, which are higher than turnover rates for teachers, both nationally (Buckman, 2021; Goldring & Taie, 2018) and in North Carolina (Henry & Harbatkin, 2019). Principal turnover rates tend to be highest in schools with more low income and students of color (Beteille et al., 2012). Research on consequences of these trends indicates that principals play a vital role in shaping the school environment, as is reflected in negative impacts of principal departure on student test scores and school proficiency levels (Bartanen et al, 2019; Henry & Harbatkin, 2019). Consistent research evidence indicates that principal turnover contributes significantly to teacher turnover rates, especially in elementary schools and among schools with many students from less advantaged backgrounds (Bartanen et al, 2019; Beteille et al, 2012; Henry & Harbatkin, 2019). Furthermore, support from the school principal is a significant predictor of the levels of job satisfaction for teachers (Olsen & Huang, 2018).

The literature on principal turnover focuses primarily on its consequences rather than on its determinants. While some moves result from re-assignment based on decisions by school district leaders, at least part of principal movement across schools is voluntary (Loeb et al., 2010). Evidence at the school level suggests that principal mobility reflects factors such as school culture and safety, as well as the characteristics of students at that school, with most voluntary principal transfers involving moves to less challenging schools that enroll more advantaged and high-achieving students (Beteille et al., 2012; Loeb et al., 2010). We thus hypothesize that the school-level improvements in learning and teaching environments arising from the increased presence of NC pre-K students in schools also may influence their principals, resulting in higher rates of principal retention.

4. Methods and data

4.1. Sample definition

Consistent with our guiding hypotheses, the unit of analysis throughout our study is individual elementary schools in a particular school year. Although prior studies find positive impacts of NC Pre-K access for individual students through the eighth grade, we limit our current analyses to the elementary grades (through grade 6). We exclude middle schools because they typically serve students from multiple elementary feeder schools, which potentially dilutes the aggregate and cumulative impact of increasing NC Pre-K enrollments in a school across all grade levels.

Included in our analysis sample are all traditional public elementary schools in North Carolina that offer any combination of grades K through grade 6 across all years 2004 through 2018, regardless of how many grades they offer. While there are 1,408 schools with this grade configuration at least at some point during the years 2004——2018, we define our analytic sample as the 1,084 schools observed for the entire study period.[3] Table 1 summarizes the distribution of sample schools by grade configuration and school characteristics, for selected years.

4.2. Model specification

We estimate separate regression models for each teacher or principal outcome, which is measured at the school level (teacher satisfaction, retention rates, years of experience and principal retention), as a function of the changing prevalence of NC Pre-K children in a school over the period 2004–2018. In our basic model:

$$Y_{s,t} = \beta_0 + \beta_1 \%NCPK/ED_{s,t} + \beta_2 S_{s,t} + \beta_3 C_{s,t} + \beta_4 D_{s,t} + \gamma_s + \theta_t + \varepsilon_{s,t}$$

[2] Though it has long been clear that teachers with limited experience are less effective than those with more experience, researchers have now documented that teachers continue to become more effective as they continue in the profession for longer than three years (see Papay & Kraft, 2015; Sorensen & Ladd, 2020).

[3] The percentage of schools that were not observed throughout the study period is quite large (23%). It is possible that some of these schools were in fact open during these years, but they experienced a substantial change (e.g., a merge, a move) and consequently experienced a change in their identification code. Due to the de-identification of the data, we cannot see if, for instance, a school code observed for the years 2004–2006 is in fact the same school observed with a different code for the years 2007–2018. Because we rely on within-school changes, our best approach is to use a balanced sample. However, the results are qualitatively similar when using the whole (unbalanced) sample.

Table 1
Descriptive statistics of North Carolina public elementary schools, selected years.

	2004	2008	2012	2016	All years
Former NC Pre-K student enrollment					
% NCPK students	0.68	8.27	23.02	25.78	16.44
	(1.08)	(6.12)	(13.54)	(14.35)	(14.58)
% NCPK/ED students	0.95	11.62	29.26	31.96	21.05
	(1.34)	(7.16)	(13.00)	(13.72)	(15.91)
School Grade Configuration					
PK-05	46 %	51 %	38 %	58 %	48 %
KG-05	39 %	33 %	46 %	27 %	36 %
PK-06	1 %	3 %	2 %	2 %	2 %
KG-06	2 %	2 %	1 %	1 %	1 %
Other	11 %	11 %	12 %	12 %	12 %
School Characteristics					
Total # students (excl. PK year)	519.21	540.36	514.08	500.83	513.11
	(193.78)	(204.08)	(183.92)	(186.74)	(192.33)
% Non-Hispanic Black	31.94	27.13	26.10	26.39	28.16
	(24.59)	(23.46)	(22.81)	(22.86)	(23.49)
% Non-Hispanic White	56.29	52.81	50.56	47.76	51.20
	(27.64)	(27.99)	(27.52)	(27.61)	(27.89)
% other race non-Hispanic	3.49	7.99	7.69	7.97	6.49
	(7.86)	(8.27)	(8.45)	(8.18)	(8.38)
% Hispanic	8.28	12.08	15.65	17.88	14.16
	(8.56)	(11.45)	(12.79)	(13.74)	(12.63)
% economically disadvantaged	53.47	51.87	61.40	70.74	60.59
	(22.52)	(22.29)	(20.86)	(26.50)	(24.42)
Student-teacher ratio	15.02	14.82	15.33	15.29	14.95
	(3.82)	(2.07)	(1.99)	(1.97)	(2.69)
In rural community	43 %	44 %	46 %	38 %	42 %
Characteristics of the county where school is located					
Total population (log)	11.81	11.89	11.93	11.96	11.91
	(1.06)	(1.09)	(1.11)	(1.14)	(1.11)
Median family income (2019 $)	72,251.54	63,861.10	65,263.38	61,370.79	64,949.88
	(12,769.45)	(11,153.19)	(11,826.18)	(11,048.76)	(11,982.37)
SNAP recipients (%)	8.79	10.48	17.85	16.97	13.88
	(3.59)	(3.85)	(5.67)	(6.30)	(5.90)
Medicaid enrollees (%)	18.24	19.39	22.92	23.33	21.00
	(5.52)	(5.53)	(5.83)	(5.82)	(6.15)
School district Local PPE (2019 $)	2357.70	2501.20	2112.63	2260.18	2316.94
	(800.84)	(828.43)	(734.99)	(757.04)	(779.74)
School district State PPE (2019 $)	6418.01	7016.00	6208.06	6299.07	6427.93
	(646.97)	(827.36)	(780.79)	(773.84)	(801.35)
School district Federal PPE (2019 $)	1032.70	1067.90	1398.49	1146.98	1203.90
	(337.85)	(345.66)	(361.61)	(337.45)	(410.67)
Observations (N schools)	1,084	1,084	1,084	1,084	1,084

Notes: Standard deviations in parentheses. "Other" grade configuration includes PK-01/02/03/04 (n = 56 schools), KG-01/02/03/04 (n = 22 schools), 03–05 (n = 22 schools), and 21 schools offering grades 04–05, 02–05, 01–05, 04–06, 02–03, 02–04, 03–06. PK=Pre-Kindergarten, KG=Kindergarten, SNAP=Supplemental Nutrition Assistance Program, PPE=Per Pupil Expenditures, % NCPK students = share of students in the elementary school who were funded by the North Carolina Pre-Kindergarten program when they were four years old, %NCPK/ED students (in 10p.p. units) = share of students in the elementary school who were funded by the North Carolina Pre-Kindergarten program when they were four years old, among the students classified as economically disadvantaged.

$\boldsymbol{Y}_{s,t}$ is the teacher or principal outcome Y for school s and year t, % $\boldsymbol{NCPK/ED}_{s,t}$ is the share of K-6 economically disadvantaged students in the elementary school s, in year t, that were formerly enrolled in NC pre-K when they were four years old. $\boldsymbol{S}_{s,t}$, $\boldsymbol{C}_{s,t}$, and $\boldsymbol{D}_{s,t}$ are vectors of time-varying school, county, and school district covariates; and γ_s and $\boldsymbol{\theta}_t$ are school and year fixed effects. Standard errors are clustered at the school level.

While teacher and principal outcomes are described in more detail in the next section, it is important to specify the timing of these measures. Teachers' perceptions of working conditions are measured in the Spring of year t; teacher retention in the school is measured as the proportion of teachers in year t who continue in the same school in year t + 1; principal retention measures whether the principal in year t is still in the school in year t + 1; and the proportion of experienced teachers is measured as the proportion of teachers in year t + 1 having more than 3 years of experience.

In our two-way-fixed effects model, the year indicators, $\boldsymbol{\theta}_t$, account for unmeasured secular trends in teacher outcomes or state policies that may be correlated with changes in NC Pre-K enrollments as well as with outcomes for teachers. The school indicators, γ_s, control for time-invariant characteristics of each school. In other words, we are exploiting within-school variation over time in the enrolled proportion of former NC pre-K children.

The within- and between-school variation exploited in our analysis is further shown in Fig. 1. Thin gray lines depict all the individual schools in our sample. Five darker lines illustrate the observed variation: the black line represents a school where the proportion of former NC Pre-K enrollees grew quickly from the beginning of the program rollout up to more than 60 % in 2012. Schools represented in orange, green, and blue had about 20 % former NC Pre-K children at the end of our study period; however, enrollment patterns varied considerably over time among the three schools. In some schools, former NC Pre-K children were a growing share of the student membership and then decreased (e.g., orange); in

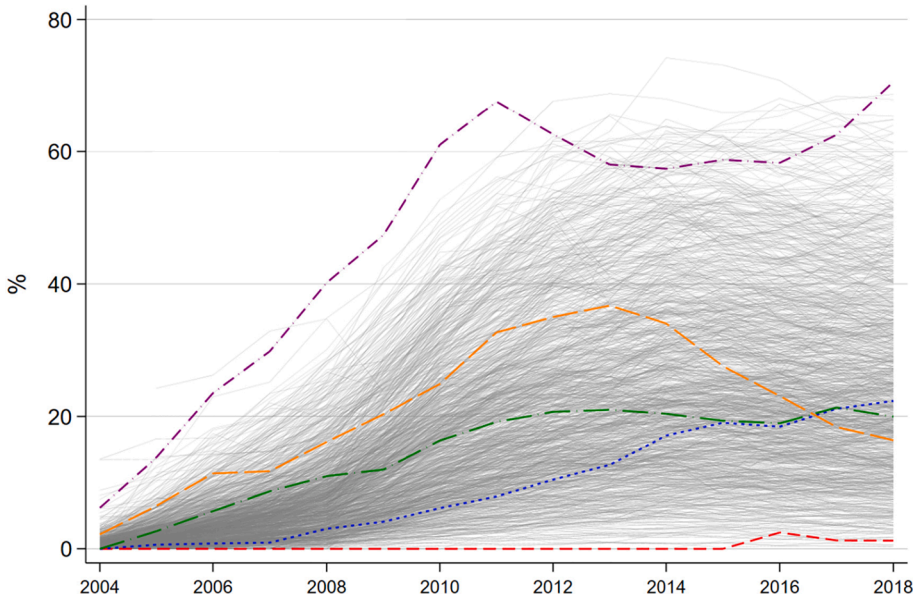


Fig. 1. School variation in the proportion of students in elementary schools who previously participated in NC Pre-K. Note: This graph illustrates time changes in the share of students in elementary schools who attended NC pre-K, for all schools in the analytic sample (in gray). Dark lines are used to highlight five schools with different variation for descriptive purposes. They were selected based on their position on the distribution of schools using the average share of NCPK children in entire the study period: these schools belong to the 1st, 25th, 50th, 75th, and 99th percentile (red, blue, green, orange, and black lines, respectively).

others, the growth was slower and then remained constant (e.g., green); while other schools started to enroll former NC Pre-K children some years later and then grew at a constant rate (e.g., blue). Finally, schools like the one represented in red always had close to zero former NC Pre-K enrollees.

Despite the inclusion of year and school fixed effects, our model cannot completely rule out concerns about a potential endogenous relationship between the teacher or principal outcomes on the one hand and school specific changes in the explanatory variable (%NCPK/ED) on the other. It is possible that changes in the share of former NC Pre-K students in a school is also associated with other school-specific changes that influence elementary school experiences. For instance, one could be concerned if NC Pre-K slots were expanded simultaneously with other programs that supported four-year-old's school readiness in the same neighborhoods. On the other hand, due to the difference in the timing of experiences, one should not be too concerned about a potential correlation between the timing of NC Pre-K expansions and teacher-focused improvements in elementary schools: our main predictor is slowly changing as former NC Pre-K students move through elementary school grades, and not when NC Pre-K investments are actually taking place. We include a series of time-varying school, county and district vectors to help to assuage such concerns and we acknowledge the limitations of our study for inferring causality.

4.3. Measures

To create our school-level variables, we combined a variety of student, teacher, and school records housed at the North Carolina Education Research Data Center (NCERDC) at Duke University.[4] In this section, we describe our variables, their sources, and how we operationalize them.

4.3.1. NC Pre-K enrollments

Given the targeted nature of the program, our primary predictor of interest is the share of economically disadvantaged K-6 students in a school who previously were in a funded NC Pre-K slot regardless of where that slot was provided (e.g. in a public school classroom, Head Start center, or a private for-profit or non-profit organization). We also present our main results using a variation of this variable: the share of all students in an elementary school (counting as students only those in grades K to whatever grade up to 6 the school offers) who previously participated in NC Pre-K. There are a few differences between these two variables, which lead us to present both measures. On the one hand, measuring the share of economically disadvantaged students that attended NC Pre-K offers a better proxy of the extent to which the pre-K program is reaching its eligible population. If the program were meeting its goals of improving the school readiness of eligible children, we would expect that a higher value in this variable would be associated with a better school environment across schools, regardless of their socio-economic context. On the other hand, we expect that teachers and schools will be more likely to experience school-wide differences with the growth of the share of NC Pre-K among their entire student population; thus, we also estimate our models with the second measure.

To calculate these variables, we use NC Pre-K program enrollment data assembled at the University of North Carolina from the NC Pre-K Reporting System. The Economically Disadvantaged status variable (ED) comes from administrative records provided by the North Carolina Department of Public Instruction (NCDPI), which were de-identified and linked at the student level by the North Carolina Education Research Data Center (NCERDC) at Duke University. Economically disadvantaged status is available for all study years for students in 3rd grade or later, and for kindergarten to 2nd grade students after 2014. For years prior to 2014, we assigned students' ED status in the early grades to their ED status when they were in 3rd grade or later.

Fig. 2 illustrates the average growth over time in prevalence of elementary school children who formerly participated in NC Pre-K, for each version of this primary predictor variable. In both versions, the shares increased steeply during the years in which the program was being rolled out across North Carolina, and remained stable after 2014. This is in line with changes in program funding levels. However, since we are observing the timing in which NC Pre-K students enter elementary school, the variation in this variable is "delayed" in comparison with the timing of the expansion of NC Pre-K funding across counties,

[4] A full description of available data files and encrypted NCERDC identifiers is available here: https://childandfamilypolicy.duke.edu/north-carolina-education-research-data/data-housed-at-the-ncerdc/.

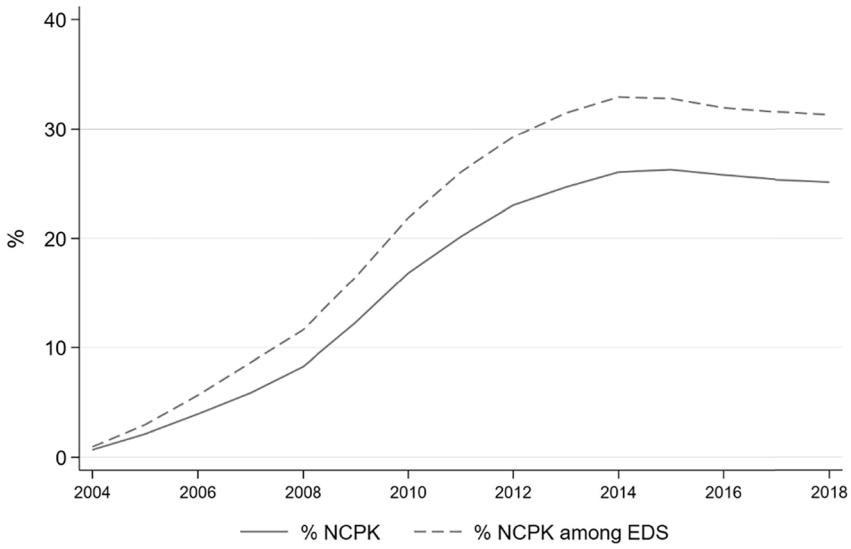


Fig. 2. Proportion of students in elementary schools who previously participated in NC Pre-K. Notes: The figure plots the average share of NC Pre-K students in the school and the share of economically disadvantaged students that previously participated in NC Pre-K by year. Each unit is an elementary school.

which slowed down around 2008 (e.g., see Watts et al., 2023). By the end of our study period, on average, 25 % of all students and 30 % of economically disadvantaged students in elementary schools had been enrolled in NC Pre-K when they were four years old.

4.3.2. Teacher outcomes

Our outcomes of interest are teachers' perceptions of the working conditions in the school, and educators' mobility and experience. Table 2 shows descriptive statistics for selected years.

Table 2
Descriptive statistics of outcome variables, selected years.

	2004	2008	2012	2016	All years
A. Teachers' Perceptions of the School (1–5 scale)					
Overall satisfaction	4.07	4.01	3.98	4.06	4.03
	(0.68)	(0.48)	(0.41)	(0.46)	(0.44)
Time for the role of educating students	2.76	3.30	3.54	3.68	3.41
	(0.67)	(0.48)	(0.42)	(0.43)	(0.52)
Time to collaborate with colleagues	2.92	3.31	3.47	3.62	3.38
	(0.75)	(0.57)	(0.50)	(0.48)	(0.56)
Time for individual planning	2.22	2.18	2.41	2.50	2.35
	(0.35)	(0.19)	(0.20)	(0.22)	(0.25)
Safety of school environment	4.26	4.30	4.26	4.23	4.24
	(0.58)	(0.44)	(0.33)	(0.37)	(0.38)
School leadership support	3.67	3.87	3.76	3.85	3.79
	(0.68)	(0.58)	(0.53)	(0.53)	(0.52)
Class size	2.96	3.43	3.36	3.30	3.28
	(0.75)	(0.57)	(0.55)	(0.59)	(0.56)
B. Educators' Mobility and Experience					
% teacher continuity	80.45	88.49	87.10	87.07	86.07
	(9.63)	(6.42)	(7.57)	(8.11)	(8.69)
"% teachers with 3 + years of experience"	77.33	78.26	80.56	79.08	78.92
	(10.62)	(10.52)	(11.12)	(11.41)	(11.12)
Principal continuity indicator	0.79	0.78	0.72	0.76	0.77
	(0.40)	(0.41)	(0.45)	(0.42)	(0.42)
Observations (N schools)	1,084	1,084	1,084	1,084	1,084

Notes: Standard deviations in parentheses. For variables included in Panel A, teachers are asked their level of agreement using a 5-point Likert scale, except for the question regarding the available time for individual planning, for which the response categories are: none, less than 3 h, 3–5 h, 5–10 h, or more than 10 h per week.

4.3.2.1. Teachers' Perceptions of School Environments.. In our analyses, the first set of teacher outcomes represents teacher perceptions of the school environment that may influence teachers' level of satisfaction and contribute to their willingness to continue teaching at a school. We derive school-level measures of teacher satisfaction from the biennial North Carolina Teacher Working Conditions Survey (TWCS). North Carolina was the first state to administer a statewide survey of teachers in Spring 2002 and has continued to do so every other year since then, with the purpose of providing data to schools, districts, and state officials to make informed policy decisions. This survey includes questions about time management, school facilities and resources, school leadership, personal empowerment, and professional development.

Due to important changes in the questionnaire following the first survey implementation, our analysis includes data starting from 2004. Since the TWCS is anonymous, responses are aggregated at the school level for our analyses. Importantly, completing the survey is voluntary. However, response rates are considerably high. In 2018, the response rate for all invited teachers was 90.5 percent, with some variation across districts and schools (North Carolina Teacher Working Conditions Survey, n.d.). All North Carolina elementary schools are represented in the survey, with a few exceptions in 2006 (<1% schools missing) and 2004 (5 % schools missing). Across the study period, close to 30 teachers per school have responded to the survey, except for the first year, 2004, when the average was 14 teachers per school.[5] In our analysis, we use all data available regardless of the number of teachers in the school that responded to the survey. However, in our robustness checks, we excluded schools with less than 10 teacher responses and note that our results are not sensitive to this decision.

[5] Unfortunately, we do not have the official TWCS response rates at the school level before 2018. Since the TWC Survey data do not provide the total number of teachers that were eligible to fill out the survey, we cannot calculate exact response rates in our sample. However, combining these data with administrative data from teacher licensing and payroll information, we estimate teachers' response rates about 75–80% in years 2008–2018. Given that our denominator includes all teachers who worked in a school at least at some point in a given year, these are likely lower bounds. Additionally, our pre-2008 estimates are likely largely under-estimated since we cannot exclude teacher assistants, who are not eligible to complete the TWCS.

Earlier studies using the working conditions survey typically used factor analysis or some other aggregating technique to construct a few basic categories of teacher perceptions from a very large number of survey questions related to working conditions (e.g., Ladd, 2011). Unfortunately, the longitudinal nature of our analysis limits our ability to exploit the richness of the data collected across the years. Thus, we selected items for our analyses from the subset of questions that were included over the eight biennial administrations of the survey during our study period (2004–2018). In selecting from this subset of items, we considered the extent to which the presence of pre-K students might plausibly affect the specified aspect of the school teaching and learning environment.

We selected the following TWCS variables: a variable that measures overall satisfaction with the school ("overall, the school is a good place to work and learn"); three variables that measure teachers' perceptions of time allocations ("teachers are protected from duties that interfere with their essential role of educating students," "teachers have time available to collaborate with colleagues," and "in an average week, how much time do you devote to individual planning during the school day?"); teachers' perceptions of the safety of the school environment ("the faculty works in a school environment that is safe"); and school leadership ("school leadership consistently supports teachers"). In these items, teachers are asked their level of agreement using a 5-point Likert scale, except for the question regarding the available time for individual planning, for which the response categories are: none, less than 3 h, 3–5 h, 5–10 h, or more than 10 h per week. In other words, larger values in these ordinal variables are interpreted as more agreement with the statements and more time available for individual planning, respectively.

In addition, we selected one more topic from the TWCS, namely a question about how teachers view the size of classes within their school ("class sizes are reasonable to meet the needs of all students"). We note that the sizes of classes within schools are determined primarily by statewide administrative policies and are not typically affected by the school readiness of students in an individual school. For that reason, we do not expect teacher attitudes toward class size to be influenced by the share of NC pre-K students within the school.

In order to examine changes in teacher satisfaction over the entire period, we imputed values for the odd numbered years in which no survey was administered. Imputed values were calculated as the average of schools' teacher responses in consecutive survey years. In sensitivity analyses discussed below, we found that including imputed values for these outcomes did not materially affect the results.

4.3.2.2. Teacher and Principal Mobility and Teacher Experience. The second set of teacher outcomes considered in our analyses includes two indicators of educators' employment and mobility decisions, aggregated to the school level: annual teacher and principal mobility, and experience of the teachers in the school. Operationally, the annual teacher retention rate is defined as the proportion of teachers who continue to work at a school from one academic year to the next. The experience of teachers in the school is defined as the school's proportion of teachers with more than three years of experience. Principal retention has a value of 1 if the principal stayed from one year to the next, and zero otherwise. Information on years of teaching experience and retention rates was obtained from the NC School Report Card data files, which provide aggregated information from the teacher employment records collected each year by NCDPI. These two teacher outcomes are not available for 2018, our last year of analysis. Principal retention was calculated using payroll administrative data provided by NCDPI through the NCERDC.

4.3.3. School, County, and District-Level covariates

Schools differ one from another in many ways including, for example, their size and the characteristics of the local neighborhoods they serve. In addition, they typically differ in their success in attracting and retaining quality teachers and school principals. Along some dimensions, the variation across schools is relatively constant over time, but in others it varies from one year to the next because of changes in state- wide policies that affect all North Carolina schools, or county-wide policies that affect schools within a county. Given that many of these school-specific differences may well be associated with outcomes for teachers and confounded with changes over time in a school's share of pre-K students, we control for as many of them as possible. School fixed effects control for unmeasurable differences across schools that are relatively constant over time and the year fixed effects control for statewide factors that affect all schools in similar ways over time such as changes in the economy, or state- wide education policies, including, for example, changes in the statewide educator salary structure.

The regression models include time-varying control variables for several measures of school composition that have been shown in prior research to be associated with teacher employment decisions and levels of satisfaction with the school environment (Borman & Dowling, 2008). These include, for each school and year: school size (or the total number of students in the school), proportion of students who are economically disadvantaged, proportion of students of minority race or ethnicity (Black/Hispanic/Other), whether the school offers on-site pre-K, the school's student to teacher ratio, and whether it is located in a rural community. These school-level measures were drawn from the NCES Public School Universe data files.

Underlining the importance of controlling for school characteristics, Fig. 3 illustrates associations between some of the school characteristics of note and NC Pre-K enrollments, for the single year 2017. Consistent with the targeted goal of the program, schools that serve more economically disadvantaged students also have higher shares of students who had previously participated in NC Pre-K. Similarly, schools that serve more non-White students also have higher concentrations of former NC Pre-K children. Enrollments of former NC Pre-K children vary with elementary school size, with lower proportions in larger schools, which tend to be located in urban areas.

Socioeconomic and demographic characteristics of the counties in which schools are located may also be associated with teachers' turnover outcomes and their working conditions (Borman & Dowling, 2008). The measures included in the model, retrieved from the NC Office of State Budget and Management (NCOSBM) for each North Carolina county and year, are: county's total population (log), median household income (inflation adjusted), share of the population who are SNAP recipients, and share of population eligible for Medicaid. Additional influences on teacher outcomes include a set of measures of the financial resources of the school district in which the school is embedded (Imazeki, 2005). Most school districts in the state are county wide. For each school district/year, we include measures defined as the local, state, and federal per pupil expenditures as reported by the NCDPI.

5. Findings

Our main results are reported in Panel A of Table 3 for which the main predictor variable is former NC pre-K students as a share of the school's economically disadvantaged students, i.e., a proxy of the NC Pre-K eligible population. The reported coefficients refer to the association between the outcome and a 10-percentage point increase in the main predictor. Consistent with our hypotheses, we find a number of statistically significant positive coefficients. Notably, a 10-percentage-point increase in the share of economically disadvantaged NC pre-K children in the school is positively associated with overall teacher satisfaction with a coefficient of 0.03 points ($p < 0.010$) and also with teachers' perceptions that they have adequate time for the role of educating students (+0.03, $p < 0.001$). The associations with the perceptions of time for collaboration or planning also are positive, though smaller and only marginally statistically significant. In addition, the main predictor is positively associated with teachers' perceptions that the school environment is safe (+0.03, $p < 0.001$) and that the school

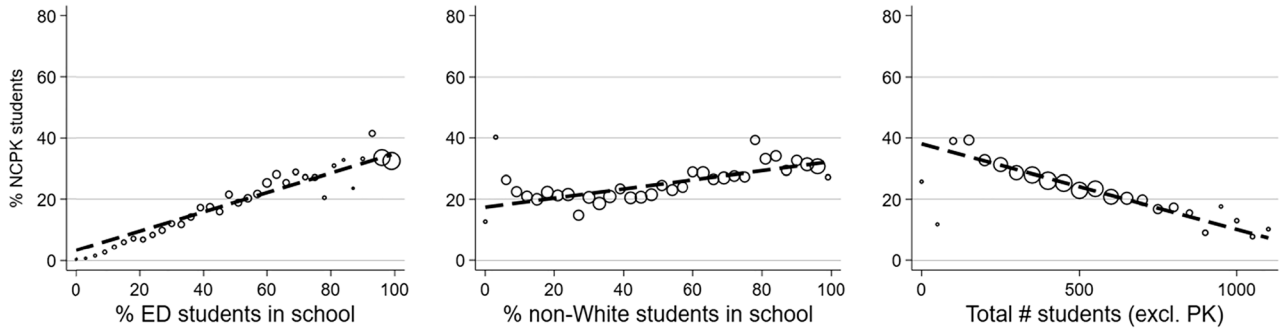


Fig. 3. Shares of NCPK children in school, by school characteristics (2018). Note: The size of the bubbles represents the number of schools in that bin (varying by graph).

Table 3
Estimated associations between educators' outcomes and the share of NC pre-K children in elementary schools.

	Teachers' perceptions of the school (1–5 scale)							Educator retention		
	Overall satisfaction	Time for the role	Time to collab.	Time for planning	Safety of school environment	School leadership support	Class size	% teacher retention	% experienced teachers	Principal retention
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. Preferred specification. Predictor variable is % economically disadvantaged students in the school who were previously enrolled in NC Pre-K										
% NCPK/ED students (in 10p. p. units)	0.03**	0.03***	0.02*	0.01+	0.03***	0.03**	0.01	0.51***	0.83***	0.01*
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.15)	(0.22)	(0.00)
Observations	16,102	16,102	16,102	16,102	16,102	16,102	16,102	15,081	15,145	16,215
Panel B. Alternative specification. Predictor variable is % all students in the school who were previously enrolled in NC Pre-K										
% NCPK students (in 10p.p. units)	0.03**	0.03**	0.01	0.00	0.03***	0.03**	0.02	0.51**	0.53*	0.01
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.16)	(0.25)	(0.01)
Observations	16,102	16,102	16,102	16,102	16,102	16,102	16,102	15,081	15,145	16,215

Notes: Standard errors in parentheses. + p < 0.10 * p < 0.05 ** p < 0.01 *** p < 0.001. All regressions included time-varying covariates, school, and year fixed effects. Perception outcomes (columns 1–7) have imputed values for non-survey years, using the average between the two adjacent years. Time-varying covariates: number of students in the school, whether school has pre-K on site, % Black students, % Hispanic students, % other non-white students, % economically disadvantaged students, student–teacher ratio, school in rural community indicator, total county population (in log), median family income in the county, % SNAP recipients in the county, % Medicaid eligible in the county, federal, state, and local per pupil expenditure. %NCPK/ED students (in 10p.p. units) = share of students in the elementary school who were funded by the North Carolina Pre-Kindergarten program when they were four years old, among the students classified as economically disadvantaged. Outcomes estimated in columns 8 and 9 are not available in 2018, which explains the smaller sample size.

leadership is supportive (+0.03, $p < 0.010$). In contrast, no relationship emerges between the predictor variable and satisfaction with class size, which makes sense given that the average class size within a school is determined by state and district policies rather than internal school policies. Hence, the finding of no associations with class size satisfaction can be interpreted as a confirmatory robustness check.

As for educators' continuity in the school, a 10-percentage-point increase in the share of former NC Pre-k children is associated with an increased teacher retention rate of 0.51 percentage points ($p < 0.001$) and principal retention by 1 percentage point ($p < 0.050$). We also find a positive association with the share of experienced teachers in the school (+0.83 percentage points, $p < 0.001$). These findings make sense in the context of reduced teacher turnover: when more teachers remain in the school, it is more likely that they gain more experience and pass our 3-year threshold, thus reducing the need to hire new teachers who may be less experienced.

It is important to note that, while statistically significant, these estimates are small in magnitude; they represent about 1 percent or less of the mean values of the outcome variables over the period. We return to this point in our conclusions.

Panel B of Table 3 presents the models in which the presence of NC Pre-K students is measured as a share of all students in the school rather than as the share of the school's economically disadvantaged students. We find similar results for many of the outcome variables. The main differences are the smaller and insignificant relationships between the predictor variable and perceptions of time to collaborate or plan, as well as for principal retention. These varying patterns are not surprising, given that some schools have relatively small percentages of disadvantaged students and therefore would experience small school-wide impacts of even a large increase in the share of pre-K students measured as a percentage of disadvantaged students.

Next, since previous research has shown that teachers' employment decisions and perceptions of the environment may vary by the socioeconomic context of the school (Borman & Dowling, 2008), we examine whether our results differ based on school characteristics (Table 4). Specifically, using a fully interacted model, we analyze whether higher shares of former NC Pre-K children among the economically disadvantaged students in elementary schools play a different role depending on the overall proportion of economically disadvantaged students in the school, the rurality of the community where it is located, or the school's size. The positive associations with teachers' perceptions do not differ significantly based on many of these characteristics except for the result on the proportion of experienced teachers in the school, which is significantly larger in schools that serve more economically disadvantaged students and the result on teacher retention, which seems to be driven by smaller schools.

Table 4
Subgroup Analysis: Estimated associations between educators' outcomes and the share of NC pre-K children in elementary schools by school characteristics. Fully interacted models.

	Teachers' perceptions of the school (1–5 scale)							Educator retention		
	Overall satisfaction	Time for the role	Time to collab.	Time for planning	Safety of school environment	School leadership support	Class size	% teacher retention	% experienced teachers	Principal retention
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. EDS Status										
% NCPK/ED students (in 10p. p. units)	0.04**	0.03+	0.03	0.01	0.03**	0.03+	0.04+	0.43+	0.38	0.02+
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.23)	(0.34)	(0.01)
High EDS * % NCPK/ED students	−0.02	0.01	−0.01	0.01	−0.00	−0.01	−0.04	0.19	1.14*	−0.00
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.31)	(0.46)	(0.01)
Observations	16,102	16,102	16,102	16,102	16,102	16,102	16,102	15,081	15,145	16,215
Panel B. Rurality										
% NCPK/ED students (in 10p. p. units)	0.02	0.03*	0.01	0.01+	0.04**	0.02	−0.00	0.57**	0.96**	0.02*
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.21)	(0.32)	(0.01)
Rural * % NCPK/ED students	0.02	0.01	0.04	−0.00	−0.01	0.01	0.03	−0.05	−0.15	−0.01
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.30)	(0.45)	(0.01)
Observations	16,102	16,102	16,102	16,102	16,102	16,102	16,102	15,081	15,145	16,215
Panel C. School size										
% NCPK/ED students (in 10p. p. units)	0.02*	0.03*	0.01	0.01	0.02*	0.02+	0.01	0.76***	0.94**	0.01+
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.21)	(0.31)	(0.01)
Large school * % NCPK/ED students	0.00	0.01	0.02	0.00	0.01	0.01	0.02	−0.77**	−0.21	−0.01
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.28)	(0.45)	(0.01)
Observations	16,102	16,102	16,102	16,102	16,102	16,102	16,102	15,081	15,145	16,215

Notes: Standard errors in parentheses. + $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. All regressions included time-varying covariates, school, and year fixed effects, and interactions between the subgroup indicator and all variables. Perception outcomes (columns 1–7) have imputed values for non-survey years, using the average between the two adjacent years. Time-varying covariates: number of students in the school, whether school has pre-K on site, % Black students, % Hispanic students, % other non-white students, % economically disadvantaged students, student–teacher ratio, school in rural community indicator, total county population (in log), median family income in the county, % SNAP recipients in the county, % Medicaid eligible in the county, federal, state, and local per pupil expenditure. With the purpose of classification of schools into subgroups, we averaged school membership and share of ED students across the study period. Although generally time invariant, rurality can change over time; we grouped schools based on the 2004 classification. %NCPK/ED students (in 10p.p. units) = share of students in the elementary school who were funded by the North Carolina Pre-Kindergarten program when they were four years old, among the students classified as economically disadvantaged. Outcomes estimated in columns 8 and 9 are not available in 2018, which explains the smaller sample size.

6. Robustness checks

We conducted a series of tests to confirm that our results were not sensitive to some of our methodological decisions. Table 5 presents the results of regression analyses with our preferred specification in Panel A (similar to Table 3, repeated for convenience), and model variations in Panels B-F. These variations included removing schools with limited grade configurations (i.e., keeping schools PK-05, PK-06, KG-05, and KG-06 only), maintaining a consistent sample across outcomes, using an unbalanced school sample (including schools that were not observed for the entire period of analysis), removing imputed years from the TWC Survey, and removing schools with less than 10 teachers responding to the TWC Survey. Overall, the results are not sensitive to any of these changes. Furthermore, as noted earlier, we included as a robustness check in our analyses an outcome variable that we did not expect to be significantly related to pre-K presence in schools (satisfaction with school size). This expectation was confirmed, with no significant relationship in any of the model specifications in Table 3 (column 7).

7. Conclusions and policy implications

The current study measures the association between the proportions of economically disadvantaged children within individual elementary schools who had formerly enrolled in North Carolina's high quality pre-school program (NC Pre-K) and the working environments in those schools. We focus on outcome measures at the school level: teachers' perceptions of the school environment, shares of experienced teachers, teacher retention from one year to the next, and principal retention. Each of these outcomes is measured at the school level, with a focus on the variation within individual schools over time. We find small but positive and statistically significant associations between the presence of students that previously participated in NC Pre-K and most of the teacher and principal outcome variables.

One limitation of our study is that we are not able to link teacher responses on the North Carolina Teachers Working Conditions Survey to the grade or classroom level. While aggregating the analysis at the school level has the advantage of providing the overall picture of the school environment, it is possible that the influence of increasing shares of NC Pre-K students is being diluted by this level of aggregation. This

Table 5
Robustness checks.

	Teachers' perceptions of the school (1–5 scale)							Educator retention		
	Overall satisfaction	Time for the role	Time to collab.	Time for planning	Safety of school environment	School leadership support	Class size	% teacher retention	% experienced teachers	Principal retention
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. Main specification										
% NCPK/ED students (in 10p. p. units)	0.03**	0.03***	0.02*	0.01+	0.03***	0.03**	0.01	0.51***	0.83***	0.01*
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.15)	(0.22)	(0.00)
Observations	16,102	16,102	16,102	16,102	16,102	16,102	16,102	15,081	15,145	16,215
Panel B. Removing schools with limited grade configuration										
% NCPK/ED students (in 10p. p. units)	0.03**	0.03**	0.02	0.01+	0.04***	0.03*	0.01	0.73***	0.84***	0.01*
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.16)	(0.25)	(0.01)
Observations	14,207	14,207	14,207	14,207	14,207	14,207	14,207	13,325	13,381	14,324
Panel C. Maintaining sample across outcomes										
% NCPK/ED students (in 10p. p. units)	0.03***	0.04***	0.02*	0.01*	0.03***	0.03**	0.02	0.54***	0.82***	0.01+
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.15)	(0.23)	(0.01)
Observations	14,885	14,885	14,885	14,885	14,885	14,885	14,885	14,885	14,885	14,885
Panel D. Unbalanced school sample										
% NCPK/ED students (in 10p. p. units)	0.02**	0.03***	0.02*	0.01+	0.03***	0.03**	0.01	0.32*	0.44*	0.01**
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.13)	(0.21)	(0.00)
Observations	18,348	18,348	18,348	18,346	18,348	18,348	18,348	17,417	17,494	18,896
Panel E. Removing imputed years from TWCS										
% NCPK/ED students (in 10p. p. units)	0.03**	0.03**	0.02	0.01	0.03**	0.03*	0.01			
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)			
Observations	8594	8594	8594	8594	8594	8594	8594			
Panel F. Removing schools with less than 10 responses to TWCS										
% NCPK/ED students (in 10p. p. units)	0.03***	0.04***	0.02*	0.01	0.03***	0.03***	0.02			
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)			
Observations	15,571	15,571	15,571	15,571	15,571	15,571	15,571			

Notes: Standard errors in parentheses. + $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. All regressions included time-varying covariates, school, and year fixed effects. Perception outcomes (columns 1–7) have imputed values for non-survey years, using the average between the two adjacent years. Time-varying covariates: number of students in the school, whether school has pre-K on site, % Black students, % Hispanic students, % other non-white students, % economically disadvantaged students, student–teacher ratio, school in rural community indicator, total county population (in log), median family income in the county, % SNAP recipients in the county, % Medicaid eligible in the county, federal, state, and local per pupil expenditure. In Panel B, we removed schools with the following grade configurations: PK-01/02/03/04 (n = 56 schools), KG-01/02/03/04 (n = 22 schools), 03–05 (n = 22 schools), and 21 schools offering grades 04–05, 02–05, 01–05, 04–06, 02–03, 02–04, 03–06. % NCPK/ED students (in 10p.p. units) = share of students in the elementary school who were funded by the North Carolina Pre-Kindergarten program when they were four years old, among the students classified as economically disadvantaged. Outcomes estimated in columns 8 and 9 are not available in 2018, which explains the smaller sample size.

possibility helps to contextualize the small associations that we found, which we interpret as lower bounds. However, the fact that we can detect even small but significant associations at the school level suggests that NC Pre-K attendance is playing a role in improving elementary school environments. Our study serves as a starting point for future research to explore this further in other states and with other sources of data.

A second limitation is that we do not have direct measures of classroom instruction or teacher-student interactions over time. Ideally, we would also want to know what exactly is being changed by the increasing share of NC Pre-K students. However, we argue that capturing teachers' perceptions about different dimensions of their work in the school may be even more illustrative than classroom evaluations when thinking about how school environments affect teachers' decisions and behaviors.

We acknowledge that further research is needed to understand the relationship between high-quality pre-K and teacher perceptions and behaviors. Our study, while incorporating a two-way-fixed effect model and important time-varying controls at the school level, might be subject to bias from the existence of potential unmeasured covariates. Despite the study limitations, our results have implications for future research on NC Pre-K spillovers. Prior research found that access to NC Pre-K is associated with considerable academic gains across groups of age-eligible children. While those studies identified benefits for the

individual student, our study supports the hypothesis that potential improvements in the school environment generated by the increased presence of school-ready children could be one of the mechanisms for imparting NC Pre-K benefits.

A positive school environment where teachers feel safe, supported, and satisfied with their role is clearly conducive to successful school experiences for students (Henry & Redding, 2018; Ladd, 2011; Ronfeldt, Loeb, & Wyckoff, 2013). Furthermore, improving conditions for teachers is a policy imperative. While we acknowledge that the focus of our study is not a key determinant or a tool to directly improve teachers' working conditions, our results indicate that teachers' time allocations and mobility decisions might be associated with improved school readiness of students once they enter elementary school. The findings in this study suggest that, in their decisions on expanding access to high quality Pre-K, policymakers should factor in the potential school-wide benefits accruing through more positive working environments for teachers and principals, which may lead to more positive learning environments for students.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Acknowledgement

This research study was supported by grant funding from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (1R01HD095930). The authors are thankful to Kenneth Dodge, Jade Jenkins, Tyler Watts, Ellen Peisner- Feinberg, and all members of the Consortium on Early Childhood Intervention Impact for their feedback on earlier versions of this work.

References

Adnot, M., Dee, T., Katz, V., & Wyckoff, J. (2017). Teacher turnover, teacher quality, and student achievement in DCPS. *Educational Evaluation and Policy Analysis, 39*(1), 54–76. https://doi.org/10.3102/0162373716663646

Bai, Y., Ladd, H. F., Muschkin, C. G., & Dodge, K. A. (2020). Long-term effects of early childhood programs through eighth grade: Do the effects fade out or grow? *Children and Youth Services Review, 112*, 104890. https://doi.org/10.1016/j.childyouth.2020.104890

Bailey, D. H., Jenkins, J. M., & Alvarez-Vargas, D. (2020). Complementarities between early educational intervention and later educational quality? A systematic review of the sustaining environments hypothesis. *Developmental Review, 56*, Article 100910.

Bartanen, B., Grissom, J. A., & Rogers, L. K. (2019). The impacts of principal turnover. *Educational Evaluation and Policy Analysis, 41*(3), 350–374.

Beteille, T., Kalogrides, D., & Loeb, S. (2012). Stepping stones: Principal career paths and school outcomes. *Social Science Research, 41*(4), 904–919.

Borman, G. D., & Dowling, N. M. (2008). Teacher attrition and retention: A meta-analytic and narrative review of the research. *Review of Educational Research, 78*(3), 367–409. https://doi.org/10.3102/0034654308321455

Boyd, D., Grossman, P., Ing, M., Lankford, H., Loeb, S., & Wyckoff, J. (2011). The influence of school administrators on teacher retention decisions. *American Educational Research Journal, 48*(2), 303–333.

Boyd, D., Lankford, H., Loeb, S., Rockoff, J., & Wyckoff, J. (2008). The narrowing gap in New York City teacher qualifications and its implications for student achievement in high-poverty schools. *Journal of Policy Analysis and Management, 27*, 793–818.

Buckman, D. G. (2021) The Influence of Principal Retention and Principal Turnover on Teacher Turnover. *Journal of Educational Leadership and Policy Studies*. Volume V: Fall 2021.

Dodge, K. A., Bai, Y., Ladd, H. F., & Muschkin, C. G. (2017). Impact of North Carolina's Early Childhood Programs and Policies on Educational Outcomes in Elementary School. *Child Development, 88*(3), 996–1014. https://doi.org/10.1111/cdev.12645

Friedman-Krauss, A. H., Barnett, W. S., Garver, K. A., Hodges, K. S., Weisenfeld, G. G., & Gardiner, B. A. (2020). The state of preschool 2019: State preschool yearbook. *National Institute for Early Education Research, 369*.

Goldring, R., & Taie, S. (2018). *Principal attrition and mobility: Results from the 2016–17 principal follow-up survey (NCES 2018–066) (Technical report)*. Washington, DC: National Center for Education Statistics.

Gray-Lobe, G., Pathak, P. A., & Walters, C. R. (2023). The long-term effects of universal preschool in Boston. *The Quarterly Journal of Economics, 138*(1), 363–411.

Hanushek, E. A., Kain, J. F., & Rivkin, S. G. (2004). Why public schools lose teachers. *Journal of Human Resources, 39*(2), 326–354.

Henry, G. T., & Harbatkin, E. (2019). Turnover at the top: Estimating the effects of principal turnover on student, teacher, and school outcomes (EdWorkingPaper: 19–95). *Retrieved from Annenberg Institute at Brown University*. http://www.edworkingpapers.com/ai19-95.

Henry, G. T., & Redding, C. (2018). The Consequences of Leaving School Early: The Effects of Within-Year and End-of-Year Teacher Turnover. *Education Finance and Policy, 15*(2), 1–52.

Horng, E. L. (2009). Teacher tradeoffs: Disentangling teachers' preferences for working conditions and student demographics. *American Educational Research Journal, 46*(3), 690–717.

Imazeki, J. (2005). Teacher salaries and teacher attrition. *Economics of Education Review, 24*(4), 431–449. https://doi.org/10.1016/j.econedurev.2004.07.014

Johnson, S. M., Kraft, M., & Papay, J. P. (2012). How context matters in high-need schools: The effects of teachers' working conditions on their professional satisfaction and their students' achievement. *Teachers College Record, 114*(10), 1–39.

Loeb, S., Darling-Hammond, & Luczak, J. (2005). Teacher turnover: The role of working conditions and salaries in recruiting and retaining teachers. *Peabody Journal of Education*, 80(3), 44–70.

Ladd, H. F. (2011). *Teachers' Perceptions of Their Working Conditions: How Predictive of Planned and Actual Teacher Movement? Educational Evaluation and Policy Analysis, 33* (2), 235–261. https://doi.org/10.3102/0162373711398128

Ladd, H. F., Muschkin, C. G., & Dodge, K. A. (2014). From Birth to School: Early Childhood Initiatives and Third-Grade Outcomes in North Carolina. *Journal of Policy Analysis and Management, 33*(1), 162–187. https://doi.org/10.1002/pam.21734

Loeb, S., Kalogrides, D., & Horng, E. (2010). Principal preferences and the unequal distribution of principals across schools. *Education Evaluation and Policy Analysis., 32*, 205–229.

Muschkin, C. G., Ladd, H. F., Dodge, K. A., & Grade. (2015). Impact of North Carolina's Early Childhood Initiatives on Special Education Placements in. *Educational Evaluation and Policy Analysis, 37*(4), 478–500. https://doi.org/10.3102/0162373714559096

Olsen, A. A., & Huang, F. L. (2018). Teacher job satisfaction by principal support and teacher cooperation: Results from the Schools and Staffing Survey. *Education Policy Analysis Archives, 27*(11). https://doi.org/10.14507/epaa.27.4174

Papay, J. P., & Kraft, M. A. (2015). Productivity returns to experience in the teacher labor market: Methodological challenges and new evidence on long-term career improvement. *Journal of Public Economics, 130*, 105–119. https://doi.org/10.1016/j.jpubeco.2015.02.008

Peisner-Feinberg, E. S., & Schaaf, J. M. (2011). *Effects of the North Carolina More at Four Pre-kindergarten Program on Children's School Readiness Skills*. FPG Child Development Institute: The University of North Carolina.

Peisner-Feinberg, E., Zadrozny, S., Kuhn, L., & Van Manen, K. (2019). *Effects of the North Carolina Pre-Kindergarten Program: Findings through Pre-K of a small-scale RCT study*. FPG Child Development Institute: The University of North Carolina.

Ronfeldt, M., Loeb, S., & Wyckoff, J. (2013). How teacher turnover harms student achievement. *American Educational Research Journal, 50*(1), 4–36. https://doi.org/10.3102/0002831212463813

Sorensen, L. C., & Ladd, H. F. (2020). The Hidden Costs of Teacher Turnover. *AERA Open, 6*(1), Article 2332858420905812. https://doi.org/10.1177/2332858420905812

Steinberg, M. P., & Garrett, R. (2006). Classroom Composition and measured teachers' performance: What do Teacher observarion scores really measure? *Educational Evaluation and Policy Analysis., 38*(2), 293–317.

Watts, T. W., Jenkins, J. M., Dodge, K. A., Carr, R. C., Sauval, M., Bai, Y., … Ananat, E. (2023). Understanding heterogeneity in the impact of public preschool programs. *Monographs of the Society for Research in Child Development, 87*(4).

Yesil-Dagli, U. (2012). America's public school kindergarten teachers' job turnover and associated factors. *Educational Sciences: Theory and Practice, 12*(4), 3121–3134.

Yoshikawa, H., Weiland, C., Brooks-Gunn, J., Burchinal, M. R., Espinosa, L. M., Gormley, W. T., & Zaslow, M. J. (2013). Investing in our future: The evidence base on preschool education. *Society for Research Child Development.*