Predicting On-Time Promotion to and Literacy Achievement in Eighth Grade in Relation to Public PreKindergarten in Virginia

By

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MAY 2015

Suggested citation: Virginia University Research Consortium on Early Childhood (2015), Predicting On-Time Promotion to and Literacy Achievement in Eighth Grade in Relation to Public Prekindergarten in Virginia. Richmond, VA: Virginia Early Childhood Foundation.

SMART BEGINNINGS
Virginia Early Childhood Foundation

This study is the first to examine middle school outcomes for students who attended public prekindergarten in Virginia. Sixty-seven percent of students who attended Virginia public kindergarten in 2005-2006 could be followed into eighth grade in 2013-2014 (N = 77,451). This cohort was examined because it is the first to have VDOE-collected data extending across prekindergarten and into eighth grade.

The study focused on on-time promotion and literacy achievement. On-time promotion predicts higher high school graduation rates, and grade retention is costly to both students and funders. Literacy represents a primary focus for prekindergarten. Statistical propensity score weighting techniques were used to estimate equivalent comparison groups between students who had attended a Virginia prekindergarten program and students whose prekindergarten experience was unknown. A host of student and school characteristics known to be related to academic achievement were accounted for in analyses in order to highlight associations just with prekindergarten enrollment.

Key Findings

- Of the followed cohort, students who had attended Virginia public prekindergarten were 3.9 percent more likely to be promoted on-time to eighth grade, compared to peers with unknown prekindergarten experience and accounting for demographic and some school factors often associated with academic performance. Similar patterns were found for on-time promotion to first and third grades.

- In contrast, for students who were promoted to 8th grade on time, prekindergarten status did not differentiate between students' performance on Standard of Learning (SOL) Reading and Writing tests. Data challenges make interpreting the lack of literacy findings problematic. This lack of difference may reflect a true pattern, or it may be an artifact of the fact that some of the students in the comparison group had some form of prekindergarten, potentially diluting later academic achievement differences. Modifying current procedures in order to identify prekindergarten enrollment by student and type of program is critical for future evaluations of the Virginia Preschool Initiative and other early childhood educational investments.

Virginia's state- and locally-funded prekindergarten program, the Virginia Preschool Initiative (VPI), is 20 years old in 2015. Increasingly integrated into public schools across most of Virginia, the voluntary, eligibility-specific program served approximately 17,378 four-year olds in 2013-2014,[1] or about 17% of four-year olds in the state.[2] The program began in 1996 to serve poor children not eligible for Head Start, in light of national research showing preschool benefits for children's later achievement.[3] Evaluations from the mid-2000s show benefits in Kindergarten and into first and third grades, but whether these benefits last or fade out over time is not known. This study aimed to investigate longer-term results, extending to the end of middle school.

The study reported here follows a cohort of students that could be traced from prekindergarten into eighth grade. Using statistical matching procedures to create comparison groups, we compared students on two indicators of academic progress: on-time promotion and literacy achievement. Elementary and middle school grade retention reflects more diverse factors than test scores, including several that are a primary focus of preschool instruction. For example, grade retention may reflect students' social-emotional development and behavior, educational achievement across multiple content areas, and in the lower grades, children's age relative to their peers. Grade retention is associated with a host of deleterious effects, including substantial risk of later school dropout.[4] Grade retention is also costly for schools, with an annual per-pupil expenditure in FY 13 of $11,256.[5] Literacy achievement is arguably the most intensive academic emphasis in prekindergarten and elementary school, thus representing the domain in which long-lasting benefits may be most expected; further, reading proficiency in 8th grade predicts high school coursework and college enrollment.[6] Therefore, we prioritized on-time promotion and literacy achievement to examine into eighth grade.

Earlier studies of VPI: What do we know?

VPI began in the mid-1990s to serve children deemed at-risk for school difficulties and not served by Head Start.[3] Projected into 2015, all but three localities (98%) are eligible to participate.[7] Budgeted per-child program costs are $6,000.[8] The program is free to eligible families and includes transportation, health and family services. Costs are shared between the state and local school systems.

In 2006, the General Assembly directed the Joint Legislative Audit Review Commission (JLARC) to study VPI's costs, implementation and effectiveness. Results showed that programs were generally well administered with medium to high quality, but that considerable local variation existed. Risk

factors, length of day, structure of the program and the percentage of local match money invested varied by locality. Despite the variability, more former VPI students (89%) met early literacy benchmarks in kindergarten than did kindergarteners overall (83%). A companion study conducted by the Virginia Department of Education on a portion of an early cohort found that the percentage of students who passed 2007 third grade Standard of Learning (SOL) tests was four to five points greater for children who had attended publicly-funded preschool compared to economically disadvantaged children with no known public preschool experience; this analysis combined all publicly-funded preschool (also including Head Start, Title I and Early Childhood Special Education).[3] A separate study found that more established VPI programs and programs located in public schools as opposed to community settings showed stronger pre-literacy gains across the prekindergarten year in a subsample of mostly newer VPI programs.[9]

In the only peer-reviewed study of VPI, researchers found that students who had attended VPI in 2006-2007 were much more likely to meet early literacy benchmarks in Kindergarten compared to similar children with no prekindergarten experience; Black, Hispanic and learning-disabled VPI attendees retained that advantage through the spring of first grade, despite more often attending schools with higher concentrations of poor and minority students.[10] When student and school-level factors were statistically controlled, VPI students were also less likely to repeat Kindergarten than peers with no prekindergarten experience (11% vs. 17%).

The current study builds on these studies by following the 2004-2005 prekindergarten cohort through middle school. Because prior studies also followed single but different cohorts from the one studied here, we first set out to replicate earlier work showing that children who attended public prekindergarten were more likely to meet early literacy benchmarks in Kindergarten and to be promoted to first grade. Our subsequent research questions were:

1. Are students who participated in VPI more likely to be promoted on time to third and eighth grades than are their peers?

2. Do students who participated in VPI demonstrate greater literacy competence than similar peers in eighth grade?

We also review some of the opportunities and limitations of using available state data to evaluate Virginia's publicly funded prekindergarten and recommend ways to improve the data system.

Method

Data for the study came from de-identified student records provided through the Virginia Longitudinal Data System (VLDS). The sample consists of all students who attended public school Kindergarten in Virginia in 2005-2006. We linked student Kindergarten records to subsequent school records through eighth grade, and to prekindergarten early literacy screeners to identify children who

participated in public preK in 2004-05. On-time promotion represents the percentage of the original sample that started in Kindergarten, were still in Virginia public schools, and were on track at 1st, 3rd and 8th grades (indicated by child data being available from that grade during the year that the Kindergarten cohort was supposed to be in those grades). Literacy achievement was measured by the literacy screener PALS (Phonological Awareness Literacy Screener[11]) in Kindergarten and Virginia's *Standard of Learning* (SOL) test in reading and writing in grade 8.

Three types of student records were linked through the Virginia Longitudinal Data System (VLDS), which uses a computerized algorithm to match records at the student-level so that personally identifying information is not revealed.[12] VDOE's Student Record Collection contributed demographic information and promotion status; student prekindergarten status and results on the fall literacy screener used in kindergarten came from Phonological Awareness Literacy Screener (PALS) data collection; and Standard of Learning (SOL) test results came from the student assessment records. Ordinary least square (OLS) and logistic regression models were used to test patterns and magnitudes of associations between prekindergarten status and on-time promotion and literacy achievement.

Creating equivalent comparison groups.   In academic year 2004-2005, all but one local VPI program administered the prekindergarten version of the PALS; most school divisions reported results to the central PALS Office.[i] The PALS PreK records established students' enrollment in a public prekindergarten program. Unfortunately, no code reliably identified whether or not a child attended a VPI-only program, or whether the child received prekindergarten through other public funding sources (such as early special education, Title I or in some cases, Head Start).   Therefore, the focal group is more accurately represented as "Known Public PreK;" prekindergarten experience for all other students in the comparison group is unknown.

Comparing the Known Public PreK group directly to all other students would provide a meaningless estimate, since public prekindergarten specifically targets children at-risk for academic difficulties who historically perform less well than peers from more advantaged backgrounds. Comparing only students who were economically disadvantaged ignores the considerable number of children identified as "at risk" and eligible for VPI for non-economic reasons, such as family and health challenges.[ii] Therefore, to establish an appropriate comparison group, we used a statistical procedure -- propensity-score matching -- that calculates the probability ("propensity") of a given child having been eligible for any public PreK program, based on the proportional characteristics of students who clearly attended public prekindergarten in the 2004-2005 cohort. The matched-eligibility group constituted the comparison group for purposes of this study. Students in the

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[i] We do not know the exact number of school divisions that reported PALS PreK data for this sample. However, it is important to note that when this has been tracked, there are a fair number of divisions that offer VPI, but do not report PALS PreK data. For example, in 2006 only 75 of 110 localities that offered VPI reported PALS PreK data (JLARC, 2007).
[ii] Localities establish their own risk indicators that include but are not limited to economic disadvantage (JLARC, 2007).

comparison group did not take the PALS PreK in 2004-2005, are likely to have been eligible for public prekindergarten, and may or may not have attended prekindergarten. In fact, some proportion of the comparison group likely attended public prekindergarten through Head Start or, less commonly, through a local VPI program that did not report PALS-PreK scores. Therefore, any results favoring the focal group are likely to underrepresent the magnitude of benefit associated with public prekindergarten participation.

In all analyses, a set of student characteristics at Kindergarten were taken into account (e.g., statistically controlled for) in order to isolate potential effects of prekindergarten. Further details regarding propensity-score procedures and models, as well as about the analytic procedures employed, are presented in Appendix A.

Results

For AY 2004-2005, 11,239 students were enrolled in VPI, and 8,993 students had PALS-PreK data that could be linked to public school records in Kindergarten the following year ("Known Public PreK" group). In all analyses, this group was compared to students in the Kindergarten 2005-2006 cohort without known public prekindergarten experience (N = 86346, "Unknown PreK" group). A substantial percentage of both groups could be followed across grades, ranging equally for both groups from 93 percent (1st grade on-time promotion) to 67 percent (8th grade Reading SOL tests). Details are available in Appendix A (see Tables A3, A4, and A7).

Findings replicated earlier results showing Kindergarten benefits.

Participating in public prekindergarten was positively associated with performance on the Kindergarten PALS assessment. Keeping other student characteristics constant, students known to have attended public prekindergarten scored an average of six points higher on the PALS K compared to students whose prekindergarten experience was unknown. Children in the known PreK group[iii] were also more likely to be promoted on time to first grade (described below).

Students with known public prekindergarten participation were more likely to be promoted on time in later grades.

Most students were promoted to 3rd (85%) and 8th grades (81%) as expected. However, students known to have attended public prekindergarten in 2004-2005 had a higher probability of being promoted on time, compared to peers who had similar characteristics in Kindergarten. The figure

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[iii] Student demographic characteristics and background variables such as gender, socioeconomic status (disadvantaged), English language proficiency (LEP), race, ethnicity, eligibility for Title I funding, disability status, and attendance to multiple schools within the same year were controlled for in each regression model.

below shows the differential rates for each grade, translated from probabilities into adjusted on-time promotion rates. These adjusted rates indicate the likelihood that Virginia's students will be in these on-time promotion counts based on a collection of characteristics (i.e., predictor and control variables).

Figure 1. *Adjusted On-Time Promotion Rates, by Grade and Prekindergarten Status*
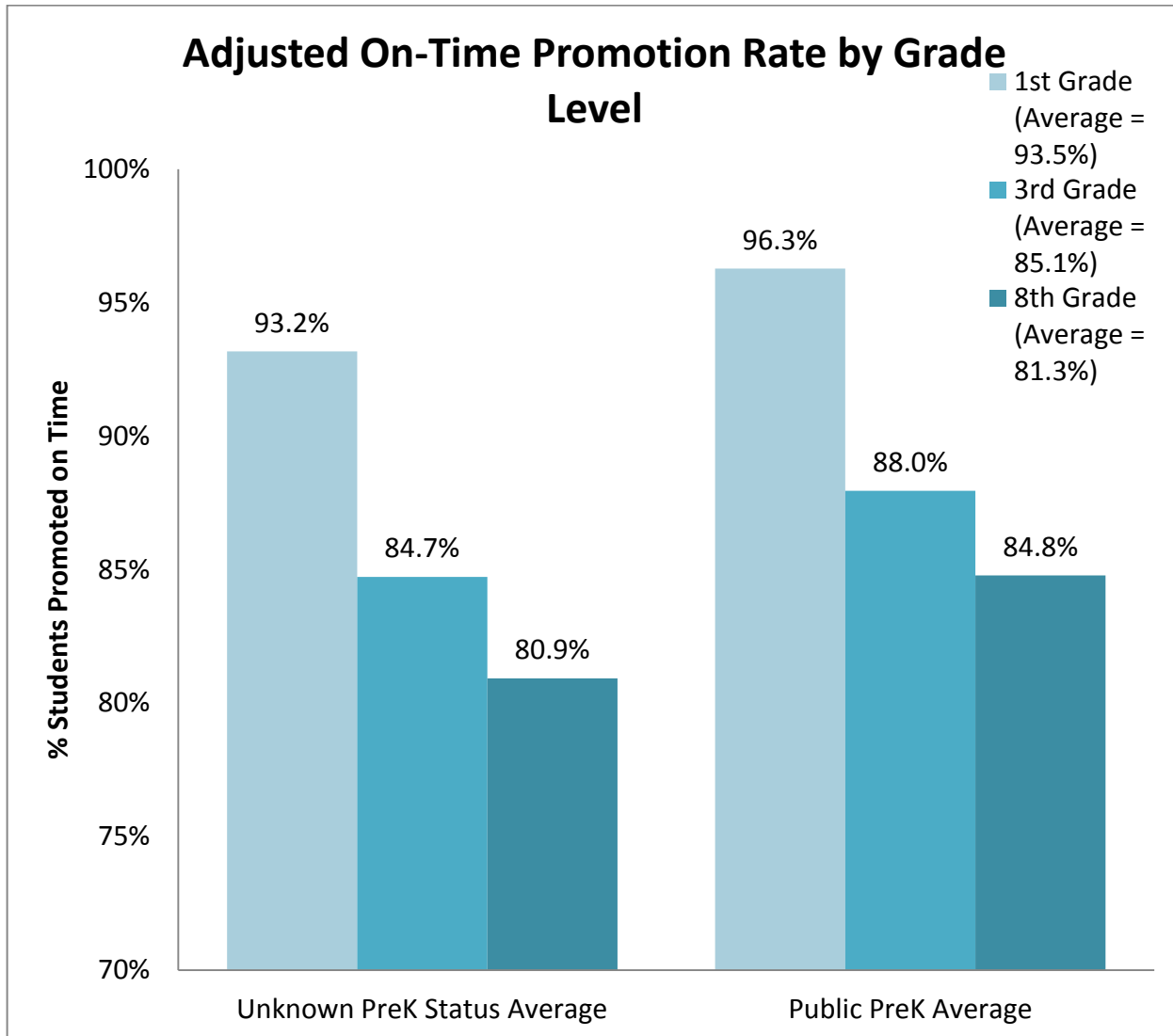
Source: Virginia Department of Education. N_{G1} = 88,823, N_{G3} = 83,946, N_{G8} = 77,451.
Probability percentages based on log-odds for students who attended Virginia public schools and attended public prekindergarten in 2004-2005.

Across grades, results show that on average, students known to have participated in public prekindergarten were promoted on time approximately three percent more frequently than similar students whose prekindergarten status was unknown. In first grade, rates favored the known PreK

student group by 3.1 percent (96.3% Public PreK *vs.* 93.2% Unknown Public PreK. In third grade, rates differed by 3.3 percent (88% Public PreK *vs.* 84.7% Unknown Public PreK). By eighth grade, students known to have participated in public prekindergarten were promoted 3.9 percent more frequently than similar peers with unknown prekindergarten (84.8% Public PreK *vs.* 80.9% Unknown Public PreK). Appendix A provides further details.

As noted earlier, models took into account student characteristics at Kindergarten that might also be associated with differential performance in later grades. In fact, many demographic factors - such as age, gender, disadvantaged and disability statuses – also showed differential likelihood of on-time promotion when prekindergarten status is taken into account. The interested reader can review specific findings on the demographic factors in Appendix A.

For students who were promoted to 8th grade on time, literacy achievement did not differ by prekindergarten participation.

To assess the degree to which public PreK participation was associated with later student literacy outcomes, we compared grade 8 SOL reading and writing test results for on-time (i.e., never retained) students.[iv] We analyzed literacy outcomes using two different measures from Virginia's state test: overall scaled score (out of 600) and whether or not students met Virginia's passing score as defined for state and federal accountability. For students with available SOL records in the linked data, no association was found between students' participation in public prekindergarten and their subsequent scaled scores on the 2014 eighth grade SOL reading or writing assessments in models that included other student characteristics from Kindergarten (see Appendix A for details). The same held true for proficiency rates: Students known to have attended public prekindergarten were not more likely to meet SOL language arts proficiency standards in eighth grade than their comparison peers.

In contrast, gender, ethnicity, economic risk status, disability, age, and if a student attended more than one school in kindergarten all were strongly associated with eighth grade reading and writing scores, after holding public PreK participation constant. Females and Asian students, on average, scored considerably higher on both the eighth grade SOL reading and writing assessments than males and their Caucasian peers, respectively. On the other hand, disadvantaged students, students who received Title I-funded assistance, Blacks, Hispanics, students with a disability, and those attending multiple schools performed lower than their peers, ranging from almost 6 (Hispanic) to 23 points (Disability) lower than the Reading reference average, and almost 6 (Hispanic) to 34 points (Disability) lower on the Writing reference average.

[iv] The majority of, but not all, 8th graders take SOL tests in the spring of the academic year.

Summary and Conclusions

This study is the first to follow students who received publicly funded prekindergarten in Virginia into middle school. Similar to findings from earlier work that used different cohorts and methodologies, we found that students in the 2005-2006 Kindergarten cohort showed early literacy benefits in the first year of school. Early gains were maintained in the form of on-time promotion across all grades examined, as far out as eighth grade. If replicated with other cohorts, these findings point to a powerful long-term benefit associated with Virginia's public prekindergarten, spanning the first nine years of students' formal education. For example, if the 3.1 percent difference in promotion rates was applied to the 27,717 children in the unknown public prekindergarten group who were designated as economically disadvantaged, this would mean that 859 more children might be expected to receive promotion into the first grade after experiencing public prekindergarten. As retention predicts greater chances of dropping out of high school and as the annual cost of educating a student is approximately $11,257,[13] even small differences can translate into meaningful student benefits and potential cost savings for the Commonwealth.

The study did not find differences associated with known public prekindergarten participation and 8th grade scores or proficiency on Standard of Learning (SOL) literacy tests for students who were promoted to 8th grade on-time and took the traditional SOL test. This may reflect a true pattern, or it may be an artifact of the fact that some of the students in the comparison group had some form of prekindergarten, potentially diluting later academic achievement differences. For example, University of Virginia researchers found literacy benefits into first grade, but they compared VPI students to similar peers with *no* prekindergarten experience.[10] Students with no prekindergarten experience represent a much starker contrast than does the comparison group in this study. The fact that we could not account for students with disabilities in either the focal or the comparison groups may also have contributed to null findings.

On the other hand, using a similar comparison breakdown as used in this study – known public prekindergarten versus unknown prekindergarten experience – the Virginia Department of Education reported a four to five percent proficiency advantage for students known to have attended public prekindergarten on third grade SOLs.[3] That analysis used a different statistical technique and compared only students identified as economically disadvantaged. Reasons for the different findings could thus be analytical, be based on different cohort patterns, or could reflect associations fading out in the five years from third to eighth grades. For all these reasons, it is difficult to know whether the lack of 8th grade achievement differences reflects a true lack of association between public prekindergarten enrollment and later reading and writing achievement ("fade-out").

Study limitations. The current study has several important limitations.[v] First, the inability to distinguish between the type of program students attended even within the known public prekindergarten group hampers our ability to draw clear conclusions about the impact of VPI, a challenge compounded by the "black box" nature of the comparison group.

Second, limited resources available for this project prevented a more in-depth examination of whether public prekindergarten was associated with different patterns of promotion and achievement for different groups of students, such as solely economically disadvantaged children, ethnic minorities, and students with limited English proficiency (LEP). Reducing disparities between these groups and more advantaged children upon entering school is a primary objective of the Virginia Preschool Initiative[3] and indeed, of all public preschool programs. As students who are demographically at-risk starting Kindergarten showed trenchant differences from their peers in both on-time promotion and 8th grade achievement patterns (holding known public prekindergarten constant), a critical next step is to ascertain whether these differences were reduced or ameliorated for students in these at-risk groups who attended public prekindergarten, as Huang et al. (2012) found in first grade.[10]

Third, the available data tell us nothing about what students actually experienced in prekindergarten. Research literature linking preschool to later positive outcomes for students emphasizes that specific features of preschool predict future benefits, not simply preschool itself. Quality of instruction, emotional climate and organization of the classroom, curricula, teacher qualifications and characteristics of the peer group have been shown to promote or detract from academic and social learning. If such information were available, associations with later school functioning may more clearly emerge.

Similarly, the study did not account for differences between elementary and middle schools that students attended. Factors that yield greater benefits from preschool also pertain to later schooling. Some schools may help students retain and build upon their prekindergarten advantage, whereas others may not. For example, consistently low-performing schools located in poverty-dense communities in Virginia often have less prepared or effective teachers and use poor instructional practices,[14] that could swamp prekindergarten benefits for already at-risk children. Studies that

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[v] These limitations refer to limitations given the non-experimental nature of the study. The decision to enroll students in public prekindergarten was determined by parents and by the availability of local public prekindergarten slots, precluding our ability to *conclusively* attribute results to prekindergarten itself, even with a matched comparison group. However, the statistical method used here approximates random assignment in that information is used to estimate the likelihood that a given student would be eligible for public prekindergarten, thereby providing a sound basis on which to presume prekindergarten effects, where demonstrated.

include school-based factors during elementary school in particular are needed to promote better understanding of ways that early prekindergarten boosts can be maintained into later grades.

Lastly, including student attitude, "citizen" or behavioral factors in evaluation models may show additional long-term preschool advantages or suggest routes by which academic benefits might be maintained (or not). For example, many of the substantial benefits identified in return-on-investment studies of experimental preschool interventions coalesce around educational persistence[15] and other non-cognitive factors.[16] Findings in this study may partly exemplify this point, to the extent that on-time promotion – which preferentially benefitted at-risk students known to have attended public prekindergarten even through middle school - reflects non-cognitive as well as academic factors. Attendance and disciplinary infractions are two types of behavioral data routinely collected by schools that could be profitably incorporated into future evaluation studies.

As for any study with policy implications, results should be replicated with several cohorts to ensure findings are not unique to particular years.

Future Directions and Recommendations

This brief represents a first look at how students known to have attended public prekindergarten were faring into eighth grade. Several critical additional steps are recommended to adequately address in what ways early childhood education may or may not continue to benefit students. Top priorities are conceptual and methodological.

Conceptually, we recommend developing a model that describes different ways that state-funded prekindergarten may be expected to exert long-term effects on later schooling. This kind of differentiated model – including direct and indirect effects - would help guide further evaluations and could provide actionable information for quality improvement efforts.

Methodologically, the top priority for future evaluations of Virginia's investment in public prekindergarten is to be able to identify where a student attended prekindergarten, and for how long. These data are available, but not for all cohorts and the quality of the data is currently not known. In Appendix B, we suggest ways to test aspects of data completeness and quality, so that future studies can select the most complete and accurate cohorts and sets of indicators. To maximize the potential of the VLDS, we further recommend the integration of additional data and data systems that – by adding characteristics of programs and additional points by which to link students to early education experiences – can greatly improve the state's capacity to routinely evaluate this signature

investment in student education. At the state level, some of this is expected to be accomplished as part of Virginia's U.S. Department of Education Preschool Expansion grant, awarded in 2014.

Below, we offer additional recommendations for specific short- and long-term strategies to rigorously and informatively evaluate the Virginia Preschool Initiative and other publicly funded early childhood education services.

Short-term:

1. Using this study sample, conduct additional analyses to address limitations of the current study, including

   - Examine differential associations of VPI with particular at-risk student groups;
   - Examine additional school engagement factors in relation to academic outcomes, such as attendance and tardiness rates;
   - Include school-level factors in models to examine impact of subsequent school experiences on later outcomes in relation to prekindergarten.

2. Conduct data analytic studies on different prekindergarten placement indicators, as suggested in Appendix B. At the same time, given that none of the current indicators are directly tied to funding – which typically improves data accuracy – VDOE might consider more closely linking prekindergarten student identification with funding. Rather than continuing the current system – in which funding is calculated based on aggregate student counts reported through a separate, VPI-only process – local programs could be required to identify prekindergarten students by Student Testing Identifiers and attendance records uploaded to the Student Record Collection, as is done for K-12. This type of reporting has the potential to measurably improve identification of children who participated in VPI, and for how long, factors that are critical to evaluating long-term effects in the future.

3. Replicate findings from this study with additional cohorts as data become available, testing different ways to identify and group students who attended public prekindergarten, based on results from data analytic studies. For example, state-wide data using Student Testing Identifiers established in prekindergarten and PreK PALS data could be compared to Virginia Preschool Initiative attendance or other indicators from select school divisions that are known to closely track VPI participation.

4. Once the best indicators and/or cohorts have been identified, conduct longitudinal trajectory analyses to identify potential pathways to success and failure, particularly for students identified early on as at-risk for less optimal school functioning.

***Longer-term*:**

1. Develop and test a conceptual logic model that describes ways in which public prekindergarten might be expected to have long-lasting effects. For example, what kinds of elementary school supports or characteristics might best maintain or build upon students' better school readiness in Kindergarten?

2. Capitalize on state data integration efforts currently underway to add data related to preschool program quality in evaluation models. Data from the Virginia Star Quality Initiative, the Professional Registry and other relevant state early childhood data systems could measurably enhance VPI follow-up studies. Many of these records are being prepared to become available to approved users through the Virginia Longitudinal Data System.

3. In addition, policymakers may wish to consider creating a state and local school system data working group with localities that collect additional metrics of both student progress, and interventions or services students receive during elementary school (such as use of reading enrichment programs or use of specialists), that are not currently available through the state system.   Aggregating common local data to test for effects should help promote additional understanding of ways that early childhood education can be enhanced for maximal benefit to students and the Commonwealth.

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Sample Description

The sample included the cohort of Kindergarten students who entered Virginia public schools in 2005-06. Using the Virginia Longitudinal Data System (VLDS), we linked de-identified records from these students to their subsequent school records through 8th grade, and to prekindergarten PALS records to identify children who participated in public PreK in 2004-05, identified through PreK PALS test data (referred to as the "Known Public PreK" group above).   Important to note is that the matching of students over time in VLDS is not perfect.   Of 11,239 unique PreK students in the VA DOE database for the 2005-06 academic year, we were able to match 8,993 (80% match rate). Overall, the sample included 95,339 children from the 2005-06 Kindergarten cohort; 8,993 of these had linked PALS PreK score and were placed in the "Known Public PreK" group, whereas 86,346 were designated as the non-Public PreK group. Tables A1 and A2 below provide descriptive information in each group across the predictors and outcomes.

Table A1. Sample Description of Non-Public PreK Group

Variable	N	Mean %	Std. Dev.
Female	86346	47.3%	--
White	86346	57.8%	--
Black	86346	23.0%	--
Hispanic	86346	10.2%	--
Unknown Race/ethnicity	86346	3.3%	--
Asian/PI/AI	86346	5.5%	--
Disadvantaged	86346	32.1%	--
Limited English Proficiency	86346	6.0%	--
Title1 Status	86346	54.7%	--
Disability Status	86346	10.2%	--
Age in Years	86346	5.57	0.38
Multiple schools	86346	6.4%	

Note: All demographic data are reported from the Kindergarten year.

Table A2. Sample Description of Public PreK Group

Variable	N	Mean %	Std. Dev.
Female	8993	50.2%	--
White	8993	35.8%	--
Black	8993	54.6%	--
Hispanic	8993	6.4%	--

Unknown Race/ethnicity	8993	1.3%	--
Asian/PI/AI	8993	1.9%	--
Disadvantaged	8993	67.5%	--
Limited English Proficiency	8993	5.1%	--
Title1 Status	8993	81.4%	--
Disability Status	8993	11.7%	--
Age in Years	8993	5.51	0.30
Multiple schools	8993	9.1%	

Note: All demographic data are reported from the Kindergarten year.

Measures

All measures were gathered from the VDOE through the VLDS system (either Student Records, PALS Test Results, or State Assessment Results), and are described in further detail below.

Predictors

Public PreK. Children were placed into the 'Known Public PreK' group if they had PALS PreK data from 2004-05.

Gender. Gender was collected from the Student Records database (Female = 1).

Disadvantaged. The Disadvantaged Status Flag comes from Student Records and identifies the student as economically disadvantaged, based on one or more of the following criteria: eligible for Free/Reduced Meals, receives TANF, eligible for Medicaid, or identified as Migrant or experiencing Homelessness.

Limited English Proficiency (LEP). The LEP Flag comes from Student Records and identifies any student who can be considered Limited English Proficient for the purposes of NCLB Accountability (i.e., currently receive services, eligible to receive services but do not, completed receipt of services with the last two years).

Title I. The Title I Flag comes from Student Records and identifies students who participate in Title I programs at Target Assistance schools or attended a Title I school in kindergarten.

Race. Racial/ethnic Code comes from Student Records and identifies the racial category that reflects the student's recognition of his/her community or with which the student most identifies, including White, Black, Hispanic, Asian/Pacific Islander/Hawaiian, and Unknown (White used as the reference group in all models).

Disability Status. The Primary Disability Type variable comes from Student Records and identifies a student's primary disability as represented on an Individual Education Plan (IEP). Any child with a disability designation within this variable was coded as 1, which includes a wide range of disabilities (e.g., autism, intellectual disability, specific learning disabilities, visual impairments).

Multiple Schools. Within Student Records, any student who had more than one school identification number in a given year were coded as having attended multiple schools.

Age at Kindergarten Entry. Age at Kindergarten entry comes from Student Records and represents their age in years on October 1st of the 2005-06 school year.

Outcomes

PALS Kindergarten. The Sum Score from the PALS was used based on administration in the Fall of Kindergarten (2005).

On-time Promotion – 1st, 3rd, and 8th Grades. On-time promotion represents the percentage of the original sample who started in Kindergarten, were still in Virginia public schools, and were on track at 1st, 3rd and 8th grades (indicated by child data being available from that grade during the year that the Kindergarten cohort was supposed to be in those grades).

Reading and Writing SOL Test – students promoted on-time to 8th Grade. From the available State Assessment Results, we used the scaled scores from the Standards of Learning test in 8th grade for Reading and Writing (as well as proficiency rates, which designates whether or not a student meets Virginia's passing score as defined for state and federal accountability).

Data Analytic Approach

The analyses contained in this report were conducted in two stages. In the first stage, we estimated a propensity score model[17] to quantify the probability that a child would have been in public PreK (as defined by them having a PALS PreK score). In the second stage, the estimated propensity scores were used to examine differences between known public PreK and unknown public PreK children on PALS Kindergarten, on-time promotion at 1st, 3rd, and 8th grades, and the 8th grade Reading and Writing SOL test (scaled scores and proficiency). See Table A3 and A4 for descriptives on each outcome measure across the public PreK and non-public PreK groups, prior to the propensity matching process.

Table A3. Descriptive (unadjusted) Information about Outcomes of Unknown Public PreK Group

Variable	n	Mean %	Std. Dev.	Min	Max
PALS-K Summary Score	62737	56.69	24.555	0	102
On-time Promotion – 1st Grade	80166	94.6%	--	--	--
On-time Promotion – 3rd Grade	75560	89.2%	--	--	--
On-time Promotion – 8th Grade	69547	87.7%	--	--	--
Reading SOL Standard Score – 8th Grade	57846	433.6	58.423	0	600
Reading SOL Proficiency – 8th Grade	57846	73.1%	--	--	--
Writing SOL Standard Score – 8th Grade	57896	438.56	68.91	0	600
Writing SOL Proficiency – 8th Grade	57896	72.3%	--	--	--

Note: PALS K score of 28 or greater is considered meeting the benchmark (JLARC, 2007).

Table A4. Descriptive (unadjusted) Information about Outcomes of Public PreK Group

Variable	n	Mean %	Std. Dev.	Min	Max
PALS-K Summary Score	6905	56.05	21.73	0	102
On-time Promotion – 1st Grade	8657	94.9%	--	--	--
On-time Promotion – 3rd Grade	8386	86.3%	--	--	--
On-time Promotion – 8th Grade	7904	83.1%	--	--	--
Reading SOL Standard Score – 8th Grade	6268	409.52	52.42	0	600
Reading SOL Proficiency – 8th Grade	6268	57.9%	--	--	--
Writing SOL Standard Score – 8th Grade	6292	411.59	60.33	0	600
Writing SOL Proficiency – 8th Grade	6292	57.6%	--	--	--

Note: PALS K score of 28 or greater is considered meeting the benchmark.

We used propensity score methods to model the selection process by which children enroll in public PreK. Ideally, a rich set of data is used to model the selection process, with particular attention paid to factors that may be related to the choice of attending public PreK. In the present analysis, we drew on information about children and their families from the VLDS, including each child's gender, race, age, disability status, English proficiency status, and Title I status and their family's socioeconomic status (all collected when children were in Kindergarten).

Because the decision to enroll a child in public PreK is likely constrained by PreK options available to families in their immediate geographical context, we estimated a *multilevel* propensity score model that incorporated information about locality (based on the Kindergarten school) to predict a child's probability of being in public PreK[18, 19]. Given the presence of a dichotomous treatment (either a student was in public PreK or not) and multilevel data, the final propensity score model was estimated using hierarchical general linear modeling[20] with the previously listed child and family information included as key covariates. All covariates in the model were estimated as fixed effects

(i.e., their effect on public PreK enrollment was fixed to be the same across school clusters) with the exception of socioeconomic status, which was allowed to randomly vary in its effect on public PreK enrollment across school clusters. Additionally, socioeconomic status was interacted with each of the covariates. Propensity scores were created based on a child's predicted probability of being in public PreK.

We then created a set of weights from the propensity scores to use in subsequent analyses. Children in the treatment group received a weight of *one* and children in the control group were weighted to be similar to the treatment group (i.e., *control weight = propensity score/(1-propensity score)*. A key benefit of propensity score models is the ability to check for equivalence (i.e., balance) across treatment and control groups on the key covariates. Tests of balance across treatment and control groups on the covariates included in our model are shown in Appendix Table A5.

Prior to applying the weights, the two groups were not balanced on any of the covariates, but after applying the weights, all covariates were balanced, and reductions in standardized bias from the propensity score estimation were substantial (ranging from 72% to 92%). To probe a bit further, we split the propensity scores into five equally sized groups (quintiles) and examined whether balance was achieved within each of these quintiles. Although we largely achieved balance across the covariates within each of the quintiles, some important exceptions should be noted (see Appendix Table A6). In the quintile containing students with the highest probability of receiving public PreK, we were not able to balance covariates for white and black races, disability status, and age. Additionally, balance could not be achieved on the socioeconomic status covariate in the second and third quintiles. This would, in turn, suggest that the findings in this study underestimate the relationship between public PreK and the outcomes presented here.

Although it would be ideal to have all covariates balanced, this is rarely achieved in applied contexts, and the overall levels of standardized bias reduction provides support for the effectiveness of our propensity score estimation. An additional indicator of the quality of the propensity score estimation is the degree to which the propensity score range is similar in the treatment and control groups, referred to as *common support*. We found evidence for common support in our sample across almost the entire range of propensity scores with the only exception being in bottom quarter of the 1st quintile, which was comprised of control students with the lowest probability of being in public PreK. Given that such students were heavily down-weighted, it is not surprising that subsequent analyses with and without these students included produced nearly identical results. We therefore included these students in all predictive analyses.

Table A5. Omnibus Tests of Balance across the Public PreK and Non-Public PreK Groups on Covariates

Variable	Pre-Propensity Score	Post-Propensity Score (IPTW*)	% Bias Reduction
Female	No	Yes	96.7%
White	No	Yes	95.0%
Black	No	Yes	95.4%
Hispanic	No	Yes	95.5%
Unknown Race/ethnicity	No	Yes	97.9%
Asian/PI/AI	No	Yes	96.7%
Disadvantaged	No	Yes	97.4%
Limited English Proficiency	No	Yes	87.0%
Title1 Status	No	Yes	96.6%
Disability Status	No	Yes	71.7%
Age in Years	No	Yes	87.5%

*Inverse Propensity Score Weighting Method (RI, RS, Interactions)

Table A6. Tests of Balance within Quintiles across the Public PreK and Non-Public PreK Groups on Covariates

Variable	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Female	yes	yes	yes	Yes	yes
Disadvantaged	yes	no	no	Yes	yes
Limited English Proficiency	yes	yes	yes	Yes	yes
Title1 Status	yes	yes	yes	No	yes
White	yes	yes	yes	Yes	no
Black	yes	yes	yes	Yes	no
Hispanic	yes	yes	yes	Yes	yes
Unknown Race/ethnicity	yes	yes	yes	Yes	yes
Asian/PI/AI	yes	yes	yes	Yes	yes
Disability Status	yes	yes	yes	No	no
Age in Years	yes	yes	yes	No	no
N of public prek/quintile	3	78	449	2018	6445
N of non-public prek/quintile	19064	18990	18619	17050	12623

Logistic regression was used to predict promotion and SOL proficiency outcomes. In all cases, these models corrected the standard errors for the nesting of students within schools and employed the weights generated from the propensity score models. To make the results more easily interpretable,

we calculated marginal effects estimates of the logistic regression results. Marginal effects express the regression coefficients in terms of predicted probability increase (or decrease) associated with a 1-unit change in the independent variable. For PALS-K and eighth grade SOL scaled score models, we estimated ordinary least squares regressions that corrected for the nesting of students within schools and employed the weights generated from the propensity score models.

Table A7. *Sample Sizes across Grades for Kindergarten Cohort 2005-2006*

	n
Public Prekindergarten$_{2004\text{-}2005}$[a]	8,993
Kindergarten$_{2005\text{-}2006}$	
Full Cohort Sample	95,339
Subsample with PALS-K Summary Scores	69,642
Grade 1$_{2006\text{-}2007}$ with On-time Promotion Data	88,823
Grade 3$_{2008\text{-}2009}$ with On-time Promotion Data	83,946
Grade 8$_{2013\text{-}2014}$	
Subsample with On-time Promotion Data	77,451
Subsample with Reading SOL Standard Scores	64,114
Subsample with Reading SOL Proficiency	64,124
Subsample with Writing SOL Standard Scores	64,278
Subsample with Writing SOL Proficiency	64,289

Sources: Virginia Department of Education; University of Virginia Curry School of Education (PALS data). *Note*. n = sample size. [a]Public prekindergarten refers to students with PALS PreK records (the focal study group, "Known Public PreK,") and not to the entire population of students enrolled in public prekindergarten in Virginia during 2004-2005.

On-Time Promotion Models

The first research question, *Are students who participated in public PreK more likely to be promoted on-time to first, third and eighth grades than are their peers?,* was addressed using binary logistic regression models with participation in 'Known Public PreK' as the predictor variable in each model and students on-time promotion in grades 1, 3, and 8 as the outcome variables in three separate models. Student demographic characteristics and background variables based on their status in Kindergarten such as gender, socioeconomic status (disadvantaged), English language proficiency (LEP), race, ethnicity, eligibility for Title I services, disability status, and age in years upon entry into Kindergarten were controlled for along with attendance to multiple schools within the same year. Standard errors were adjusted for the clustering of students within schools. Results are described below in terms of marginal effects estimates and reflected in Table A8.

First Grade. The sample size for the first grade model was 88,823 and the predictors accounted for 12% of the variance in the outcome variable (i.e., on-time promotion to 1st grade). This regression model and the associated marginal effects estimates in Table A8 provide a statistical measure of

students' probability for on-time promotion to first grade if they participated in public PreK compared to the statistical probability of students with unknown PreK status being promoted on time. The marginal effects estimate of .03 indicates that students participating in public PreK had a 3% probability increase in being promoted on-time to first grade compared to the promotion rates of children whose PreK status was not known, holding all other predictor variables at their sample mean. Although there was a significant contribution by the predictor variable and several background and demographic variables to the logistic regression model, the interactions between participation in public PreK and each of the significant control variables were not evaluated.

Third Grade. The sample size for the third grade model was 83,946 and the predictors accounted for 8% of the variance in the outcome variable. For this model, the marginal effect of students in the known public PreK group being promoted on time was .03, indicating a 3% increase in the 3rd grade promotion rate for PreK students relative to students whose PreK status was unknown. The interactions between participation in public PreK and each of the significant control variables were not evaluated.

Eighth Grade. The sample size for the eighth grade model was 77,451 and the predictors accounted for 7% of the variance in the outcome variable. For this model, the marginal effects estimate of .04 indicates that students participating in public PreK had a 4% probability increase in being promoted on time to eighth grade compared to the promotion rates of children whose PreK status was not known. The interactions between participation in public PreK and each of the significant control variables were not evaluated.

Table A8. Marginal Effects of PreK Participation on On-time Grade Advancement

	K1 Promotion		K3 Promotion		K8 Promotion	
Public PreK	0.03***	(0.00)	0.03***	(0.00)	0.04***	(0.01)
Female	0.02***	(0.00)	0.05***	(0.00)	0.07***	(0.01)
Disadvantaged Status	-0.03***	(0.00)	-0.08***	(0.01)	-0.09***	(0.01)
Limited English Proficiency	0.01	(0.01)	0.02	(0.02)	0.03	(0.02)
Title I Status	0.01	(0.00)	0.01	(0.01)	-0.00	(0.01)
Race/ethnicity						
Black	0.00	(0.00)	-0.01	(0.01)	-0.02*	(0.01)
Hispanic	0.00	(0.01)	0.00	(0.01)	0.01	(0.01)

Unknown	0.01	(0.01)	0.03	(0.02)	0.02	(0.02)
Asian/PI/Haw	0.02***	(0.01)	0.05***	(0.01)	0.09***	(0.01)
Disability Status	-0.06***	(0.01)	-0.08***	(0.01)	-0.10***	(0.01)
Multiple schools	-0.04***	(0.01)	-0.06***	(0.01)	-0.07***	(0.01)
Age in Years	0.11***	(0.01)	0.19***	(0.01)	0.20***	(0.01)
N	88823		83946		77451	
pseudo R-sq.	0.12		0.08		0.07	

Note: Marginal effects coefficients are probabilities of a positive outcome for students in the identified category relative to the comparison group (e.g., public PreK students relative to non-public PreK students), and are estimated with all other variables held at their sample mean. Standard errors (in parentheses) were adjusted based on clustering of students in a given school year. All control variables measured during Kindergarten year. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Participation in public PreK and literacy competence

The second research question was addressed using linear regression models with public PreK status as the predictor variable in each model and students' Kindergarten PALS summary score, reading SOL scaled score in grade 8, and writing SOL scaled score in grade 8 as the outcome variables in three separate models (two additional models were run as a follow-up to examine the link between public PreK participation and proficiency on the reading and writing SOL tests. The analysis was limited to students who were promoted on-time to 8th grade.). Again, student demographic characteristics and background variables as documented in Kindergarten such as gender, socioeconomic status (disadvantaged), English language proficiency (LEP), race, ethnicity, eligibility for Title I funding, disability status, and attendance to multiple schools within the same year were controlled for in each regression model. The models did not evaluate the interaction of public PreK participation and control variables.

Kindergarten PALS. A summary of the regression model looking at the association between participation in public PreK and PALS performance in Kindergarten is found in Table A9. The sample size for this model was 69,642 and accounted for 12% of the variance in the study sample's PALS scores in kindergarten.

Table A9. Public PreK and Fall of Kindergarten PALS Summary Scores

	(1 - ATT RS)		(2 - Overlap RS)	
Public PreK	6.97***	(0.47)	6.28***	(0.43)

Female	4.32***	(0.33)	4.38***	(0.33)
Disadvantaged Status	-6.80***	(0.47)	-6.68***	(0.45)
Limited English Proficiency	-5.17***	(1.34)	-5.64***	(1.33)
Title I Status	-1.07	(0.74)	-1.05	(0.71)
Race/ethnicity				
Black	0.37	(0.56)	0.35	(0.54)
Hispanic	-6.16***	(1.01)	-6.14***	(0.99)
Unknown	-0.56	(1.34)	-0.63	(1.27)
Asian/PI/Haw	6.14***	(1.51)	5.91***	(1.40)
Disability Status	-9.75***	(0.57)	-9.78***	(0.54)
Multiple Schools	-4.02***	(0.77)	-4.03***	(0.73)
Age in Years	11.25***	(0.72)	11.07***	(0.69)
Constant	-8.02*	(4.07)	-6.68	(3.94)
N	69642		69642	
R-sq.	0.12		0.11	

Note: Unstandardized (raw score) coefficients. Standard errors (in parentheses) were adjusted based on clustering of students in Kindergarten year. All control variables measured during Kindergarten year unless otherwise noted. * p<0.05, ** p<0.01, *** p<0.001

For this model, the coefficients represent the relative strength of the contribution by each variable on the outcome variable, Kindergarten PALS score. Looking at the model in Table A9 participating in public PreK is positively associated with performance on the Kindergarten PALS assessment. With a coefficient of 6.97, public PreK students, on average, scored approximately six points higher than their peers not participating in public PreK. Significant associations were also found between control variables and Kindergarten PALS performance, as shown in Table A9.

Eight Grade Reading and Writing SOL Assessments. A summary of the regression models looking at the association between participation in public PreK and performance on the eighth grade reading and writing SOL tests is found in Table A10. The sample size for the reading model was 64,119 and accounted for 11% of the variance in the study sample's reading SOL test scores in the eighth grade. The sample size for the writing model was 64,278 and accounted for 14% of the variance in the study sample's writing SOL test scores in the eighth grade.

Table A10. Public PreK and 8th Grade Reading and Writing SOL Scores

	Reading SOL Score		Writing SOL Score	
Public PreK	-0.28	(0.89)	-0.51	(1.09)
Female	8.44***	(1.02)	22.53***	(1.21)
Disadvantaged Status	-17.65***	(1.08)	-21.49***	(1.22)

Limited English Proficiency	-1.53	(2.66)	-1.20	(2.89)
Title I Status	-7.80***	(1.32)	-6.91***	(1.65)
Race/ethnicity				
Black	-19.48***	(1.46)	-18.86***	(1.57)
Hispanic	-6.40*	(2.68)	-6.52*	(2.69)
Unknown	-8.40*	(3.69)	-6.54	(4.27)
Asian/PI/Haw	20.98***	(3.36)	23.84***	(3.82)
Disability Status	-22.08***	(1.59)	-31.86***	(1.93)
Multiple Schools	-13.64***	(1.89)	-15.24***	(1.76)
Age in Years	-5.03***	(1.42)	-5.53***	(1.53)
Constant	465.25***	(8.13)	465.42***	(8.76)
N	64114		64278	
R-squared	0.108		0.137	

Note: Unstandardized coefficients. Standard errors (in parentheses) were adjusted based on clustering of students in Kindergarten year. All control variables measured during Kindergarten year unless otherwise noted. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Looking across both models in Table A10, participating in public PreK is not significantly associated with 8th graders' performance on the reading or writing SOL assessments. That is, for students who are promoted on-time to 8th grade, there is no association between a student's participation in public PreK and their scaled scores on the eighth grade SOL reading and writing assessments.

Significant associations were found between control variables and both reading and writing SOL performance. Females and Asians, on average, scored better on the eighth grade SOL reading and writing assessments than males and their Caucasian peers. On the other hand, disadvantaged students, students eligible for Title I services, Blacks, Hispanics, students with a disability, and those attending multiple schools did not fare as well as their peers. These particular demographic and background variables are negatively associated with performance on the eighth grade SOL reading and writing assessments.

Two follow-up analyses were then conducted, replacing reading and writing SOL scaled scores with proficiency rates (i.e., whether or not students met state standards). Using the same set of covariates, binary logistic regression models were applied with participation in 'Known Public PreK as the predictor variable in each model and students' proficiency on the 8th grade reading and math SOL tests as the outcome variables in two separate models. Results are reported as marginal effects estimates of the logistic regression results in Table A11. Both models follow the same pattern of findings from the linear regressions with scaled scores; for students who were promoted on-time to 8th grade, participating in public PreK is not significantly associated with meeting proficiency on the eighth grade reading or writing SOL assessments.

Table A11. Marginal Effects of PreK Participation on 8th Grade Reading and Writing SOL Proficiency

	Reading Proficiency		Writing Proficiency	
Public PreK	-0.00	(0.01)	0.00	(0.01)
Female	0.06***	(0.01)	0.16***	(0.01)
Disadvantaged Status	-0.13***	(0.01)	-0.15***	(0.01)
Limited English Proficiency	-0.01	(0.03)	-0.03	(0.03)
Title I Status	-0.08***	(0.01)	-0.05***	(0.01)
Race/ethnicity				
Black	-0.16***	(0.01)	-0.14***	(0.01)
Hispanic	-0.04	(0.03)	-0.01	(0.02)
Unknown	-0.11**	(0.04)	-0.05	(0.04)
Asian/PI/Haw	0.13***	(0.03)	0.13***	(0.03)
Disability Status	-0.17***	(0.02)	-0.19***	(0.01)
Multiple Schools	-0.08***	(0.02)	-0.09***	(0.02)
Age in Years	-0.03**	(0.01)	-0.02*	(0.01)
N	64124		64289	
pseudo R-sq.	0.0529		0.0672	

Note: Marginal effects coefficients are probabilities of a positive outcome for students in the identified category relative to the comparison group (e.g., public PreK students relative to non-public PreK students), and are estimated with all other variables held at their sample mean. Standard errors (in parentheses) were adjusted based on clustering of students in a given school year. All control variables measured during Kindergarten year. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

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Appendix B: *Data Validation Studies*

To provide data that can evaluate the Virginia Preschool Initiative (VPI), VLDS needs to offer the Commonwealth a valid means by which to identify students enrolled in different types of public preschool who later attend public school in Virginia. As of early 2015, there are three potential sources available: PALS-PreK records (since 2008, all localities have used this instrument in VPI); VPI and related school-administered enrollment and attendance records; and parent reports. Data validation studies can help determine source data quality, identify which sources are the most reliable and useful for future VPI evaluations, and provide information for future improvement recommendations.

Methods for Identification of Prekindergarten Attended

PALS-PreK Records
VPI programs across Virginia are required to use fall and spring PALS-PreK through the PALS Office at the University of Virginia (Virginia Department of Education, personal communication, March, 2015). Since 2008, all localities have used PALS PreK in their VPI programs. At least since 2007, codes exist within the PALS-PreK dataset that identify where a student received prekindergarten and the type of program in which he or she was enrolled. These codes are typically reported by VPI coordinators or other school or program administrators to the PALS Office.

School-administered prekindergarten enrollment and attendance records
Schools are required to certify the number of students enrolled in October, March, and at year-end, and to document all students they serve - including prekindergarten - in the Student Record Collection (SRC). These records are therefore available through VLDS. Schools also report attendance and tardiness data throughout students' enrollment period in the SRC; less clear is whether all schools report prekindergarten attendance data.

Parent-reported Prekindergarten Experience Form
In 2006, the Virginia Department of Education asked all local divisions to start collecting information about the type of program that incoming Kindergarteners attended preschool, or to document that they did not attend preschool. Local schools are required to complete two data fields pertaining to this question, one coding for the type of preschool experience (e.g., VPI, Head Start, family child care home, no preschool, and so on) and the other for whether preschool was full or half-day. Parents complete Kindergarten registration forms that includes preschool information.

A primary challenge with all these data sources lies in their unknown level of accuracy. The PALS PreK information is locally reported and not routinely verified. Similarly within the SRC, student-level data

for prekindergarteners are not used for any high stakes purposes (e.g., VPI funding), so their accuracy is not independently verified and their quality is uncertain. Prekindergarten experience forms that parents complete as part of Kindergarten enrollment have many potential sources of error, including parental confusion (many forms rely on Department of Education funding codes, which many parents are unlikely to understand), and interpretation by the school secretary entering data into SRC.

Studies that examine the quality of these data are urgently needed in order to determine whether any, some or all of the prekindergarten experience codes accurately represent children's preschool histories.

Some analyses could be conducted fairly easily and inexpensively. As a first step, the concordance between the different data sources for the same students could be compared. This would likely identify pockets of high and low accuracy and help pinpoint areas for further study. Verification studies the PALS Office conducted for some cohorts might provide accuracy base rates for comparison purposes. If some data sources are better quality than others, those data should be prioritized for future VPI evaluations. If some school divisions routinely provide more accurate information than others, their practices should be described for others to follow.

Other data validation studies may require surveys or otherwise sampling VPI administrators across the state to understand their reporting practices and comparing them to data received reported to the PALS PreK data system and in the Student Record Collection. This may be particularly important in divisions that offer blended prekindergarten classrooms and that administer Head Start programs in addition to VPI.