January 2014

Early Childhood Education for Low-Income Students: A Review of the Evidence and Benefit-Cost Analysis

The 2013 Washington State Legislature directed the Washington State Institute for Public Policy (WSIPP) to review "the research evidence on components of successful early education program strategies" for low-income children.[1] In this report, we present findings from our analysis of early childhood education (ECE) research.

We conducted this analysis by reviewing all credible evaluation studies from the United States and elsewhere. We systematically analyzed the studies to estimate whether various approaches to ECE have a cause-and-effect relationship with outcomes for low-income students. We then calculated whether the long-term monetary benefits of ECE investments outweigh the costs.

Research on ECE programs serving low-income children can provide insight on the effectiveness of Washington's own program, the Early Childhood Education and Assistance Program (ECEAP). The 2013 Legislature also directed WSIPP to "conduct a comprehensive retrospective outcome evaluation and return on investment analysis" of ECEAP. That evaluation will be completed by December 2014. The full legislative direction to WSIPP is in Exhibit 1 (next page).

In this report, we first describe WSIPP's approach to systematic research reviews and benefit-cost analysis. We then highlight our findings on the average effectiveness of ECE for low-income children.[2]

Summary

WSIPP analyzed how various approaches to early childhood education (ECE) for low-income children impact student outcomes and whether benefits exceed costs. We examined three types of programs: state and district pre-kindergarten, the federal Head Start program, and "model" programs.

To investigate, we conducted a systematic review of research by collecting all studies we could find on the topic. We screened for scientific rigor and only analyzed studies with strong research methods.

We identified 49 credible evaluations of whether the three types of ECE for low-income children have a cause-and-effect relationship with student outcomes. The studies in our review measured academic as well as social and emotional development outcomes; a few studies also measured longer term outcomes including crime and teen births.

Our bottom-line findings. Our analysis shows that ECE for low-income children can improve outcomes. In scaled-up state, district, and federal programs, the long-term benefits have a relatively high probability of outweighing program costs. We find that the typical state program outperforms the federal Head Start program, but both have favorable results.

Unfortunately, scientifically rigorous research identifying specific ECE program components critical to producing improved outcomes is scarce. In this report we present preliminary evidence on the association between teacher degree attainment, classroom quality, and student outcomes.

Next steps. As directed by the 2013 Legislature, WSIPP is conducting a retrospective outcome evaluation of Washington State's Early Childhood Education and Assistance Program. Results will be available by December 2014.

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[1] Senate Bill 5904, Laws of 2013.
[2] We focus our analysis on programs for low-income children because Washington's ECEAP primarily serves this population.

I. Research Approach

When WSIPP carries out assignments from the legislature to identify what works (and what does not) in public policy, we implement a three-step research approach.

Step 1: What Works? What Does Not?

In the first research step, we estimate whether various public policies and programs can achieve desired outcomes, such as high school graduation. We carefully analyze all high-quality studies from the United States and elsewhere to identify policy options tried, tested, and found to impact outcomes. We look for research studies with strong evaluation designs and exclude studies with weak research methods.

Our empirical approach then follows a meta-analytic framework to assess systematically all credible evaluations we can locate on a given topic. Given the weight of the evidence, we calculate an average expected effect of a policy on a particular outcome of interest, as well as an estimate of the margin of error for that effect.

Step 2: What Makes Economic Sense?

Next, we insert costs and benefits into the analysis by answering two questions:

- How much would it cost Washington taxpayers to produce the results found in Step 1?
- How much would it be worth to people in Washington State to achieve the improved outcome?

That is, in dollars and cents terms, what are the costs and benefits of each policy option?

Exhibit 1
Legislative Study Direction

The 2013 Washington State Legislature, in Senate Bill 5904, adopted the following study language for WSIPP:

(1) *During the 2013-2015 biennium, the Washington state institute for public policy shall conduct a comprehensive retrospective outcome evaluation and return on investment analysis of the early childhood program established in RCW 43.215.400. To the extent possible based on data availability, the evaluation must:*

   a) *Assess both short-term and long-term outcomes for participants in the program, including educational and social outcomes;*

   b) *Examine the impact of variables including, but not limited to, program fiscal support, staff salaries, staff retention, education level of staff, full-day programming, half-day programming, and classroom size on short-term and long-term outcomes for program participants;*

   c) *Report findings from a review of the research evidence on components of successful early education program strategies;*

   d) *Examine characteristics of parents participating in the early childhood and education assistance program; and*

   e) *Examine family support services provided through early childhood programs.*

(2) *The institute shall submit a report to the appropriate committees of the legislature by December 15, 2014.*

This report focuses on section (1)(c) of the study direction. A December 2014 report will address the remainder of the study assignment.

To answer these questions, we developed, and continue to refine, an economic model that estimates benefits and costs. The model provides an internally consistent monetary valuation so that policy options can be compared on an apples-to-apples basis. Our benefit-cost results include standard financial statistics: net present values and benefit-cost ratios.

We present monetary estimates from three perspectives:

a) program participants,
b) taxpayers, and
c) other people in society (for example, we estimate "spillover" effects to society of increases in education).[3]

The sum of the three perspectives provides a "total Washington" view on whether a policy or program produces benefits that exceed costs.

Step 3: What is the Risk in the Benefit-Cost Findings?

Any tabulation of benefits and costs involves some degree of risk about the estimates calculated. This is expected in any investment analysis, whether in the private or public sector. To assess the riskiness of our conclusions, we perform a "Monte Carlo simulation" in which we vary the key factors in our calculations. The purpose of the risk analysis is to determine the odds that a particular policy option will at least break even.

Thus, for each option analyzed, we produce two "big picture" findings: expected benefit-cost results and, given our understanding of the risks involved, the odds that the policy will at least have benefits that are greater than the costs. Readers interested in an in-depth description of the research methods for these three steps can reference our Technical Manual.[4] A summary Technical Appendix is included at the end of this report.

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[3] McMahon, M. (2010). "The external benefits of education." In Brewer, D.J., & McEwan, P.J. eds. *Economics of education.* Oxford, UK: Academic Press.

[4] Washington State Institute for Public Policy, (2013). *Benefit-cost technical manual: Methods and user guide.* (Doc. No. 13-09-1201b). Olympia, WA: Author.

II. Early Childhood Education for Low-Income Children

The impact of ECE for low-income children has been studied since the 1960s when model programs such as Perry Preschool and Head Start demonstration programs were initiated.

As of 2011, 40 state governments and Washington, D.C. funded ECE—in most cases for low-income children, and in a few, for all children within the state.[5] Other low-income children receive federally funded preschool through Head Start.

In Washington State, low-income students are served by two publicly funded ECE programs: Head Start and the state-funded program, ECEAP.

In 2011, Head Start funded slots for 12,336 three- and four-year-old children in Washington State.[6] Children are eligible for Head Start if their family's income is at or below 130% of the federal poverty level, the child has special needs, or the family has environmental risk factors (such as homelessness, foster care, child welfare system involvement, or receiving Temporary Assistance for Needy Families).[7]

Through ECEAP, Washington State has provided ECE to low-income children since 1985.[8] Eligibility requirements for ECEAP are similar to Head Start—family income at or less than 110%

of federal poverty level, the child has special needs, or the family has environmental risk factors. In 2011, the state funded 8,391 ECEAP slots.[9]

Whether students attend ECEAP or Head Start depends on eligibility and local provider decisions. In 2010, about 18,600 ECEAP-eligible children in Washington State were not enrolled in either Head Start or ECEAP.[10]

WSIPP has previously published findings on ECE programs for low-income three- and four-year-old children. In April 2012, we found that ECE for low-income children had a relatively high likelihood of a positive return on investment.[11] This report updates our prior analysis with recent literature including new evaluations of state pre-kindergarten programs.

To focus our analysis on the legislative assignment (the effect of Washington State's program), we separated the research into three categories (described in Exhibit 2):

- state and district programs,
- Head Start, and
- model programs.

Our previous analysis combined these three categories into one statement about ECE for low-income children. This report focuses on the research most pertinent to ECEAP—state and district pre-kindergarten programs. We also include benefit-cost results for Head Start, which serves many children in Washington State.

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[5] Florida, Georgia, Oklahoma, West Virginia, and D.C. offer "universal" preschool for all students, regardless of income level throughout the state. Barnett, W. S., Carolan, M. E., Fitzgerald, J., & Squires, J. H. (2012). *The state of preschool 2012: State preschool yearbook.* New Brunswick, NJ: National Institute for Early Education Research.

[6] Including Region X Head Start, American Indian/Alaska Native Head Start and Migrant and Seasonal Head Start.

[7] Washington State Department of Early Learning. (2012). *Early Childhood Education and Assistance Program, Head Start and Early Head Start in Washington State.* Retrieved from http://www.del.wa.gov/publications/partnerships/docs/ECEAP_HS_Profile_2012.pdf

[8] RCW 43.215.400

[9] Washington State Department of Early Learning, (2012).

[10] Ibid.

[11] Lee, S., Aos, S., Drake, E., Pennucci, A., Miller, M., & Anderson, L. (2012) *Return on investment: Evidence-based options to improve statewide outcomes, April 2012 (Doc. No. 12-04-1201)* [Technical Appendix I: Detailed Tables]. *Olympia: Washington State Institute for Public Policy.*

Exhibit 2

Description of Early Childhood Education Programs for Low-Income Children

<u>State and District Pre-kindergarten</u>
The structure and funding of state and district programs varies. In Washington State, ECEAP provides $6,812 per child; this amount is similar to average funding in ten states included in the evaluation literature ($6,305).* ECEAP currently meets nine out of ten benchmarks of quality rated by Rutgers Graduate School of Education's National Institute for Early Education Research.[#] The benchmarks measure program factors such as education requirements for teachers and assistants, maximum class size, and health screening. The average rating is 7.4 out of 10 for the state programs included in our meta-analysis.

<u>Head Start</u>
Head Start is a nationally funded ECE program for low-income children administered by local grantees that adhere to national program guidelines. Head Start services can be classroom-based, home-based, or a combination of the two. Head Start funding and program guidelines have changed over time. Currently, average funding for Head Start ($9,332 per child) is higher than ECEAP, and Head Start provides more classroom hours per year than ECEAP (448 hours compared with 320 hours). Both Head Start and ECEAP require teachers to have at least an associate's degree in early childhood education, provide health and dental screening, and offer family support services.

<u>Model Programs</u>
The model programs in the research literature were generally small programs implemented in the 1960s and 1970s with highly trained teachers, a consistent curriculum, and oversight by the program developer. Many studies included in our analysis were of two well-known and often-cited model programs: Perry Preschool and the Abcedarian Project. Perry Preschool provided two years of half-day preschool with weekly home visits to most participants. The Abcedarian Project provided year-round full-day early childhood education to students from birth to age five.

* Washington State Department of Early Learning. (2013). Early Childhood Education and Assistance Program (2013 Legislative Briefing Paper). Retrieved from http://del.wa.gov/publications/laws/docs/Legislative_briefing_ECEAP_2013.pdf; Costs include funds distributed to grantees as well as Department of Early Learning costs and are expressed in 2012 dollars.
[#] Barnett et al.,(2012).

In addition to examining average program impacts in this updated report, we investigate ECE program factors including teachers' education and classroom quality.

Meta-Analysis Findings

We identified 49 scientifically rigorous studies that compared outcomes of students who attended a specific preschool program to those who did not.[12] The studies measured several outcomes that we can link to benefits and costs, including standardized test scores, high school graduation, grade retention, special education services, crime, and teen births.

We also examined two measures of social and emotional learning: self-regulation and emotional development. Although we do not, at the present time, have sufficient data to link these outcomes to monetary benefits and costs, the topic is a growing area of research and of

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[12] Citations to the studies are at the end of this report.

Exhibit 3

Meta-Analytic Results: Early Childhood Education for Low-Income Three- and Four-Year Olds
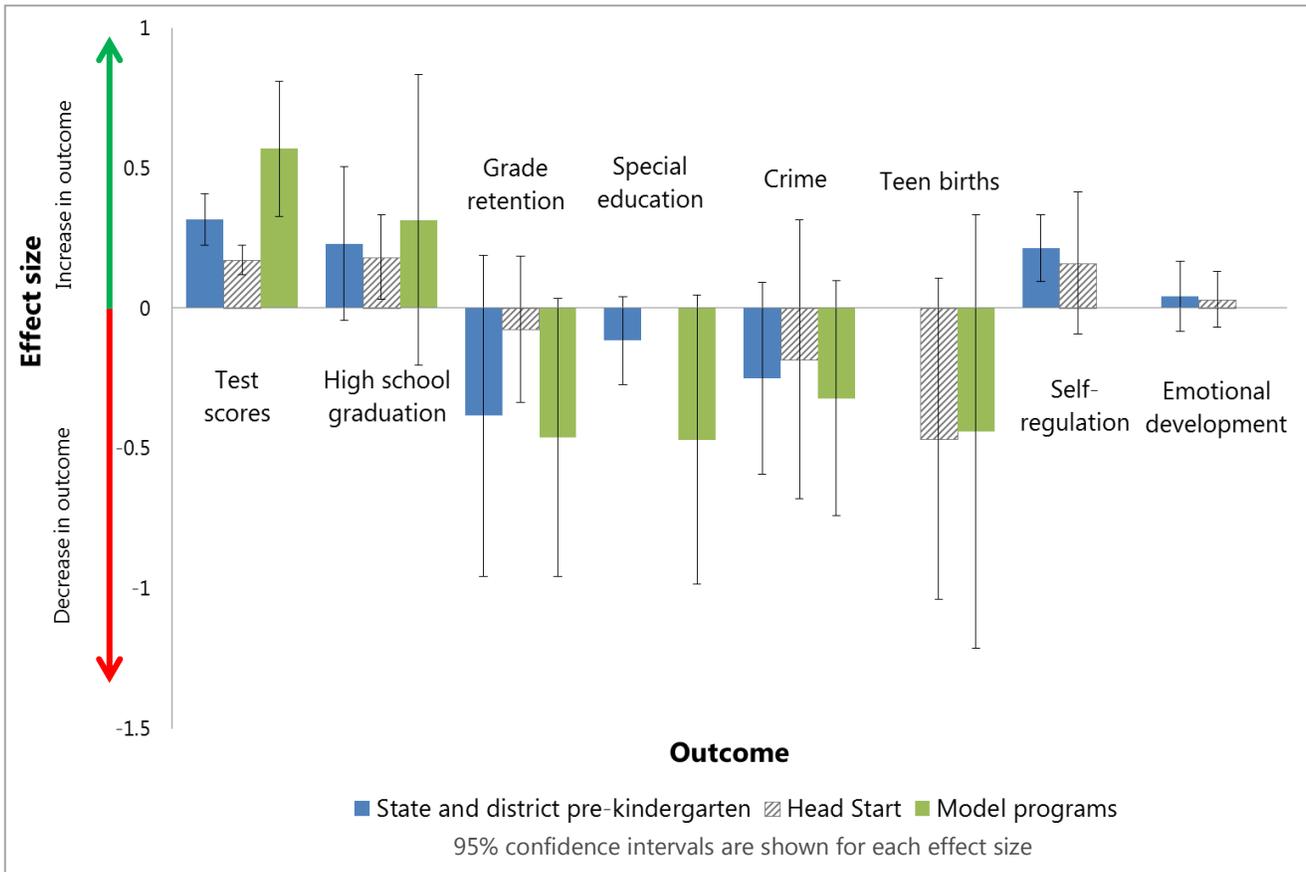
interest to the legislature and educators.[13] As consensus emerges on this topic using consistent measures of "non-cognitive" skills, WSIPP's benefit-cost model will be updated to incorporate these outcomes.

In Exhibit 3 we present average effect sizes for the three types of pre-kindergarten for low-

income students. All three—state and district, Head Start, and model programs—have statistically significant positive impacts on test scores immediately after preschool.[14]

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[13] Recent studies investigate the association between social and emotional skills in adolescence and future earnings. Duckworth, K., Duncan, G. J., Kokko, K., Lyyra, A., Metzger, M., & Simonton, S. (2012). *The relative importance of adolescent skills and behaviors for adult earnings: A cross-national Study* (DoQSS Working Paper No. 12-03). Retrieved from http://repec.ioe.ac.uk/repec/pdf/qsswp1203.pdf; Heckman, J. J., Stixrud, J., & Urzua, S. (2006). *The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior* (NBER Working Paper 12006). Retrieved from http://www.nber.org/papers/w12006

[14] In some studies academic gains in pre-kindergarten are not sustained. For example, the recent random assignment study of Head Start found few significant increases in academic test scores in first and third grade. Our analysis includes this random assignment study as well as other rigorous quasi-experimental studies of Head Start. The benefit-cost analysis uses estimates of test scores at the end of high school were calculated using WSIPP's model of test score fadeout described in section A2 of the Technical Appendix. Puma, M., Bell, S., Cook, R., Heid, C., Broene, P., Jenkins, F., Mashburn, A., & Downer, J. (2012) *Third Grade Follow-Up to the Head Start Impact Study: Final Report* (OPRE Report 2012-45). Washington, DC: U.S. Department of Health and Human Services; Hill, C. J., Gormley, W. T., & Adelstein, S. (2012) Do short term effects of a strong preschool program persist? (Center for Research on Children in the U.S. Working Paper). Retrieved from http://www.crocus.georgetown.edu/reports/CROCUSWorkingPaper18.pdf

Since a small number of studies measured outcomes such as high school graduation, grade retention, special education services, crime, and teen births, there is a larger degree of uncertainty around these effect sizes. Still, ECE programs for low-income children have beneficial effects, on average. High school graduation rates increase and we found decreases in grade retention, special education, crime, and teen births.

We also found positive impacts on self-regulation and emotional development in the few studies that measured these outcomes immediately after preschool.

Benefit-Cost Analysis Findings

We conducted a benefit-cost analysis for state and district ECE programs for low-income children as well as for the federal Head Start

program.[15] The bottom-line results are presented in Exhibit 4. In December 2014, when we have evaluation results for Washington State's ECEAP, we will replicate this analysis with those findings, as directed by SB 5904.

Benefits. We estimate that the total life-cycle, net present value per-participant benefits from state and district ECE programs are $29,210, on average. The monetary benefits accrue from increases in labor market earnings, lower K–12 education and criminal justice system expenditures, and lower health care costs. For Head Start, we estimate the per-participant benefits to be $22,452.

Costs. We used per-student funding levels for Washington State's ECEAP program to represent state and district pre-kindergarten costs. Since attending preschool might impact the need for child care, we also included

Exhibit 4

Benefit-Cost Results: Early Childhood Education Programs for Low-Income Three- and Four-Year-Olds

	Benefits	Costs	Benefits minus costs (net present value)	Benefit to cost ratio	Odds of a positive net present value
State and district programs	$29,210	$6,974	$22,236	$4.20	91%
Head Start	$22,452	$8,564	$13,888	$2.63	89%

The estimates are present-value, life-cycle benefits and costs expressed in 2012 dollars.

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[15] We did not perform a benefit-cost analysis on model programs such as Perry Preschool and the Abcedarian Project. These interventions are not particularly relevant to the Washington Legislature because they were small scale programs with intensive services that were implemented in the 1960s and 1970s, a time when many children received no preschool. Benefit-cost analyses on these model programs have been conducted by other researchers, see e.g., Heckman, J. J., Moon, S. H., Pinto, R. Savelyev, P. A., & Yavitz, A. (2010). The rate of return to the High Scope Perry Preschool Program. *Journal of Public Economics. 94*(1), 114-128; and Barnett, W. S., & Masse, L. N. (2007). Comparative benefit–cost analysis of the Abecedarian program and its policy implications. Economics of Education Review, 26(1), 113-125.

state-funded childcare subsidies issued to children who attended ECEAP and similar children who did not attend the program. The net costs of ECE and child care assistance are $6,974 per student who attended ECEAP; the figure is $8,564 for Head Start. A detailed description of program costs and benefits are in the Technical Appendix.

Benefit-Cost Statistics. State and district public preschool programs have an expected net present value of $22,236 per student. We estimate returns of approximately $4 for every dollar invested in these programs. The level of investment risk is relatively low; we find that there is a 91% chance that the investment at least breaks even.

Head Start has a positive expected net present value of $13,888. We estimate returns on investment of $2.63 for every dollar invested in Head Start, with an 89% chance that the investment at least breaks even.

Preliminary Evidence on Program Components

In addition to examining average outcomes for low-income children in ECE, we reviewed scientifically rigorous studies that examine the relationship between program components and student outcomes.

We conducted a literature review of studies that investigate ECE per-pupil funding, staff salaries, staff retention, class size, child-to-teacher ratio, length of instructional day, teacher education levels, and classroom quality. WSIPP has previously analyzed how some of these program components impact student outcomes in the K–12 school system.[16] For early childhood education, we located a sufficient

number of rigorous studies to conduct meta-analyses on only two of these topics: teacher education and classroom quality.

For teacher education, we analyzed rigorous research on the association between teachers having a bachelor's degree (BA) or higher and student test scores. We located ten studies on this topic and estimated a relatively small positive, but not statistically significant, impact. It is important to note that the impact of a BA might interact with other policy-relevant factors such as the content of teacher training programs, salary levels, and local labor market conditions.[17]

We also reviewed studies with strong research designs that investigate the relationship between standardized measures of classroom quality and student outcomes. We focused our analysis on the most commonly reported measure of quality—the total score from the Early Childhood Environment Rating Scale (ECERS-R).[18] We located four rigorous studies and found a relatively small, positive association between a one-point increase on the ECERS-R and student test scores. The Technical Appendix provides additional detail.

[16] Kay, N. & Pennucci, A. (2014). *Full-day kindergarten: A review of the evidence and benefit-cost analysis* (Doc. No. 14-1-2202). Olympia: Washington State Institute for Public Policy; Aos, S. & Pennucci, A. (2013). *K–12 class size reductions and student outcomes: A review of the evidence and benefit-cost analysis* (Doc.

No. 13-01-2201). Olympia: Washington State Institute for Public Policy; Aos, S. & Pennucci, A. (2012). *K–12 Education spending and student outcomes: A review of the evidence*. (Doc. No. 12-10-2201). Olympia: Washington State Institute for Public Policy; Pennucci, A. (2012). *Teacher compensation and training policies: Impacts on student outcomes*. (Doc. No. 12-05-2201). Olympia: Washington State Institute for Public Policy

[17] Whitebrook, M. & Ryan, S. (2011, April). *Degrees in context: Asking the right questions about preparing skilled and effective teachers of young children* (National Institute of Early Education Research Preschool Policy Brief). Retrieved from http://nieer.org/resources/policybriefs/23.pdf

[18] We did not find enough studies using other measures of quality such as the Classroom Assessment Scoring System (CLASS) to analyze using meta-analysis.

III. Conclusions

Research on early childhood education for low-income three- and four-year-olds consistently finds positive impacts on short- and long-term student outcomes. For scaled-up public programs, the monetary benefits outweigh program costs with a relatively low investment risk.

As noted, the 2013 Legislature directed WSIPP to review research evidence on components of successful early education program strategies.

Unfortunately, scientifically rigorous research identifying specific ECE program components critical to producing improved outcomes is scarce. We found preliminary evidence to suggest that teacher education levels and standardized measures of classroom quality are associated with small increases in student test scores immediately following preschool. We have not yet developed a method to estimate costs associated with these program components.

Technical Appendix

Early Childhood Education for Low-income Students: A Review of the Evidence and Benefit-Cost Analysis

A1. Meta-Analysis Methodology

A1a. Study Selection and Coding Criteria

A meta-analysis is only as good as the selection and coding criteria used to conduct the study.[19] Following are the key choices we made and implemented for this study.

Study Selection. We use four primary means to locate studies for meta-analysis of programs: (1) we consult the bibliographies of systematic and narrative reviews of the research literature in the various topic areas; (2) we examine the citations in the individual studies themselves; (3) we conduct independent literature searches of research databases using search engines such as Google, Proquest, Ebsco, ERIC, PubMed, and SAGE; and (4) we contact authors of primary research to learn about ongoing or unpublished evaluation work. After first identifying all possible studies via these search methods, we attempt to determine whether the study is an outcome evaluation that has a valid comparison group. If a study meets this criterion, we secure a full copy of the study for our review.

Peer-Reviewed and Other Studies. We examine all evaluation studies we can locate with these search procedures. Many studies are published in peer-reviewed academic journals while others are from reports obtained from the agencies themselves. It is important to include non-peer reviewed studies because it has been suggested that peer-reviewed publications may be biased to show positive program effects. Therefore, our meta-analysis includes all available studies that meet our other criteria, regardless of publication source.

Control and Comparison Group Studies. Our analysis only includes studies that have a control or comparison group or use a quasi-experimental design such as regression discontinuity with multiple statistical controls. We do not include studies with a single-group, pre-post research design. This choice was made because it is only through rigorous studies that causal relationships can be reliably estimated.

Random Assignment and Quasi-Experiments. Random assignment studies are preferred for inclusion in our review, but we also include non-randomly assigned comparison groups. We only include quasi-experimental studies if sufficient information is provided to demonstrate comparability between the treatment and comparison groups on important pre-existing conditions such as age, gender, and pre-treatment characteristics such as test scores.

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[19] All studies used in the meta-analysis are identified in the references to this paper. Many other studies were reviewed but did not meet the criteria set for this analysis.

Enough Information to Calculate an Effect Size. Following the statistical procedures in Lipsey and Wilson, a study has to provide the necessary information to calculate an effect size. [20] If the necessary information is not provided, and we are unable to obtain the necessary information directly from the study's author(s), the study is not included in our review.

Mean-Difference Effect Sizes. For this study, we code mean-difference effect sizes for continuous measures following the procedures outlined in Lipsey and Wilson.[21] For dichotomous measures, we use the d-Cox transformation to approximate the mean difference effect size, as described in Sánchez-Meca, Marín-Martínez, and Chacón-Moscoso.[22] We choose to use the mean-difference effect size rather than the odds ratio effect size because we frequently code both dichotomous and continuous outcomes (odds ratio effect sizes could also be used with appropriate transformations).

Outcome Measures of Interest. In this analysis we are interested in academic achievement, long-term outcomes, and social and emotional learning. We include standardized, validated assessments of student learning. Reading and math test scores are the most frequently measured outcomes. We also include measures of grade retention, special education services, high school graduation, crime, and teen births when available.

The methods for measuring social and emotional learning vary in the studies we reviewed. We include measures based on validated instruments used by teachers and parents to assess students such as the Child Behavior Checklist, Adaptive Social Behavior Inventory, and Adjustment Scales for Preschool Intervention. The instruments used in the studies measure a range of underlying constructs of "social and emotional learning" including attention, working memory, externalizing behaviors, and internalizing behaviors. While some studies report these constructs separately, others report a summary score or use factor analysis to report correlated behaviors. We examine effect sizes for two broad categories of social and emotional learning: self-regulation and emotional development. Self-regulation includes measures of impulse control, ability to sustain focus, attention shifting, and working memory. Emotional development includes positive social development, emotion recognition, absence of internalizing behavior, and absence of externalizing behavior. Studies that report a summary measure combining aspects of both self-regulation and emotional development are not included in this analysis.

Previously, WSIPP included the outcomes of child abuse and neglect and out-of-home placement in our analysis of ECE programs. Those results, however, were based on only one program, the Chicago Child-Parent Centers (CCPC). This program has features such as comprehensive services, parent outreach and an early elementary school-age program, which not all state and district pre-kindergarten programs provide. Since no other study measured these outcomes, we do not have evidence that non-CCPC programs would also impact child abuse and neglect or out-of-home placement. For this reason we do not include the outcomes of child abuse and neglect or out-of-home placement in the current meta-analysis and benefit-cost analysis.

Program Types. For this study we conduct separate meta-analyses for three types of ECE programs: state and district pre-kindergarten, Head Start, and model programs. We conduct separate meta-analyses in order to examine the impact of each strategy.

In previous meta-analyses of ECE, WSIPP included studies that used survey data to evaluate the impact of attending any preschool program. While many of these studies are scientifically rigorous, we cannot describe the type of ECE programs that were evaluated. Since these programs could not be categorized as state and district

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[20] Lipsey, M. W. & Wilson, D. B. (2001). *Practical meta-analysis* (Vol. 49). Thousand Oaks, CA: Sage.
[21] Ibid.
[22] Sánchez-Meca, J., Marín-Martínez, F., & Chacón-Moscoso, S. (2003). Effect-size indices for dichotomized outcomes in meta-analysis. *Psychological Methods*, *8*(4), 448-467.

pre-kindergarten, Head Start, or model programs, we do not include them in the analysis. We did, however, use these studies to model test score fadeout (see Appendix A2).

A1b. Procedures for Calculating Effect Sizes

Effect sizes summarize the degree to which a program or policy affects an outcome. In experimental settings this involves comparing the outcomes of treated participants relative to untreated participants. Several methods are used by analysts to calculate effect sizes, as described in Lipsey and Wilson.[23] The most common effect size statistic is the standardized mean difference effect size—that is the measure we use in this analysis.

Weighted Mean Different Effect Size. The mean difference effect size is designed to accommodate continuous outcome data, such as student test scores, where the differences are in the means of the outcome.[24] The standardized mean difference effect size is computed with:

$$(1)\ ES = \frac{M_t - M_c}{\sqrt{\dfrac{(N_t - 1)SD_t^2 + (N_c - 1)SD_c^2}{N_t + N_c - 2}}}$$

In this formula, ES is the estimated effect size for a particular program; M_t is the mean value of an outcome for the treatment or experimental group; M_c is the mean value of an outcome for the control group; SD_t is the standard deviation of the treatment group; and SD_c is the standard deviation of the control group; N_t is the number of subjects in the treatment group; and N_c is the number of subjects in the control group. The variance of the mean difference effect size statistic in (1) is computed with:[25]

$$(2)\ ESVar = \frac{N_t + N_c}{N_t N_c} + \frac{ES^2}{2(N_t + N_c)}$$

In some random assignment studies or studies where treatment and comparison groups are well-matched, authors provide only statistical results from a t-test. In those cases, we calculate the mean difference effect size using:[26]

$$(3)\ ES = t\sqrt{\frac{N_t + N_c}{N_t N_c}}$$

In many research studies, the numerator in (equation 1), $M_t - M_c$, is obtained from a coefficient in a regression equation, not from experimental studies of separate treatment and control groups. For such studies, the denominator in (equation 1) is the standard deviation for the entire sample. In these types of regression studies, unless information is presented that allows the number of subjects in the treatment condition to be separated from the total number in a regression analysis, the total N from the regression is used for the sum of N_t and N_c, and the product term $N_t N_c$ is set to equal $(N/2)^2$.

Pre/Post Measures. When authors report pre- and post-treatment measures without other statistical adjustments, we start by calculating two between-groups effect sizes: (a) at pre-treatment and (b) at post-treatment. Then, we calculate the overall effect size by subtracting the post-treatment effect size from the pre-treatment effect size.

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[23] Lipsey & Wilson, (2001).
[24] Ibid, Table B10, equation 1, p. 198.
[25] Ibid, Table 3.2, p. 72.
[26] Ibid, Table B10, equation 2, p. 198.

Adjusting Effect Sizes for Small Samples. Since some studies have very small sample sizes, we follow the recommendation of many meta-analysts and adjust for this. Small sample sizes have been shown to upwardly bias effect sizes, especially when samples are less than 20. Following Hedges,[27] Lipsey and Wilson[28] report the "Hedges correction factor," which we use to adjust all mean-difference effect sizes (where N is the total sample size of the combined treatment and comparison groups):

$$(4)\ ES'_m = \left[1 - \frac{3}{4N - 9}\right] * ES_m$$

Adjusting Effect Sizes and Variances for Multi-Level Data Structures. Most studies in the education field use data that are hierarchical in nature. That is, students are clustered in classrooms, classrooms are clustered within schools, schools are clustered within districts, and districts are clustered within states. Analyses that do not account for clustering will underestimate the variance in outcomes at the student level (the denominator in (equation 1) and, thus, may over-estimate the precision of magnitude on effect sizes). In studies that do not account for clustering, effect sizes and their variance require additional adjustments.[29] There are two types of studies, each requiring a different set of adjustments.[30] First, for student-level studies that ignore the variance due to clustering, we make adjustments to the mean effect size and its variance,

$$(5)\ ES_T = ES_m * \sqrt{1 - \frac{2(n - 1)\rho}{N - 2}}$$

$$(6)\ V\{ES_T\} = \left(\frac{N_t + N_c}{N_t N_c}\right)[1 + (n - 1)\rho] + ES_T{}^2 \left(\frac{(N - 2)(1 - \rho)^2 + n(N - 2n)\rho^2 + 2(N - 2n)\rho(1 - \rho)}{2(N - 2)[(N - 2) - 2(n - 1)\rho]}\right)$$

Where ρ is the intraclass correlation, the ratio of the variance between clusters to the total variance; N is the total number of individuals in the treatment group, N_t, and the comparison group, N_c; and n is the average number of persons in a cluster, K. In the educational field, clusters can be classes, schools, or districts. We used 2006 Washington Assessment of Student Learning (WASL) data to calculate values of ρ for the school-level ($\rho = 0.114$) and the district level ($\rho = 0.052$). Class-level data were not available, so we use a value of $\rho = 0.200$ for class-level studies.

Second, for studies that report means and standard deviations at a cluster level, we make adjustments to the mean effect size and its variance:

$$(7)\ ES_T = ES_m * \sqrt{\frac{1 + (n - 1)\rho}{n\rho}} * \sqrt{\rho}$$

$$(8)\ v\{ES_T\} = \left\{\left(\frac{N_t - N_c}{N_t N_c}\right) * \left(\frac{1 + (n - 1)\rho}{n\rho}\right) + \frac{[1 + (n - 1)\rho]^2 * ES_T{}^2}{2n\rho(K - 2)}\right\} * \rho$$

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[27] Hedges, L. V. (1981). Distribution theory for Glass's estimator of effect size and related estimators. *Journal of Educational Statistics, 6*(2), 107-128.

[28] Lipsey & Wilson, (2001), equation 3.22, p. 49.

[29] Studies that employ hierarchical linear modeling, fixed effects with robust standard errors, or random effects models account for variance and need no further adjustment for computing the effect size, but adjustments are made to the inverse variance weights for meta-analysis using these methods.

[30] These formulas are taken from: Hedges, L. (2007). Effect sizes in cluster-randomized designs. *Journal of Educational and Behavioral Statistics, 32*(4), 341-370.

We do not adjust effect sizes in studies reporting dichotomous outcomes. This is because the d-Cox transformation assumes the entire normal distribution at the student level.[31] However, when outcomes are dichotomous, or an effect size is calculated from studies where authors control for clustering with robust standard errors or hierarchical linear modeling, we use the "design effect" to calculate the "effective sample size."[32] The design effect is given by:

$$(9) \ D = 1 + (n - 1)\rho$$

The effective sample size is the actual sample size divided by the design effect. For example, the effective sample size for the treatment group is:

$$(10) \ N_{t(eff)} = \frac{N_t}{D}$$

Adjusting Effect Sizes for Study Design, Research Involvement, Study Setting and Control Group

In this report we show the "adjusted effect sizes" that we use in our benefit-cost analysis. These adjusted effect sizes, which are derived from the unadjusted results, may be smaller, larger, or equal to the unadjusted effect sizes. In this analysis we considered adjusting effect sizes for the following reasons: research design, researcher involvement in the intervention, and laboratory (not "real world") settings. For a full description of the rationale for these adjustments see the WSIPP Technical Manual.[33]

Additionally, we considered the impact of the preschool experience of the control group on the effect size of ECE programs. The preschool experience of the control groups used in evaluations ECE programs varied widely. Many control groups had preschool experience other than the intervention of interest; often the preschool experience of the control group is unknown. Since it is possible that using a control group composed of children who attended a different preschool program may yield systematically different effect sizes than using a control group composed of children with no preschool experience, we controlled for this variable in a meta-regression to assess whether the adjusted effect size should account for this difference.

For ECE programs for low-income three- and four-year-olds, we performed a meta-regression of all effect sizes controlling for research design, researcher involvement, laboratory setting, and control groups with no preschool experience. As in our 2011 analysis, we found no statistically significant differences based on these attributes and, therefore, used the unadjusted effect sizes as the adjusted effect sizes in our benefit-cost analysis.

Computing Weighted Average Effect Sizes, Confidence Intervals, and Homogeneity Tests. Once effect sizes are calculated for each program effect, and any necessary adjustments for clustering are made, the individual measures are summed to produce a weighted average effect size for a program area. We calculate the inverse variance weight for each program effect and these weights are used to compute the average. These calculations involve three steps. First, the standard error, SE_T of each mean effect size is computed with:[34]

$$(11) \ SE_T = \sqrt{\frac{N_t + N_c}{N_t N_c} + \frac{ES^2}{2(N_t + N_c)}}$$

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[31] Mark Lipsey (personal communication, November 11, 2007).
[32] Formulas for design effect and effective sample size were obtained from the Cochrane Reviewers Handbook, section 16.3.4, Approximate analyses of cluster-randomized trials for a meta-analysis: effective sample sizes. http://handbook.cochrane.org/
[33] Washington State Institute for Public Policy, (2013).
[34] Lipsey & Wilson, (2001), equation 3.23, p. 49.

Next, the inverse variance weight w is computed for each mean effect size with:[35]

$$(12) \; w = \frac{1}{SE_T^2}$$

The weighted mean effect size for a group with i studies is computed with:[36]

$$(13) \; \overline{ES} = \frac{\sum(w_i ES_{T_i})}{\sum w_i}$$

Confidence intervals around this mean are then computed by first calculating the standard error of the mean with:[37]

$$(14) \; SE_{\overline{ES}} = \sqrt{\frac{1}{\sum w_i}}$$

Next, the lower, ES_L, and upper limits, ES_U, of the confidence interval are computed with:[38]

$$(15) \; \overline{ES_L} = \overline{ES} - z_{(1-\alpha)}\left(SE_{\overline{ES}}\right)$$

$$(16) \; \overline{ES_U} = \overline{ES} + z_{(1-\alpha)}\left(SE_{\overline{ES}}\right)$$

In equations (15) and (16), $z_{(1-\alpha)}$ is the critical value for the z-distribution (1.96 for α = .05). The test for homogeneity, which provides a measure of the dispersion of the effect sizes around their mean, is given by:[39]

$$(17) \; Q_i = \left(\sum w_i ES_i^2\right) - \frac{\left(\sum w_i ES_i^2\right)}{\sum w_i}$$

The Q-test is distributed as a chi-square with k-1 degrees of freedom (where k is the number of effect sizes).

Computing Random Effects Weighted Average Effect Sizes and Confidence Intervals. Next, a random effects model is used to calculate the weighted average effect size. Random effects models allow us to account for between-study variance in addition to within-study variance.[40] This is accomplished by first calculating the random effects variance component, v:[41]

$$(18) \; v = \frac{Q_i - (k-1)}{\sum w_i - (\sum wsq_i / \sum w_i)}$$

Where wsq_i is the square of the weight of ES_i. This random variance factor is then added to the variance of each effect size and finally all inverse variance weights are recomputed, as are the other meta-analytic test statistics. If the value of Q is less than the degrees of freedom (k-1), there is no excess variation between studies and the initial variance estimate is used.

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[35] Ibid., equation 3.24, p. 49.
[36] Ibid., p. 114.
[37] Ibid.
[38] Ibid.
[39] Ibid., p. 116.
[40] Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research Synthesis Methods, 1*(2), 97-111.
[41] Ibid., p. 134.

A2. Adjustment Factors for Decaying Test Score Effect Sizes

The magnitude of gains in standardized test scores of children who participate in ECE does not remain constant over time. Researchers have found that test score gains from program participation get smaller (the test scores "fade out") as years pass after the intervention.[42]

As noted in Appendix A1, for the fadeout analysis we include studies that use survey data to evaluate the impact of attending any preschool program in addition to the studies that evaluate state and district, Head Start, and model programs. The follow-up periods for test score measures in the 59 studies we analyzed varied widely. Since the relationships in the economic literature between test scores and labor market earnings are based on test scores late in high school, it is critical to adjust earlier measurements of test scores appropriately.

We conducted meta-analyses of effect sizes from these 59 studies covering four periods of time after the early childhood intervention: immediately after preschool, kindergarten-2nd grade, 3rd-5th grade, and 6th-9th grade (Exhibit A1). We included both IQ tests and standardized academic tests from specific program evaluations and national surveys.

Exhibit A1
Meta-Analytic Results at Four Time Periods

Time of measurement	Number of effect sizes	Average time since the beginning of preschool (years)	Average effect size	Standard error
Immediately after preschool	37	1	0.309	0.030
Kindergarten-2nd grade	38	2.9	0.152	0.019
3rd-5th grade	29	5.7	0.097	0.014
6th-9th grade	12	9.4	0.085	0.033

The meta-analytic results suggest a non-linear relationship between the effect size and the time since the intervention. We tested the following models to fit a trend line to the data: quadratic, cubic, logarithmic, and power. A power curve provided the best combination fit (R^2=0.98) and a believable pattern of decay (Exhibit A2). The decrease in effect size by 3rd-5th grade was similar to that found by Camilli et al. (2010).[43] We used the power curve model to estimate the effect sizes through grade 12. We also modeled the relationship between the effect size and the time since the intervention using meta-regression. However, various model specifications led to notably different intercepts, thus we opted to use the meta-analytic results to model fadeout.

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[42] For example, a meta-analysis by Leak et al. (2010) found that early test score gains decreased by at least 54% five or more years after the post-test; another meta-analysis by Camilli et al. (2010) estimated that early test score gains fade out by more than 50% by age 10; and Goodman & Sianesi (2005) examined fade-out for a single evaluation and found that early test score gains decreased by 30 to 50% per follow-up period. Leak, J., Duncan, G., Li, W., Magnuson, K., Schindler, H., & Yoshikawa H. (2010). *Is timing everything? How early childhood education program impacts vary by starting age, program duration, and time since the end of the program.* Paper prepared for presentation at the meeting of the Association for Policy Analysis and Management, Boston, MA; Camilli, G., Vargas, S., Ryan, S., & Barnett W. S. (2010). Meta-analysis of the effects of early education interventions on cognitive and social development. *Teachers College Record, 112*(3), 579-620; Goodman, A. & Sianesi, B. (2005). Early education and children's outcomes: How long do the impacts last? *Fiscal Studies, 26*(4), 513-548.
[43] Camilli et al., (2010).

Exhibit A2

Estimation of Test Score Fadeout:

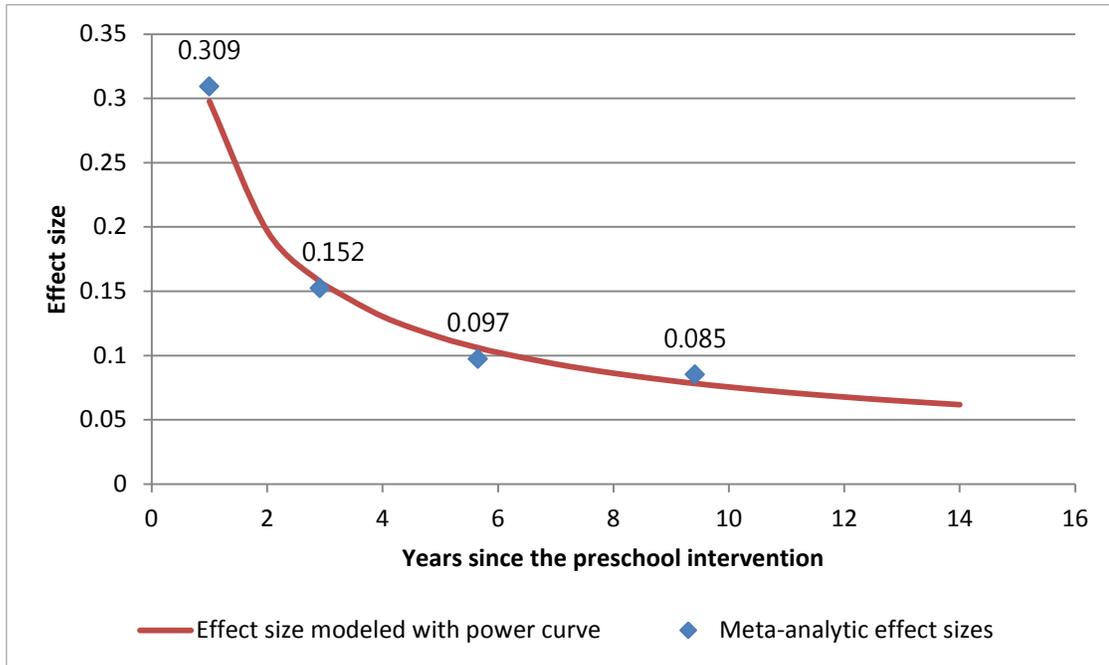Meta-Analytic Results and Power Curve Model

Exhibit A3

Fadeout Multipliers for Test Scores:

Estimates of Effect Size Decay Based on Longitudinal Evaluations of Early Childhood Education

Age at measurement	Grade level	Fadeout: Later test score effect size as a % of pre-K effect size	Fadeout multiplier: Multiply the effect size by the % below to estimate end-of-high school effect
4	Pre-K	100%	21%
5	K	66%	31%
6	1	52%	40%
7	2	44%	47%
8	3	38%	54%
9	4	34%	60%
10	5	31%	66%
11	6	29%	72%
12	7	27%	77%
13	8	25%	82%
14	9	24%	87%
15	10	23%	91%
16	11	22%	96%
17	12	21%	100%

A3. Early Childhood Education for Low-Income Three- and Four-Year-Olds Analysis

<u>Meta-Analysis Details</u>

We identified 49 scientifically rigorous studies that compared outcomes of students that attended a specific preschool program to those who did not. We reviewed all studies included in the previous ECE meta-analysis using our updated criteria for scientific rigor, method for coding effect sizes, and definition of relevant outcomes. Twenty-five studies that were in the previous WSIPP analysis are not included in the current analysis because they did not meet the criteria listed above or because they duplicated results reported in other included studies. As noted above, an additional ten studies are included in the fadeout calculation but not included in the program meta-analysis because they measured IQ or assessed "any preschool" rather than a specific program.

For the purpose of this analysis, we grouped the studies into three types of preschool programs for low-income three- and four-year old children:

- State and district funded pre-kindergarten
- Head Start
- Model programs

Displayed in Exhibit A4 are the results of the meta-analysis in detail for each outcome by program type. These effect sizes are shown in Exhibit 2 in the main body of this report.

In the benefit-cost analysis, we used the effect sizes from all outcomes except, as noted earlier, self-regulation and emotional development. The standard errors for each effect size were used in the Monte Carlo risk simulation. As described previously, the benefit-cost model links benefits to test scores at the end of high school. We used the fadeout model described in Appendix A2 to calculate the effect size in 12th grade.

As noted, in addition to examining program impacts, we reviewed scientifically rigorous studies of the association between teachers having a bachelor's degree (BA) or higher and student achievement, as well as the association between a one-point increase on the ECERS-R and student test scores. Those meta-analytic results are presented in Exhibit A5. For teacher BAs, we located ten studies and estimated a positive, but not statistically significant, impact.[44] For ECERS-R, we located four rigorous studies and found a relatively small, positive association between a one-point increase on the ECERS-R and student test scores.[45]

The citations to all studies included in these meta-analyses are provided at the end of this Technical Appendix.

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[44] Three studies used data from the National Center for Early Development and Learning's Multi-State Study of Pre-Kindergarten and State-Wide Early Education Programs Study. To account for the use of the same data set, a summary effect size from these three studies was included in the meta-analysis.

[45] Two studies used data from the National Center for Early Development and Learning's Multi-State Study of Pre-Kindergarten and State-Wide Early Education Programs Study. To account for the use of the same data set, a summary effect size from these two studies was included in the meta-analysis.

Exhibit A4

Meta-Analysis of Program Effects

Outcomes measured	No. of effect sizes	Adjusted effect sizes at the first time of measurement		
		ES	SE	Age
State and district programs				
Test scores*	17	0.316	0.032	4
High school graduation	2	0.230	0.140	22
K–12 grade repetition	4	-0.385	0.900	12
K–12 special education	3	-0.116	0.202	14
Crime	1	-0.251	0.174	22
Self-regulation**	3	0.214	0.036	4
Emotional development**	5	0.042	0.064	4
Head Start				
Test scores*	7	0.172	0.027	4
High school graduation	2	0.181	0.077	21
K–12 grade repetition	5	-0.075	0.133	12
Crime	2	-0.183	0.270	21
Teen births <18	1	-0.466	0.292	19
Self-regulation**	1	0.160	0.129	4
Emotional development**	2	0.032	0.051	4
Model programs				
Test scores*	3	0.568	0.123	4
High school graduation	3	0.314	0.265	18
K–12 grade repetition	3	-0.463	0.253	17
K–12 special education	3	-0.470	0.263	17
Crime	2	-0.322	0.214	30
Teen births <18	2	-0.441	0.395	17

*The benefit-cost model uses test scores at the end of high school which are estimated using the fadeout model multipliers described in Appendix A2.
**Self-regulation and emotional development results are not included in the benefit-cost analysis.

Exhibit A5

Meta-Analytic Results of Program Components

Outcomes measured	No. of effect sizes	Adjusted effect sizes at the first time of measurement		
		ES	SE	Age
Teachers have at least a BA	7	0.041	0.043	4
One-point higher on the ECERS-R quality scale	3	0.029	0.044	4

Benefit-Cost Analysis Details

Benefits. To estimate the benefits associated with ECE we link outcomes to research-based estimates of monetary benefits to participants, taxpayers, and others in society using WSIPP's standard methodology.[46]

Costs. We used the costs of Washington State's ECEAP program to represent the cost of state and district preschool in the benefit-cost analysis. To estimate the costs of ECEAP we used the funding per slot and number of slots for the 2011-2012 school year (see Exhibit A6). Since attending preschool might impact the need for child care, we also included the $1,157,060 in state-funded childcare subsidies that were issued to children who attended ECEAP.[47] The annual combined cost of ECE and child care assistance was $6,950 per student who attended ECEAP.

Since state and district program evaluations typically compare state pre-kindergarten participants to children who may have attended another preschool program, we estimated the cost of a comparison group composed of all ECEAP-eligible children in Washington who did not attend ECEAP but who may have attended another publically funded preschool (i.e. Head Start). We estimated that the cost of the comparison group is the amount of state-funded child care subsidies that were issued to children who were eligible for ECEAP but did not attend the program ($29,717,042).[48] The annual cost of child care assistance for the comparison group was $961 per student.

Exhibit A6
State and District Pre-Kindergarten Intervention and Comparison Group Cost Estimates

	State and district preschool costs	Comparison group costs	
Source of cost estimate	*ECEAP (WA)*	*Head Start (WA)*	*Eligible for ECEAP but did not attend ECEAP or Head Start (WA)*
Number of children[a]	8,391	12,336	18,600
State-funded ECE costs[b]	$6,812	NA	NA
Amount of state-funded child care subsidies distributed[c]	$1,157,060	$29,717,042	
Average amount of state-funded child care subsidies per child	$138	$961	
Annual amount of state funds per child	$6,950	$961	
Net state cost of state and district ECE	*$5,989*		

[a] Washington State Department of Early Learning, 2012. ECEAP and Head start slots are data from the 2011-12 school year; data for ECEAP-eligible children who were not served are from the 2010-11 school year.
[b] Washington State Department of Early Learning. (2013). Early Childhood Education and Assistance Program (2013 Legislative Briefing Paper). Retrieved from http://del.wa.gov/publications/laws/docs/Legislative_briefing_ECEAP_2013.pdf; Costs include funds distributed to grantees as well as Department of Early Learning costs.
[c] Nicole Rose (personal communication, December 4, 2013). Data are from the Early Learning Management System and Washington State Department of Social and Health Services Social Service Payment System.

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[46] Washington State Institute for Public Policy, (2013). http://www.wsipp.wa.gov/TechnicalManual/WsippBenefitCostTechnicalManual.pdf
[47] Nicole Rose (personal communication, December 4, 2013). Data are from the Early Learning Management System and Washington State Department of Social and Health Services Social Service Payment System.
[48] Ibid.

We estimated the average number of years that a child attended a state or district program using the enrollment rates of three-year-olds (two potential years of enrollment) and four-year-olds (one year of enrollment) in ECEAP during the 2011-12 school year.[49] The average ECEAP student attended the program for 1.17 years.

Similarly, we used Head Start spending in Washington State and an estimate of state-funded child care to calculate the costs of the Head Start intervention group. We used the amount of state-subsidized childcare for children who were Head Start eligible but did not attend Head Start as the comparison group costs (see Exhibit A7). We based our benefit-cost analysis on one year of Head Start attendance.

Exhibit A7
Head Start Intervention and Comparison Group Cost Estimates

	Head Start costs	**Comparison group costs**	
Source of cost estimate	*Head Start (WA)*	*ECEAP (WA)*	*Eligible for Head Start but did not attend Head Start or ECEAP (WA)*
Number of children[a]	12,336	8,391	23,900
Head Start costs[b]	$9,332	NA	NA
Amount of state-funded child care subsidies distributed[c]	$1,701,048	$29,173,054	
Average amount of state-funded child care subsidies per child	$138	$903	
Annual amount of funding per child	$9,469	$903	
Net cost of Head Start	*$8,566*		

[a] Washington State Department of Early Learning, 2012. ECEAP and Head start slots are data from the 2011-12 school year; ECEAP-eligible children who were not served are data from the 2010-11 school year.
[b] Ibid. Data from 2011-12 are converted to 2012 dollars; Head Start costs are the average cost of Region X Head Start, AI/AN Head Start and Migrant and Seasonal Head Start in Washington State.
[c] Nicole Rose (personal communication, December 4, 2013). Data are from the Early Learning Management System and Washington State Department of Social and Health Services Social Service Payment System. We did not have access to the amount of state-subsidized child care funds issued to Head Start participants. We estimated this amount by applying the amount of state-subsidized childcare per child among ECEAP participants to the number of Head Start participants.

Exhibit A8
Summary of Cost Estimates (2012 Dollars)

	Program duration	Program participants[a]	Comparison group[b]	Summary[c]	
	Years	Annual cost	Annual cost	Net program costs	Uncertainty (+ or - %)
State and district ECE	1.17	$6,950	$961	$7,007	10%
Head Start	1	$9,469	$903	$8,564	10%

[a]Program costs include the intervention program and state-funded child care costs for children in the intervention program.
[b]Comparison group costs include all other eligible children, even those who attend another ECE program.
[c]The uncertainty range is used in Monte Carlo risk simulation, described in WSIPP's Technical Manual.

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[49] Washington State Department of Early Learning, (2012).

[Benefit-Cost Results]{.underline}

Exhibit A9 summarizes the benefit-cost results. The estimates shown are present-value, life-cycle benefits and costs. All dollars are expressed in 2012 dollars. The economic discount rates and other relevant parameters are described in detail in our Technical Manual.[50]

Exhibit A9
Benefit-Cost Summary

State and district program benefits		Summary statistics	
Participants	$13,306	Benefit to cost ratio	$4.20
Taxpayers	$9,058	Benefits minus costs	$22,236
Other	$8,703	Probability of a positive net present value	91%
Other indirect[a]	($1,858)		
Total	$29,210		
Costs	($6,974)[b]		
Benefit minus cost	$22,236		
Head Start benefits		**Summary statistics**	
Participants	$11,239	Benefit to cost ratio	$2.63
Taxpayers	$7,167	Benefits minus costs	$13,888
Other	$7,186	Probability of a positive net present value	89%
Other indirect[a]	($3,139)		
Total	$22,452		
Costs	($8,564)[b]		
Benefit minus cost	$13,888		

[a]Adjustment for deadweight cost of program.
[b]Does not match Exhibit A6/A7 due to the length of the program and the use of uncertainty ranges in Monte Carlo simulation.

Exhibit A10
Detailed Monetary Benefits for State and District Programs

	Benefits to:				
Source of benefits	Participants	Taxpayers	Other	Other indirect	Total benefits
From primary participant					
Crime	$0	$1,094	$3,262	$551	$4,907
Earnings via high school graduation	$13,521	$5,767	$6,695	$0	$25,983
K–12 grade repetition	$0	$219	$0	$110	$329
K–12 special education	$0	$298	$0	$149	$447
Health care costs via education	-$215	$1,681	-$1,253	$851	$1,063
Adjustment for deadweight cost of the program	$0	$0	$0	-$3,519	-$3,519
Total	**$13,306**	**$9,058**	**$8,703**	**-$1,858**	**$29,210**

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[50] Washington State Institute for Public Policy, (2013). http://www.wsipp.wa.gov/TechnicalManual/WsippBenefitCostTechnicalManual.pdf

Exhibit A11
Detailed Monetary Benefits for Head Start

Source of benefits	Benefits to:				
	Participants	Taxpayers	Other	Other indirect	Total benefits
From primary participant					
Crime	$0	$830	$2,496	$415	$3,742
Earnings via high school graduation	$11,067	$4,720	$5,473	$0	$21,260
K–12 grade repetition	$0	$45	$0	$22	$67
Health care costs via education	-$173	$1,349	-$1,007	$677	$846
From secondary participant*					
Crime	$0	$31	$93	$16	$140
Earnings via high school graduation	$324	$138	$160	$0	$622
Child abuse and neglect	$26	$6	$0	$3	$35
K–12 grade repetition	$0	$6	$0	$3	$9
Health care costs via education	-$5	$40	-$30	$20	$25
Adjustment for deadweight cost of the program	$0	$0	$0	-$4,295	-$4,295
Total	**$11,239**	**$7,167**	**$7,186**	**-$3,139**	**$22,452**

*Benefits from secondary participants come from preventing negative outcomes associated with the children of teen mothers.

A4. Studies Used in the Meta-Analyses

Key:
\# = state and district programs
* = Head Start
~ = university-based model programs

Test Scores Measured Immediately After Preschool

* Abbott-Shim, M., Lambert, R. and McCarty, F. (2003). A comparison of school readiness outcomes for children randomly assigned to a Head Start program and the program's wait list. *Journal of Education for Students Placed at Risk, 8*(2), 191-214.

\# Barnett, W. S., Frede, E. C., Mobasher, H., & Mohr, P. (1988). The efficacy of public preschool programs and the relationship of program quality to efficacy. *Educational Evaluation and Policy Analysis, 10*(1), 37–49.

~ Deutsch, M., Taleporos, E., & Victor, J. (1974). A brief synopsis of an initial enrichment program in early childhood. In S. Ryan (Ed*.), A report on longitudinal evaluations of preschool programs, Volume 1: Longitudinal evaluations (*pp. 49-60). Washington, DC: Office of Child Development, U.S. Department of Health, Education, and Welfare.

\# Frede, E., Jung, K., Barnett, W. S., Lamy, C. E., & Figueras, A. (2007). *The Abbott Preschool Program longitudinal effects study (APPLES): Interim report.* New Brunswick, NJ: Rutgers University, National Institute for Early Education Research.

\# Gormley Jr, W. T., & Gayer, T. (2005). Promoting school readiness in Oklahoma: An evaluation of Tulsa's pre-k program. *The Journal of Human Resources. 40*(3), 533-558.

\# Gormley, W. T., Jr., Gayer, T., Phillips, D., & Dawson, B. (2005). The effects of universal pre-k on cognitive development. *Developmental Psychology, 41*(6), 872-884.

\# Gormley, W. T., Jr., Phillips, D., & Gayer, T. (2008). Preschool programs can boost school readiness [Supplemental material]. *Science, 320*, 1723-1724. doi: 10.1126/science.1156019.

\# Hustedt, J. T., Barnett, W. S., Jung, K. & Thomas, J. (2007). *The effects of the Arkansas Better Chance program on young children's school readiness.* New Brunswick, NJ: Rutgers University, National Institute for Early Education Research.

\# Hustedt, J. T., Barnett, W. S., Jung, K., & Figueras-Daniel, A. (2009, September). *Continued impacts of New Mexico pre-k on children's readiness for kindergarten: Results from the third year of implementation*. New Brunswick, NJ: Rutgers University, National Institute for Early Education Research.

* Lee, V. E., Brooks-Gunn, J., Schnur, E. (1988). Does Head Start work?: A 1-year follow-up comparison of disadvantaged children attending Head Start, no preschool, and other preschool programs. *Developmental Psychology, 24*(2), 210-222.

* Lee, V. E., Brooks-Gunn, J., Schnur, E., & Liaw, F. R. (1990). Are Head Start effects sustained? A longitudinal follow-up comparison of disadvantaged children attending Head Start, no preschool, and other preschool programs. *Child Development, 61*(2), 495-507.

\# Lipsey, M. W., Hofer, K. G., Dong, N., Farran, D. C., & Bilbrey, C. (2013). *Evaluation of the Tennessee voluntary prekindergarten program: End of pre-K results from the randomized control trial.* Nashville, TN: Vanderbilt University, Peabody Research Institute.

\# Peisner-Feinberg, E. S., & Schaaf, J. M. (2011). *Evaluation of the North Carolina More at Four Pre-Kindergarten Program.* Chapel Hill, NC: University of North Carolina, FPG Child Development Institute.

* Puma, M., Bell, S., Cook, R., Heid, C., Shapiro, G., Broene, P., ... & Spier, E. (2010). *Head Start impact study: Final report.* Washington, DC: U.S. Department of Health and Human Services.

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