

2 Synthesis of Preschool Dosage

How Quantity, Quality, and Content Impact Child Outcomes

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Introduction

In recent years, increased attention has been paid to preschool as a means of addressing the significant achievement gap that exists between children in poverty and their more advantaged peers (Duncan & Murnane, 2011; Heckman, 2006; Yoshikawa, Weiland, Brooks-Gunn et al., 2013). However, preschool is expensive, and the nature of the debate has shifted from whether federal, state, and local monies should support early childhood learning to the specifics of for whom, how much, and what programs should offer. Therefore, understanding the amount, or dosage, of preschool needed to achieve positive outcomes in young children and to increase their school readiness is critical as policymakers and educators try to balance funding challenges while attempting to increase access to early education. However, the issue of dosage cannot be addressed independently from considerations about the content of the preschool classroom because the two factors are intricately related. In order to inform the discussion of *how much* preschool is effective, we need to understand *how much of what* is needed in order to unpack what the key components of an effective preschool experience are for young children.

This chapter provides a brief overview of dosage and how it is currently used in implementation science. We then present the current research on preschool and dosage. Next, we review the research that is cited as support for preschool as an effective early intervention strategy to help close the achievement gap. We pay particular attention to both the content of the interventions and the dosage to help understand what is known about the effect of various aspects of preschool on child outcomes. Finally, we address the policy and research issues related to our findings.

History and Background of Dosage

The dosage of early childhood programs was less frequently discussed prior to the 1990s. In the last decade or two, however, increased attention

paid to implementation science and the development of evidence-based interventions has motivated some researchers to provide more careful attention to, and measurement and reporting of, various aspects of interventions, from content to dosage (Durlak & DuPre, 2008; Fixsen, Naoom, Blase et al., 2005).

Since increased dosage of an intervention often translates into higher intervention costs, understanding the dosage at which an intervention produces positive impacts also has substantial implications for developing cost-effective interventions (Karoly, 2012). Without considering dosage more carefully both in research and practice, we can neither account for how much intervention participants actually receive, nor fully understand the best delivery mechanisms for that intervention; nor can we measure its true costs or benefits at the individual, familial, or societal level (Halle, Metz & Martinez-Beck, 2013). Thus, understanding dosage is essential to advancing research, practice, and policy in the early childhood care and education field.

Dosage: Defining Key Concepts

We start with a brief overview of commonly used terminology (see also Wasik, Mattera, Lloyd & Boller, 2013). *Dosage* historically was used in the medical field, as far back as the Greek physician Galen, to refer to the quantity or amount of medicine. In early childhood education, dosage is often used more broadly to refer to years of preschool, or hours per day (usually half- or full-day). But the scientific origins of the term dosage belie its lack of precision when used in the early childhood field; in some studies, “full-day preschool” might refer to the six-hour school-year calendar, while in other contexts (e.g., studies of child care), preschool might only be considered full-day if it is available eight or ten hours a day, all year. In this chapter, we argue that to add precision to the debate over early childhood education, it is important to consider the various elements that make up dosage, including session duration (e.g., half-day vs. full school-day vs. full child care coverage), frequency (e.g., 3 vs. 5 days a week during the school year), and duration (e.g., one vs. two school years). If information is available on all these elements, it is possible to calculate the *cumulative dosage* of a program (cumulative dosage = session duration × frequency × intervention duration or length of program enrollment).

It can also be important to consider the dosage of specific elements of an intervention, program, or curriculum. For example, a pre-kindergarten curriculum that requires 30 minutes of specific literacy

activities per day for one school year would have a cumulative intended dosage at the child level of 5,400 minutes (30 minutes multiplied by 5 days multiplied by 36 weeks). For all aspects of dosage, it is critical to distinguish between the *dosage intended*, *dosage offered*, and *dosage received*.

Less frequently examined in the empirical literature is the *intensity* of an intervention and *threshold dosage*. *Intensity* of an intervention is another term that is sometimes used to describe the “strength” or the rate of exposure of an intervention, which might include elements of frequency, session duration, and intervention duration. In addition, it may also be used to describe how much of a particular component of an intervention is delivered within each session. A *threshold* dose is used to describe a specific dosage level at which an intervention affects outcomes. For example, a study may find that children only need to attend one year of preschool to achieve needed outcomes, and that an additional year does not add additional benefits.

Evidence on Preschool Dosage

Overall, research suggests that more participation in center-based preschool education is associated with increased kindergarten readiness, especially for low-income children. Below, we examine how this functions within the various aspects of dosage, including session duration, frequency, duration, cumulative dosage, intended vs. offered and received dosage, intensity, and threshold dosage.

Session duration: Non-experimental work has suggested that full-day programs offer some benefits to children over part-day programs. For example, Reynolds, Richardson, Hayakawa et al. (2014) examined the impact of length of day by comparing children who attended part-day vs. full-day in Chicago Child-Parent Centers; they found significant improvements in children’s socio-emotional development, language and math skills, and physical health for full-day children relative to children in the part-day program. A non-experimental analysis of the effects of different centers in the Head Start Impact Study (Walters, 2015) found that full-day programs boosted cognitive achievement by 0.14 SD above those in half-day programs. Recent experimental work by Gibbs (2014) in a sample of Indiana districts found that full-day kindergarten, relative to half-day, improved literacy skills by approximately 0.3 SD, with Hispanic students and students who began the year with low literacy skills experiencing the largest gains. These findings imply that more time in school might be especially beneficial for children who are farthest behind,

decreasing the early achievement gap and potentially improving students' outcomes later in life.

There is some evidence, however, that if the quality of the full-day program is subpar, greater dosage (full-day) might not only have positive effects (Magnuson, Meyers, Rhum & Waldfogel, 2004; Robin, Frede & Barnett, 2006), but negative effects, as has been suggested by the NICHD study (Vandell, Belsky, Burchinal et al., 2010), which found evidence that more hours in child care (30+ hours a week) was associated with increased risk of behavioral problems.

Frequency: Most public preschool programs that have been evaluated are 5-day per week programs; however, some states or localities offer preschool programs that have fewer days. As far as we are aware, there have been no systematic evaluations of the effects of frequency of early childhood education programming.

Duration: The aspect of dosage that has been most frequently tested is duration. Most work suggests that at-risk children who attend more preschool or child care tend to enter kindergarten better prepared, especially on academic measures, although effects may dissipate over time (Loeb, Bridges, Bassok et al., 2007; Skibbe, Connor, Morrison & Jewkes, 2011). A large, international meta-analysis (Nores & Barnett, 2010) also found that programs lasting 1–3 years had somewhat larger effect sizes compared to those of less than one year (i.e., 0.3 versus 0.2).

A recent long-term follow-up of participants in Child–Parent Centers (Arteaga, Humpage, Reynolds & Temple, 2014) used propensity score weighting to compare groups of children attending preschool for two years versus those who attended for only one, and found that the two-year group was significantly less likely to receive special education, be abused or neglected, or to commit crimes, although differences in academic or cognitive outcomes were not found.

Cumulative dosage: We are unaware of any research that attempts to quantify the effect of cumulative dosage of preschool programs.

Dosage intended, offered, and received: Research has suggested that the intended dosage of an intervention is almost always more than what is actually received (Durlak & DuPre, 2008). This can occur at the program level, when state funding is delayed and school starts late (or a day is canceled each week), or at the family level (if children miss school due to illness or other reasons). For example, in Washington DC, more than one-quarter of Head Start students enrolled in public schools miss more than 10 percent of school days (Dubay & Holla, 2015); similarly, in

Chicago, half of 3-year-olds and one-third of 4-year-olds miss more than 10 percent of school days (Ehrlich, Gwynne, Pareja et al., 2013). The Chicago researchers also noted that children's preschool absences predicted long-term attendance problems and poor achievement.

Intensity of intervention: The effect of the intensity of early childhood interventions is less often studied, beyond examination of half-day vs. full-day programs. A limited number of studies have examined the intensity of specific activities offered in an educational program, and their findings suggest that increased intensity and/or more sessions do not always lead to better outcomes for children. For example, researchers studying print referencing compared more versus fewer references to print within sessions and found that a lower intensity of print referencing was associated with larger effects (McGinty, Breit-Smith, Fan et al., 2011). Overall, however, the effect of the intensity of most programs or curricula is relatively unknown, perhaps because other aspects of preschool content and dosage are often endogenous with respect to intensity.

Threshold dosage: When comparing the marginal effect of two years versus one year of preschool, it appears that the incremental effect of attending a first year of preschool is generally greater in magnitude than that of a second year for children's short- and long-term outcomes (Arteaga et al., 2014; Reynolds, Temple, Ou et al., 2011; Wen, Leow, Hahs-Vaughn et al., 2012). Relatedly, Jenkins, Farkas, Duncan, Burchinal & Vandell (2015) found that children who attended Head Start at age 3, and then moved to public pre-K at age 4, had better outcomes than those who attended Head Start for two years. The authors speculate that this could be in part because children might "max out" on a particular program's curriculum, especially if that curriculum was not designed for the widely varying needs of children across multiple age groups. Their finding also supports the idea that the interaction of dosage and content is important to consider when examining the effect of preschool, and preschool dosage, on children's outcomes.

Defining High-Quality Preschool: Dosage and Content

In reviewing preschool programs, we observed that the term "high-quality" was used frequently in describing curricula, yet a description of high quality and data to substantiate the basis for labeling it "high quality" was typically not provided. We will briefly discuss the issue of high quality as it relates to dosage and content.

Definitions of "high quality" frequently address dosage as it relates to amount of time children spend in class and the ratio of children to adults

in the classroom. For example, the US Department of Education's definition of high-quality preschool used in the 2014 Preschool Development Grants competition includes three points pertinent to dosage: high-quality preschools are full-day, have class sizes of 20, and a staff ratio of 10 to 1. Full-day is clearly related to the dosage or amount of experience. Class size and a small staff ratio is related to dosage in that the intention is that, by decreasing the number of children adults need to attend to, the amount of adult interaction increases. Although increased time and potential opportunities to interact is important, we return to an earlier point about dosage and content being intertwined: increases in time and adult child contact is only as effective as the quality and content of the interactions.

While the Department of Education's definition states that high-quality preschools include "developmentally appropriate, culturally and linguistically responsive instruction and evidence-based curricula, and learning environments that are aligned with the State Early Learning and Development Standards," suggesting that high-quality preschools implement content that is researched-based and that will result in positive child outcomes, there is little information about specific content in this definition.

Yet research is available that can specifically inform content. Early childhood research on language and literacy, for example, unequivocally shows that developing children's oral language and vocabulary is critical to future success in learning to read (Dickinson & Porche, 2011). In addition, children's language experiences from birth to preschool, especially relating to their vocabulary learning, set a critical foundation for children's success in science and mathematics (LeFevre, Fast, Skwarchuk et al., 2010) and in building positive relationships with peers (Menting, Van Lier & Koot, 2011). Therefore, high-quality preschool classrooms must include content designed to develop children's language and vocabulary skills.

Although there may be many approaches to providing rich language and literacy experiences to young children as reflected in various curricula, there is a consensus based on research that focusing on language and vocabulary is critical. However, less is known from research about what dosage of language and literacy experiences is needed to achieve positive outcomes in young children, especially those most at risk. Attention to dosage of the curricula or specific parts of a curriculum in research studies is mostly nonexistent. For example, there is no research examining the amount of quality interaction children need with teachers daily or weekly in order to increase their language skills. Similarly, little is known about the number of times children need to hear a word in order to learn to use

the word in a meaningful way. In a recent review of book reading and vocabulary that we conducted, we identified from the research literature the number of exposures to a word children needed to have in order to learn the word. Of the 36 studies reviewed, only ten studies provided a count of the total number of exposures children had to the words they were being taught (Wasik, Hindman & Snell, 2016). Although attention to dosage at this level may seem irrelevant and/or result in an overly prescribed curriculum, information about dosage and how it relates to specific curriculum content could provide teachers with valuable information to help inform and improve instruction.

In reviewing the curricula in the following sections, we will report on dosage and curricula content to help inform what we know about effective preschool interventions. We will also note the attention to language and vocabulary, if any, given the research evidence.

Review of the Content and Dosage of Studies of the Effects of Adding Preschool

The following is a review of the research that has examined the effectiveness of preschool on child outcomes. We included eight large-scale studies (see Table 2.1) that have been used as evidence for the effectiveness of preschool (Yoshikawa et al., 2013). Specifically, we examine the dosage and content of the curriculum offered during the additional years as a means of trying to unpack what children experienced in these interventions to inform the discussion about how much of what is effective to improve child outcomes.

Three issues are important to note as we examine these studies in light of dosage and content. One important issue is that although several of the curricula examined in these studies are currently used in many preschool classrooms, the actual content of the curriculum may have changed significantly since the evaluation was conducted. This is important when we consider the impact of an intervention and how it is related to both dosage and content. We make note of the differences when applicable. The second issue, which is related to the first, is that the field's definition of curriculum has changed since the 1960s (or even 1990s), evolving from suggested frameworks and philosophical approaches to specific detailed lesson plans to be implemented with fidelity. We discuss each study's curricula in the context of current descriptions of curricula and provide as much detail as is available about what children experienced in the preschool classrooms. The third important issue is understanding the studies in their historical context, which informs our understanding of dosage and content. In the initial studies conducted in

Table 2.1 *Intended dosage and content of exemplar preschool programs*

Preschool Program	Intended Dosage	Content
Abbott	6-hour, 180-day, with additional wrap-around services; 1-year and 2-year programs	Variable
Abecedarian	5 hours a day, 5 days a week, 50 weeks a year, 5 years+	Program curriculum; focused on language and cognitive development
Boston Preschool	Full-day, 1 academic year	OWL and Building Blocks, along with other district initiatives
Chicago Child Care Center	Originally half-day preschool expanded to full-day; 5 days a week; academic year + 6-week summer program; 1 or 2 years	EARLY program
Head Start Impact Study	Mix of half-day and full-day programs; primarily academic year; 1 year of Head Start	Majority were HighScope and Creative Curriculum
Oklahoma (Tulsa) Pre-K	Full- and half-day programs, academic year, 1 year	Variable
Perry Preschool	2.5 hours a day, 5 days a week, 8 months per year, two years	High/Scope Model and home visits
Tennessee Voluntary Pre-K	Minimum of 5.5 hours a day, 180 days a year, for one year	Variable

the 1960s and 1970s, attention to dosage was in terms of the presence or absence of preschool and the ratio of adults to children. Issues concerning fidelity of implementation and other factors related to implementation science were not discussed in educational research at that time, and we do not intend our discussion to be an anachronistic criticism of the research.

The Abbott Study

The Abbott Preschool Program was created as a result of the New Jersey Supreme Court's 1998 *Abbott v. Burke* case finding that children in economically disadvantaged districts must have access to high-quality early childhood programs (Frede et al., 2007). The National Institute for Early Education Research (NIEER) conducted a regression discontinuity design (RDD) longitudinal study to determine if the learning gains found in early research at kindergarten entry continued into elementary school. The RDD results show that substantial gains in learning and

development occurred in language, literacy, and mathematics, with gains largely sustained during the kindergarten year (see Frede, Jung, Barnett et al., 2007 for the detailed report).

Curriculum: It is difficult to discern what curriculum was used in the Abbott Preschool Study and if there were differential effects depending on the specific curriculum used. In the 2014 state report, the curriculum in the Abbott Preschool program is described as “developmentally appropriate curriculum, aligned with the New Jersey CCCS and elementary school reforms.” Further documentation suggests that High/Scope is being used in many Abbott schools (Lerner, 2014). In addition, a relatively small percentage of Abbott schools use Curiosity Corner, which is part of Success for All.

Dosage: A maximum class size of 15 was mandated by the Abbott decision. Abbott preschool classrooms combine a US Department of Education (DOE)-funded six-hour, 180-day component with a US Department of Human Services (DHS)-funded wrap-around program that provides daily before- and after-care and summer programs. In total, the full-day, full-year program is available 10 hours per day, 245 days a year. Data also revealed that children who attend Abbott preschools for two years at both age 3 and 4 significantly outperform at kindergarten those who attended for only one year at 4 years of age or did not attend at all (Frede & Barnett, 2011; Frede, Barnett, Jung et al., 2010).

Abecedarian Project

The Abecedarian Project, developed by researchers from the Frank Porter Graham Center at the University of North Carolina, provided low-income children with early childhood education. The initial study of the Abecedarian Project (Ramey & Campbell, 1984) found that the preschool intervention group scored significantly higher than the control group on several cognitive measures, including vocabulary, intelligence, and memory. Similar findings were documented in additional studies (Burchinal, Lee & Ramey, 1989; Martin, Ramey & Ramey, 1990). Researchers monitored children’s progress over time with follow-up studies through age 35.

Curriculum: The Abecedarian project content is described as an approach that combines teaching and learning enrichment strategies for use in early childhood education settings comprised of four key elements: 1) learning games, 2) conversational reading, 3) language priority, and 4) enriched care giving. Each child had an individualized “prescription of

educational games” incorporated into the day. These activities focused on social, emotional, and cognitive areas of development but were described as providing particular emphasis on language.

Dosage: Children in the intervention group attended a center-based program with teacher:child ratios that ranged from 1:3 for infants/toddlers to 1:6 for older children. The center operated 7:30 a.m. to 5:30 p.m., 5 days per week, and 50 weeks out of the year, with free transportation available. Individual child attendance is not available. Controls received the same medical and nutrition support that the intervention group received. We have not been able to determine the number, if any, of the children in the control group who attended preschool.

The Boston Preschool Project

Boston Public Schools, in collaboration with researchers from the Harvard Graduate School of Education, implemented and evaluated a research-based high-quality preschool program. Findings from a RDD indicated that the program had moderate-to-large impacts on children’s language, literacy, numeracy, and mathematics skills, and small impacts on children’s executive functioning and a measure of emotion recognition (Weiland & Yoshikawa, 2013). Some impacts were considerably larger for some subgroups. Curriculum fidelity measures indicated moderate to good fidelity.

Curriculum: A research-based literacy curriculum, Opening the World of Learning (OWLTM) (Schickedanz, Dickinson & Schools, 2005) was implemented with some modifications. A research-based math curriculum, Real Math Building Blocks: Pre-K (Clements & Sarama, 2007) was also implemented. Teachers received training in Building Blocks (average of 6 days) and OWL (average of 7 days) with 2–3 days of training offered before school started and the remaining days during the school year. Each preschool teacher also received weekly or biweekly classroom coaching for (1 coach per 10 classrooms for three years).

Dosage: Full-day pre-kindergarten was offered to all children. The adult:child ratio was reported to be about 1:10. We were unable to discern what percentage of the day the OWL and Building Blocks curriculum was intended to be implemented, or in practice implemented.

Chicago Child–Parent Center

The Chicago Child–Parent Center (CPC) program is a center-based early intervention designed to provide high-quality early intervention services to

both children and their families. An important goal of the project was to provide services to the family, with the expectation that working with the family would impact the child. The results reported in Reynolds, Temple, Robertson & Mann (2001) indicate that, overall, students enrolled in CPC had higher rates of graduation and lower rates of special education, criminal justice involvement, and child maltreatment.

Curriculum: Child-Parent Center curriculum has focused on the acquisition of basic knowledge and skills in language arts and math through a relatively structured but diverse set of learning experiences (e.g., whole class, small groups, individualized activities, field trips). The cognitive domains of the activities are described in three main areas: 1) body image and gross motor skills; 2) perceptual-motor and arithmetic skills; and 3) language. Most of the activities are implemented in small groups of four or five children.

Dosage: The amount of preschool offered by the CPC has changed over the years. In the Reynolds et al. (2001) study, the dosage generally consisted of half-day preschool at ages 3 to 4 years, half- or full-day kindergarten, and school-age services in linked elementary schools at ages 6 to 9 years. More recently, many (but not all) CPC children attend full-day preschool and kindergarten (Reynolds et al., 2014).

Head Start Impact Study: Although several studies have been conducted on the effects of Head Start, the Head Start Impact Study (HSIS) (Puma, Bell, Cook et al., 2012) is the only large-scale, randomized control trial (RCT) of Head Start. The evaluation found significant benefits for Head Start children across multiple domains, particularly for 3-year-old children. By the end of first and third grade, however, few significant differences remained (Puma et al., 2012).

Curriculum: In the HSIS, sites were asked to report the curriculum that they used; most Head Start sites did use a particular curriculum, mostly HighScope or Creative Curriculum. We note, however, that the HighScope curriculum implemented in this study is not the exact same curriculum implemented in the HighScope study reviewed above. In addition, HighScope and the Creative Curriculum are not systematic curricula that guide teachers in implementing specific lessons with learning objectives. Instead, these curricula suggest specific routines (such as *Plan-Do-Review* in High/Scope), or a philosophy or framework about teaching (such as an emphasis on approaches to learning and on room arrangements) rather than explicit guided support of math and literacy content.

Dosage: There is considerable variability in the dosage reported in the

HSIS in terms of full- versus half-day, and variation in number of months attending, from 8 months to year-round programs. Bloom and Weiland (2015) examined the effects of dosage and quality in the HSIS, noting that children with higher-than-average program dosage, and sites with higher concentrations of such children, experienced larger-than-average program effects. Overall, they found variation in Head Start programs in terms of dosage and classroom quality.

High/Scope Perry Preschool Project

The High/Scope Perry Preschool Study began in the mid-1960s. (For a comprehensive review of the project, see Schweinhart, Montie, Xiang et al., 2005.) Findings from a study following an early cohort of children indicated that children who received the High/Scope early intervention performed significantly better on intellectual and language tests starting after their first year of schooling until age 7, and general school achievement and literacy was also greater through age 14. Long-term employment, family, and criminal justice outcomes at ages 27 and 40 were found to be consistently better in the program condition (Schweinhart et al., 2005). Although there are many similarities, the current HighScope program – currently implemented in 19 percent of all Head Start programs (Aikens, Hulseley, Moiduddin et al., 2011) – is not the same content that was evaluated in the High/Scope Perry Preschool Study. (See their website for details about the current program content.) In a related study, the High/Scope Preschool Curriculum Comparison study (Schweinhart & Weikart, 1997a, 1997b), which immediately followed the High/Scope Perry Preschool study, examined the impact of various curricula for a similar population of children and found long-term impacts on emotional and behavioral outcomes.

Curriculum: HighScope is defined by its developers as “a flexible framework and can be used across all settings, ages and abilities” and is not a specified curriculum. The content of the HighScope program that was evaluated was designed to support children’s self-initiated learning activities along with small-group and large-group activities. No specific details regarding content of lessons or lesson plans are provided. Although small groups do provide opportunities for greater adult and child interactions, there is no indication that there was an emphasis on vocabulary or language development.

Dosage: Children in the intervention condition received classroom instruction from October through May at the ages of 3 and 4, with 2.5 hours of daily in-class instruction followed by 1.5-hour teacher visits

to their homes weekly. Children were offered two years of preschool, and children in the study, on average, attended 1.2 years of the Perry Preschool. The program ratio was 4 teachers for 20 to 25 children. There is no specific mention of the amount of literacy and language activities provided.

Oklahoma (Tulsa) Pre-K Study

The Oklahoma Pre-K Study measured the effects of Oklahoma's universal early childhood 4-year-old program on entering kindergartners' academic skills. Findings from the Tulsa-located evaluation revealed that children in the Tulsa pre-K program were 9 months ahead of their peers in measures of reading, 7 months ahead in writing, and 5 months ahead in math (Gormley, Phillips & Gayer, 2008).

Curriculum: The curriculum used in the Tulsa Pre-K study varied. It is reported that some teachers created their own curriculum and others borrowed from such standardized curricula as Curiosity Corner, the Waterford Early Learning Program, Integrated Thematic Instruction, Creative Curriculum, and Direct Instruction. Yet, the specific curriculum used in each classroom is not reported, although Tulsa pre-K teachers scored higher on instructional quality and spent more time on reading and math (Gormley et al., 2008).

Dosage: Full- and half-day programs were offered. No differences were reported for children attending full- vs. half-day programs. Class size was limited to 20 with a child:staff ratio of 10 to 1. We are unaware of any attendance data.

Tennessee Voluntary Pre-K Program

The Tennessee Voluntary Pre-K (TN-NPK) Initiative was designed to assess the effectiveness of preschool in Tennessee. The study includes a RCT and a RDD. The RCT was implemented in a limited number of schools with more applicants than seats in the pre-K program (Lipsey, Hofer, Dong et al., 2013). The results of the RCT indicate that children who participated in TN-VPK significantly outperformed the children who did not attend TN-VPK at the end of the VPK year on all of the direct assessment scales examined, with modest effect sizes ranging from 0.28 to 0.42. Compared to results from HSES, effects were somewhat larger for literacy but not for mathematics. When the Tennessee results are compared to estimates from some other recent studies of public pre-K, they appear less robust. For example, studies of pre-K in Boston,

Oklahoma, and New Jersey (all three will be discussed below) find larger impacts on literacy and much larger effects on math.

Curriculum: Tennessee’s VPK and Head Start programs chose curricula from an approved list that are described as “research-based, reliable, age-appropriate and aligned with the TN Early Learning Developmental Standards.” In reviewing the list of the programs, with the exception of OWL, the programs listed have not shown evidence of effectiveness.

Dosage: The Tennessee program ran for a minimum of 5.5 hours per day, exclusive of nap time, for a minimum of 180 days per year within a calendar that includes 200 working days of 7.5 hours for teaching staff, with an adult:student ratio no smaller than 1:10 and a small class size maximum of 20. There are no data reported in the range of child attendance.

Summary of Curriculum Dosage and Content

The data from the review of these studies suggest several important findings. With the exception of the Boston Study, we found it challenging, in this initial review of programs that have been cited as evidence for the effectiveness of preschool on child outcomes, to find documentation of the actual content that was used in the intervention. This is important, as lack of information makes it difficult to unpack what is effective in order to scale up what works. For example, in the Oklahoma study, it is reported that a variety of curricula were used across the classrooms. Yet, if the Tulsa study is to be replicated, is the important factor that the children attended preschool or is it that the classrooms were found to devote more classroom time to reading and math than their counterparts, activities that research suggests are important for increasing child-outcomes? Although all programs refer to the curricula implemented as “high quality,” less is known about the actual content children were exposed to during the day. This makes it very difficult to discuss impact of dosage and to identify the necessary and sufficient characteristics that are needed to replicate the intervention. Critical information about the nature and quality of experiences children were exposed to is unknown, making it difficult to conclude how much is needed for preschool to be effective. Again, this brings to light the importance of documenting both content and dosage in evaluation research.

Review of Research on Preschool Curricula

To complete the discussion about the importance of the content and dosage of preschool programs in relation to child outcomes, it is relevant to discuss what is known about research on preschool curricula.

To date, the Preschool Curriculum Evaluation Research (PCER, 2008) program is the most comprehensive evaluation of the efficacy of commonly used preschool curricula. The goal of PCER was to conduct a rigorous, systematic evaluation of preschool curricula by supporting small-scale efficacy evaluations of curricula widely used in preschools. Fourteen curricula were evaluated using a common assessment protocol and a randomized experimental design. For a complete review of the study design, curricula, measures and analysis, see the PCER report (2008). In sum, the findings indicated that only two of the 14 intervention curricula had impacts on the student-level outcomes for the pre-kindergarten year. DLM Early Childhood ExpressTM supplemented with Open Court Reading Pre-K positively affected reading, phonological awareness, and language in pre-kindergarten and kindergarten. Pre-K mathematics supplemented with DLM Early Childhood ExpressTM math software curricula positively affected mathematics in pre-kindergarten.

The PCER evaluation reported limited information on dosage. In the report, very little information is provided about what teachers were asked to do in the interventions. The report documents information about required dosage for only four curricula, although it is possible that things were more specified in training materials for the other curricula. The report notes that Early Literacy and Learning Model (ELLM) required one hour of daily literacy instruction; Literacy Express and DLM Early Childhood ExpressTM supplemented with Open Court Reading Pre-K required 3–4 small group activities a week (although the time was not reported); PreK Math required small-group math activities for 20 minutes, twice per week; and Project Approach required 45–60 minutes daily in small group investigations.

An interesting point about the PCER findings is that, with the exception of Curiosity Corner, which was implemented in select preschools in the Abbott study, none of the curricula evaluated were implemented in any of the preschool studies evaluating the overall impact of preschool on young children.

Summary

When tested using rigorous designs, preschool curricula that are widely used (as compared to locally developed curricula) have small-sized effects. Our brief review suggests that this could be due to the fact that the most commonly used curricula tend to have little guidance for teachers (either described in the curricula or through training) on aspects of *dosage* (frequency, duration, or intensity) or *content* regarding activities that research suggests are most effective at boosting language, literacy, and mathematics learning in early childhood. For example, in the domain of language, Neuman and Dwyer's work (2009) suggests that many commonly used preschool curricula do not include specific instruction on the best ways to support language and vocabulary development. It has also been well documented that preschool teachers spend little time on mathematics, and that work has also shown that teachers lack knowledge and understanding about evidence-based mathematics content (Ginsburg, Boyd & Sun Lee, 2008; National Research Council [NRC], 2009). And, even when curricula might include content that would bolster learning, there is very little on-the-ground, ongoing professional development or coaching to help teachers implement with fidelity and at the most effective frequency and duration. The important message that should not be lost in these findings is that perhaps if the content of the preschool experience were more aligned with research-based content, specifically addressing children's language and literacy skills, and early mathematical foundations, the effects of a year of preschool might be larger and translate into longer-term impacts.

Research and Policy Recommendations for Sustaining Early Childhood Gains through Dosage and Content

The following are research and policy recommendations to help inform the field and to support the expansion of research-based, high-quality preschool for young children so that early childhood gains can be sustained, the achievement gap can be diminished, and all children can be successful in school. With regard to research, the following recommendations are:

- *Examine dosage as a variable in research.* We must unpack critical components of evidence-based interventions, both dosage and content, so we can communicate with educators about what to do, how much to do, and how often to do it. In addition, it is important to understand precisely what is being implemented in classrooms in order to effectively interpret findings. To do this, researchers must include fidelity

measures that detail the specifics of the program and curriculum implementation, as well as specific dosage characteristics, including session duration, frequency, intensity, and duration. Including all these elements will also help establish the total cumulative dosage associated with the intervention, allow for more accurate cost–benefit calculations, and elucidate what dosage is required to effectively sustain children’s learning gains over the school year and beyond. Reports should also include the ratio of children to staff to help unpack how much of the intervention individual children may be getting.

- *Define high-quality preschool in terms of content and dosage.* Researchers must develop a research-based definition of high-quality preschool that specifically outlines the quality and quantity of experiences children need to improve long-term outcomes in literacy, math and social/emotional issues.
- *Include teachers and parents in discussions about research questions and findings.* It seems naïve to be developing interventions without input about feasibility and alignment without feedback and cooperation from teachers and parents.

The following are policy recommendations:

- *Curricula need a strong foundation in language and vocabulary.* Not all preschool is equal. Adding a year of preschool to children’s educational experience without attention to the curricula content will not result in gains that are sustained over time. The research documenting the importance of developing language and vocabulary skills during the early years is rigorous and unequivocal. The challenge is to train teachers to effectively provide a language-rich classroom for young children that supports development of children’s skills across linguistic, literacy, mathematics, and science domains.
- *Invest in teacher training.* An effective, research-based curriculum is only effective if it is implemented as intended with fidelity (Durlak & DuPre, 2008). Teachers need to be trained to implement any program, and new programs must come with funding for training. For gains to be sustained, similar attention must be given to implementing effective, research-based education throughout the elementary years and beyond.
- *Give vulnerable populations priority access to preschool.* With limited resources and funds, the data clearly support the differential effects of preschool on high-poverty children. Funding for these populations should take priority.

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