The Role of Preschool Dosage and Quality in Children’s Self-Regulation Development

Carolina Melo1 · Robert C. Pianta2 · Jennifer LoCasale-Crouch2 · Francisca Romo3 · M. Constanza Ayala4

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Abstract

The present study examined how the dosage and quality of the federal preschool program “Head Start” (HS) in the US related to children’s self-regulation skills in kindergarten. Using Propensity Score Matching and multiple regression (OLS), this study explored how the number of years and hours a week of HS were related to self-regulation among 2,383 children, who entered the program either at 3 or 4 years old. An additional year in HS was significantly positively associated with self-regulation in kindergarten, while the number of hours a week in HS was not. However, the quality of teacher–child interactions moderated the relation between hours a week in HS and self-regulation. Findings contribute to the growing body of evidence about how dosage and quality of early childhood education experiences relate to children’s development.

Keywords Preschool · Self-regulation · Dosage · Teacher–child interactions

Introduction

Self-regulation is defined broadly as the capacity to monitor and regulate behavior, emotion, and cognition to accomplish goals, adapt to specific cognitive and social demands, and develop markedly during preschool. Self-regulation encapsulates a multidimensional set of skills (Weissberg et al., 2015) associated with success in school, health, and well-being (Moffitt et al., 2011; Ursache et al., 2012). Importantly, the quality of children’s preschool experiences plays a formative role in self-regulation development, serving as a crucial and malleable opportunity to foster this critical skill (Morris et al., 2013; Raver et al., 2008).

However, less is known about the effects of the dosage of preschool experience on the development of self-regulation. Studies report mixed evidence regarding associations between preschool dosage (e.g., number of hours a day, years, attendance) and self-regulation-related skills. Some studies, for example, indicate that children enrolled more hours a week in preschool performed more poorly on socioemotional outcomes associated with self-regulation (e.g., Huston et al., 2015; McCartney et al., 2010). On the other hand, research examining the number of years that children attend preschool presents mostly positive relations to child academic and socioemotional outcomes that encompass regulation (e.g., Moore et al., 2015; Wen et al., 2012).

Given the mixed evidence regarding the dosage of preschool experiences on the development of socio-emotional skills and considering self-regulation as a core competency involved in the development of socio-emotional skills (Weissberg et al., 2015), the next step is to examine under which conditions more years and hours in preschool can be beneficial for the development of self-regulation. Evidence about the importance of quality of early childhood experience would suggest that more years and more hours of preschool should be helpful only if these are of adequate quality (McCartney et al., 2010). However, this specific question has yet to be examined. The present study addresses this gap by examining the relation between two forms of preschool dosage, the number of hours a week and years of attendance, with self-regulation in kindergarten, and the moderation role quality of experiences may play.
Self-Regulation: A Core Component of Children’s Development

Self-regulation is a multidimensional construct with three overlapping and interrelated domains: Cognitive, Emotional, and Behavioral (Berger et al., 2007; Calkins & Williford, 2009; Murray et al., 2015). Cognitive self-regulation includes focusing and redirecting attention, having cognitive flexibility, and inhibiting impulses, skills that often fall under the domain of Executive Functions (Halle & Darling-Churchill, 2016). Emotional self-regulation is managing and modulating strong or unpleasant feelings, which partly relies on cognitive regulatory processes such as inhibitory control (Calkins, 1997). Both cognitive and emotional self-regulation are important for exerting behavioral regulation (Blair & Dennis, 2015), which is the ability to organize and monitor behavior, including compliance to adult demands and directives, delaying gratification, and inhibiting impulsive responses (Kuczynski & Kochanska, 1995). Skills such as persistence and organizing cognitive skills to solve problems and direct behavior towards a goal are also part of behavioral self-regulation (Berger, 2011, 2015; Murray et al., 2015; Smith-Donald et al., 2007).

Cognitive self-regulation skills in preschool have been found to predict a range of academic outcomes (e.g., Edossa et al., 2018; Malanchini et al., 2018; Ponitz et al., 2009), with a strong association with mathematic performance (Espy, 2004; Lenes et al., 2020). For example, the Chicago School Readiness Project (CSRP) experimental study found that children assigned to a comprehensive intervention service aimed at supporting children’s self-regulation displayed significant increases in executive functions in comparison to the control group and that these mediated gains in vocabulary, letter-naming and early math skills (Raver et al., 2011). On the other hand, behavioral self-regulation predicts a range of academic (e.g., Backer-Grøndahl et al., 2019; Edossa et al., 2018; Ponitz et al., 2009) and social and behavioral outcomes (e.g., Blair & Raver, 2015; Rimm-Kaufman et al., 2009).

Several studies have found that better self-regulation skills lead to children’s gains in socio-emotional and academic outcomes (Robson et al., 2020). Additionally, higher levels of self-regulation seem to have clear differential benefits for children in high-poverty families and schools (Akar et al., 2021; Blair & Raver, 2015; Raver et al., 2011). Importantly, these studies indicate the malleability of self-regulatory skills and that a high-quality ECE environment can affect the development of self-regulation. Thus, findings suggest the need to examine the necessary conditions more closely under which preschool may affect children’s self-regulation development.

The Role of Preschool Dosage and Children’s Development

Predominant conceptualizations of preschool dosage include attendance/absenteeism, the number of hours a week, and attending one versus two preschool years. Greater attendance (e.g., Ansari & Purtell, 2018; Ehrlich et al., 2018; Xue et al., 2016) and more years (two versus one) of preschool (e.g., Shah et al., 2017) have been associated with increases in academic and behavioral outcomes. However, preschool dosage studies examining hours a week have shown mixed associations to child outcomes. Some studies have shown that children who spend more hours in center care settings are more academically ready in kindergarten (Skibbe et al., 2011) and have higher math and preliteracy scores (Fuller et al., 2017). Nevertheless, other studies have found that children who attend more preschool hours display bigger behavioral problems than their peers who have attended fewer hours a day (Huston et al., 2015; McCartney et al., 2010).

Multiple studies found that students who attend two years of preschool have significantly stronger literacy and numeracy skills than those who attend only one year (e.g., Infurna & Montes, 2020; Reynolds et al., 2011; Xue et al., 2016). Studies examining the difference between attending two versus one year, specifically at Head Start (HS), the US federal preschool program, have shown mixed results. The Impact Study (Puma et al., 2012), for example, found that those who attended for two years (beginning at three years of age) showed almost no significant differences compared to the cohort who started HS at four years of age, except for higher scores in parent-reported measures of socioemotional skills and positive approaches to learning, by third grade. Other studies, however, have found evidence of positive associations between an additional year of HS and child academic (e.g., Infurna & Montes, 2020; Xue et al., 2016; Youn, 2016) and socioemotional outcomes in kindergarten (e.g., Moore et al., 2015; Wen et al., 2012).

Specific to regulation and behavior, some studies have found negative effects on social competence and behavior of starting preschool earlier (Loeb et al., 2007; McCartney et al., 2010), while others have seen some positive effects (Moore et al., 2015; Wen et al., 2012). For example, Loeb et al. (2007) found that children spending more than 30 h weekly in a center care setting had lower self-control and higher externalizing behavior. Magnnuson et al. (2007), however, found that the negative associations did not hold for children in Head Start centers. Nevertheless, a recently randomized control trial of full versus half-day preschool programs showed that the full-day produced substantial and positive effects on children’s academic outcomes but also on teacher-reported measures of socioemotional development. At kindergarten entry, children offered full-day continued to
outperform peers on an estimate of basic literacy (Atteberry et al., 2019).

The Moderation Role of Classroom Quality

One hypothesis that could explain the mixed evidence on preschool dosage and socioemotional outcomes is that the experience might also need to be of a certain quality for more dosage to be beneficial. The current study uses the Teaching Through Interactions (TTI) framework as a foundation to understand quality. Empirical research in the United States and worldwide using the Teaching Through Interactions (TTI) framework (Hamre & Pianta, 2007) has identified associations between specific types of teacher–child interactions and children's socio-emotional, cognitive, and academic development (e.g., Burchinal et al., 2016; Cadima et al., 2010; Leyva et al., 2015). Moreover, the nature of teacher–child interactions appears particularly important for children from low-income backgrounds (e.g., Curby et al., 2001; Hatfield et al., 2012). A meta-analysis examining preschool quality features found that teacher–child interactions were a stronger predictor of child outcomes than other general quality measures in low-income contexts (Burchinal et al., 2016). Further, experimentally controlled studies indicate that students in classrooms characterized by high-quality teacher–child interactions contributed to children developing higher executive function (Araujo et al., 2014; Kane et al., 2013).

The TTI framework classifies teacher–child interactions in preschool into three domains. The first, Emotional Support, refers to positive communication and affect in the classroom, sensitivity, and responsiveness to children's needs, and regard for students' perspectives. The second, classroom organization, refers to teachers' ability to proactively manage children's behavior, engage children in interesting activities, and organize the time in the classroom. Lastly, Instructional support involves engaging children in higher-order thinking activities (Hamre et al., 2013). The only study that, to our knowledge, has examined classroom interaction quality as a moderator between preschool dosage and child outcomes found that the quality of classroom experiences did not moderate the effects of dosage on academic outcomes (Xue et al., 2016). However, this study found no associations between one additional year of preschool and teacher-reported social outcomes for children attending Head Start.

The Present Study

Research on preschool dosage has shown a positive association between attending more preschool years and academic outcomes. Nevertheless, the benefits of preschool attendance for socioemotional outcomes such as self-regulation are less clear. Furthermore, the quality of teacher–child interactions as a moderator of dosage has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored. The present study addresses these issues by examining how children's self-regulation skill development has yet to be explored.

Methods

Participants

The present study used data from the Family and Children Experiences Survey (FACES, 2009), which followed children attending Head Start when they were three and four years old until kindergarten. The cohort structure under
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1 3

analysis is shown in Fig. 1. The sample represents the population of children who entered Head Start in the fall of 2009, excluding children already in their second year (estimated to be approximately 30% of the Head Start population). It includes 60 programs, with two centers per program, up to three classrooms per center, 486 classrooms, and 2,383 children across all programs in fall 2009. The data includes four waves of data collection: fall and spring of children’s first Head Start year, spring of the second Head Start year for children in the 3 years old cohort, and spring of the children’s kindergarten year.

Measures

Self-Regulation in this study utilized a direct and composite of teacher-reported measures of a child’s behavioral self-regulation. The Pencil Tap (Smith-Donald et al., 2007) is a direct measure adapted from the peg tap (Diamond & Taylor, 1996). In this test, the child is asked to do the opposite of what the assessor does, tap with the pencil once when the assessor taps twice, and vice versa. Pencil Tap objectively assesses children’s cognitive self-regulation, specifically inhibitory control, which relates to young children’s development in mathematics, vocabulary, and literacy (Blair & Razza, 2007; Espy et al. 2004; McClelland et al., 2007). Children were assessed on the Pencil Tap for each time point for the four-year-old cohort and the second through the fourth timepoint for the three-year-old cohort. The measure had internal reliability of 0.82 in preschool and 0.75 in kindergarten. This variable was transformed into a categorical variable to deal with the negative skewness of its distribution in this sample (skewness = 2.24). The transformed variables included three categories: low-range (under 60% of correct responses), mid-range (between 60 and 89% of correct answers), and high-range (90% or more correct responses).

Teacher-reported self-regulation comprised the Approaches to Learning scale and the Problem Behaviors scale. Approaches to Learning (U.S. Department of Education, 2002) assesses a child’s motivation, attention, organization, persistence, and independence in learning. The scale has established reliability (Cronbach alpha = 0.89) and demonstrated relations with elementary school academic achievement (Duncan et al., 2007). The Problem Behaviors scale is an abbreviated adaptation of the Personal Maturity Scale (Entwisle et al., 1987) and the Behavior Problems Index (BPI, Peterson & Zill, 1986). It measures negative child behaviors associated with learning problems and later grade retention. This scale was inversed before being standardized. Items in both scales were inter-correlated at an alpha level of 0.90. The Teacher-reported self-regulation composite was created by standardizing scores and averaging across both scales.

Classroom Quality was measured using The Classroom Assessment Scoring System (CLASS; Pianta et al., 2008). CLASS is a validated classroom observation tool that assesses teacher–child interactions across ten dimensions. Previous research demonstrates that these dimensions are organized into three broad domains (Hamre et al., 2014): Emotional Support, Classroom Organization, and Instructional Support. Each domain includes dimensions scored on a 7-point scale, with 1–2 representing low scores, 3–5 representing moderate scores, and 6–7 representing high scores. This study used a bifactor approach to interpret the CLASS, which presents a revised conceptualization of the CLASS scores that have been previously validated and shown to fit better the data than the three-domain factor solution (Hamre et al., 2014; Reise et al., 2010). We used Mplus 7.4 to fit the bifactor model of the CLASS, as shown in Fig. 2. The orthogonal factor scores created in the bifactor model were imported into Stata 14. SE, and examined concurrently in the predictive models for each outcome. The model showed adequate fit to the sample based on analyzed fit statistics and a better fit than the traditional 3-domain solution (see Table 1).

Children and Families Socio-demographic characteristics: At baseline (fall 2009), parents answered a survey

Fig. 1 Head start cohort structure

Fall 2009 Spring 2010 Spring 2011 Spring 2012

3-Year-old cohort

HS

K

4-Year-old cohort

HS

K

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about their socio-demographic characteristics (such as race, ethnicity, and age), their context (such as household size, poverty, if parents were working), and activities at home (such as reading books, time spent watching tv). They also answered questions about their children’s socio-demographic characteristics. These variables were used as covariates (see Table 2).

**Methodological Considerations in the Study of Dosage and Child Outcomes**

A challenge in studying the effects of preschool experiences, such as dosage or quality, is the absence of randomization on key variables of interest. *Propensity Score Matching* is a commonly used statistical approach to minimize selection bias and improve the ability to make causal inferences from non-randomized studies of preschool dosage (PSM; Rosenbaum & Rubin, 1984). PSM is a method that can significantly reduce selection bias and provide more robust estimates by matching participants with comparable demographic and other pre-treatment characteristics on their probability to participate in the treatment independently of their actual participation in treatment (Cook et al., 2002). PMS has become one of the preferred methods of researchers studying the dosage of preschool and child outcomes in non-randomized samples.
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Analytic Plan

To examine the number of years as dosage, we used PMS. Also, we conducted an Ordinary-Least-Squares (OLS) linear regression replicating the PSM models as a sensitivity test. We used OLS regression models to examine the number of hours weekly as dosage and the moderation analysis. All analyses were conducted using Stata/SE 14.2.

Sample Matching Process

We classified covariates into parent/family context, child-level, and program/teacher level. We examined all existing variables in each of these categories and selected variables that are the most relevant from a theoretical perspective. All covariates were measured at baseline (Fall 2009). See Table 2 for a list of the covariates and their descriptive statistics.

PSM analyzes were conducted using the nearest-neighbor matching technique with replacement and a caliper of 0.1 (Stuart, 2010). Only those with a close match were included in this set of analyses, referred to as the Region of Common Support (Harder et al., 2010). The Region of Common Support included 1653 children, excluding 730 children from the whole sample who had no match (see Table 3). Once the samples were matched, and adequate balance was achieved (see Table 4), outcomes variables were added back to the data set and estimated the effects of two versus 1 year of HS, including the full range of covariates in the model to adjust for any potential remaining bias (Coley & Lombardi, 2013). To address missing data issues, we used multiple imputation and imputed 20 data sets using the chained-equations method (White et al., 2011). We accounted for the nesting of children in classrooms by using robust standard errors clustered at the classroom level.

(see Domitrovich et al., 2013; Wen et al., 2012; Youn, 2016).

Table 1 Comparison between bifactor model of the CLASS, three-domain and one-domain CFA

| Domains | Bifactor model | CFA—Three factors | CFA—One factor |
|---------|----------------|-------------------|----------------|
|         | General domain | Positive Management and Routines | Cognitive Facilitation | Emotional support | Classroom organization | Instructional support |                 |
|         | Teaching       |                     |                          | β (B) | β (B) | β (B) | β (B) | β (B) |
| CLASS dimensions | Positive climate |Responsive Teaching |    0.70 (1.00) | 0.35 (1.00) | 0.74 (1.00) | 0.76 (1.00) |
| Teacher sensitivity | 0.92 (1.34) | 0.92 (1.27) | 0.85 (1.13) |
| Regard for student perspectives | 0.82 (1.19) | 0.81 (1.27) | 0.76 (1.02) |
| Behavior management | 0.60 (0.92) | 0.52 (1.62) | 0.72 (1.00) | 0.67 (0.96) |
| Productivity | 0.62 (1.05) | 0.43 (1.48) | 0.74 (1.12) | 0.69 (1.09) |
| Instructional learning formats | 0.70 (1.23) | 0.74 (1.16) | 0.70 (0.85) |
| Concept development | 0.60 (0.75) | 0.60 (1.00) | 0.83 (1.00) | 0.64 (0.87) |
| Quality of feedback | 0.87 (0.77) | 0.87 (1.50) | 0.93 (1.17) | 0.63 (0.89) |
| Language modeling | 0.51 (0.97) | 0.51 (1.07) | 0.76 (1.10) | 0.63 (1.02) |
| Variances | 0.18 | 0.04 | 0.14 | 0.20 | 0.22 | 0.27 | 0.21 |
| Model fit | CFI | 0.94 | 0.91 | 0.73 |
|          | RMSEA | 0.13 | 0.15 | 0.24 |
|          | SRMR | 0.05 | 0.05 | 0.09 |
Table 2  Means and standard deviations of the covariates and variables for the whole sample

| Variable                                      | Means and standard deviations (n = 2383) |
|-----------------------------------------------|----------------------------------------|
| **Family-level covariates**                   |                                        |
| Family demographic information               |                                        |
| Income/poverty ratio                         | 2.8 (1.79)                             |
| Household size                               | 4.6 (1.62)                             |
| Parents born in the US?                      |                                        |
| Both parents born in US                      | 0.62                                   |
| One parent born outside US                   | 0.09                                   |
| Both parents born outside US                 | 0.29                                   |
| Home language/non-English                    | 0.29                                   |
| Mother's age                                 | 28.7 (5.92)                            |
| Mother's education                           |                                        |
| Less than high school diploma                | 0.36                                   |
| High school diploma                          | 0.34                                   |
| Some vocational/tech-associate degree        | 0.24                                   |
| Bachelor degree or higher                    |                                        |
| Mother's employment status                   |                                        |
| Working full-time                            | 0.26                                   |
| Working part-time                            | 0.21                                   |
| Looking for work                             | 0.22                                   |
| Not in labor force                           | 0.31                                   |
| Father's employment status                   |                                        |
| Working full-time                            | 0.53                                   |
| Working part-time                            | 0.18                                   |
| Looking for work                             | 0.18                                   |
| Not in labor force                           | 0.11                                   |
| Parent depression symptoms                   | 1.60 (0.93)                            |
| Family activities                            |                                        |
| Parents read to the child 3 times a week or more | 0.75                              |
| Number of parent-child activities in the past week | 11.28 (2.07)                        |
| Time child spent watching TV                 | 2.77 (0.86)                            |
| Hours of sleep at night                      | 10.43 (0.92)                           |
| Child care before or after HS                | 0.38 (0.49)                            |
| **Child characteristics**                    |                                        |
| Child's gender/Male                          | 0.50                                   |
| Child's race                                 | 0.20                                   |
| Variable | Means and standard deviations (n = 2383) |
|----------|----------------------------------------|
| Black    | 0.32                                   |
| latino   | 0.40                                   |
| American Indian or other | 0.08                                   |
| *Child’s age in month at Kindergarten assessment | 71.2 (3.85) |
| ECLS–B Mathematics T-score at baseline | 49.45 (9.81) |
| ECLS–B Letter-Sound Knowledge T-score at baseline | 44.31 (10.8) |

**HS program/teacher characteristics**

| Type of curriculum |  |
|--------------------|---|
| Creative curriculum| 0.56 |
| High scope         | 0.17 |
| Other (montessori, high reach or Scholastic) | 0.12 |
| Locally created    | 0.15 |
| Teacher–child ratio| 8.44 (20.23) |
| Number of children in classroom | 17.12 (2.22) |
| Teacher depressive symptoms | 1.49 (0.76) |

**Predictor variables**

| Quality of teacher–child interactions in HS |  |
|--------------------------------------------|---|
| Responsive teaching                        | 0.0 (0.40) |
| Positive management and routines           | 0.00 (0.15) |
| Cognitive facilitation                     | − 0.00 (0.37) |
| Amount of head start                       |  |
| Number of hours a week                     | 25.17 (10.14) |
| Absenteeism                                | 6.19 (5.93) |

**Child outcomes**

| Pencil tap | Teacher-reported Self-regulation |  |
|------------|---------------------------------|---|
|            | 2.27 (0.76)                     | − 0.02 (0.95) |

Means for categorical variables are proportions. Standard deviations as shown in parentheses.
Table 3  Means and standard deviations for samples in the region of common support (ROCS) and outside the ROCS

| Variable                                           | Means and standard deviations | Region of common support | Not in the region of common support | p  |
|----------------------------------------------------|-------------------------------|--------------------------|------------------------------------|----|
| **Family-level covariates**                        |                               |                          |                                    |    |
| Income/poverty ratio                                | 2.76 (1.77)                   | 2.91 (1.87)              | > .250                             |    |
| Household size                                      | 4.61 (1.61)                   | 4.52 (1.55)              | > .250                             |    |
| Parents born in the US?                             |                               |                          |                                    |    |
| Both parents born in US                             | 0.59                          | 0.66                     |                                    |    |
| One parent born outside US                          | 0.08                          | 0.10                     | > .250                             |    |
| Both parents born outside US                        | 0.33                          | 0.24                     | 0.02                               |    |
| Home language/non-English                           | 0.34                          | 0.25                     | 0.02                               |    |
| Mother’s age                                        | 29.1 (5.94)                   | 28.47 (5.94)             | 0.14                               |    |
| Mother’s education                                  |                               |                          |                                    |    |
| Less than high school diploma                       | 0.39                          | 0.28                     | 0.00                               |    |
| High school diploma                                | 0.34                          | 0.39                     | 0.01                               |    |
| Some vocational/tech-associate degree               | 0.22                          | 0.26                     | 0.02                               |    |
| Bachelor degree or higher                           | 0.05                          | 0.07                     | 0.11                               |    |
| Mother’s employment status                          |                               |                          |                                    |    |
| Working full-time                                   | 0.27                          | 0.26                     | > .250                             |    |
| Working part-time                                   | 0.21                          | 0.23                     | > .250                             |    |
| Looking for work                                    | 0.21                          | 0.22                     | > .250                             |    |
| Not in labor force                                  | 0.31                          | 0.29                     | > .250                             |    |
| Father’s employment status                          |                               |                          |                                    |    |
| Working full-time                                   | 0.54                          | 0.50                     | > .250                             |    |
| Working part-time                                   | 0.16                          | 0.23                     | 0.17                               |    |
| Looking for work                                    | 0.19                          | 0.16                     | > .250                             |    |
| Not in labor force                                  | 0.11                          | 0.11                     | > .250                             |    |
| Parent depression symptoms                          | 1.6 (0.92)                    | 1.62 (0.96)              | > .250                             |    |
| **Family activities**                               |                               |                          |                                    |    |
| Parents read to the child 3 times a week or more    | 0.74                          | 0.73                     | > .250                             |    |
| Number of parent–child activities in the past week  | 11.21 (2.13)                  | 11.47 (2.03)             | 0.12                               |    |
| Time child spent watching TV                        | 2.78 (0.84)                   | 2.76 (0.88)              | > .250                             |    |
| Hours of sleep at night                             | 10.42 (0.92)                  | 10.46 (0.97)             | > .250                             |    |
| Child care before or after HS                       | 0.39                          | 0.39                     | > .250                             |    |
| **Child characteristics**                           |                               |                          |                                    |    |
| Child’s gender/male                                 | 0.5                           | 0.53                     | > .250                             |    |
| Child’s race                                        |                               |                          |                                    |    |
| White                                               | 0.19                          | 0.21                     | > .250                             |    |
| Black                                               | 0.3                           | 0.36                     | > .250                             |    |
| Latino                                              | 0.44                          | 0.33                     | 0.13                               |    |
| American Indian or other                            | 0.07                          | 0.10                     | > .250                             |    |
| *Child’s age in month at Kindergarten assessment    | 72.03 (3.86)                  | 71.32 (3.56)             | 0.01                               |    |
| ECLS–B Mathematics T-score at baseline             | 51.71 (9.36)                  | 40.23 (6.99)             | 0.00                               |    |
| ECLS–B Letter-Sound Knowledge T-score at baseline   | 45.27 (10.75)                 | 40.26 (10.29)            | 0.00                               |    |
| **HS program/teacher characteristics**              |                               |                          |                                    |    |
| Type of curriculum                                  |                               |                          |                                    |    |
| Creative curriculum                                 | 0.55                          | 0.58                     | > .250                             |    |
| High scope                                          | 0.15                          | 0.15                     | > .250                             |    |
| Other (Montessori, high reach or Scholastic)        | 0.12                          | 0.11                     | > .250                             |    |
| Locally created                                     | 0.18                          | 0.16                     | > .250                             |    |
| Teacher–child ratio                                 | 8.63 (2.30)                   | 8.03 (2.19)              | > .250                             |    |
Results

To address our research questions, the first model included the main effects of dosage and quality variables and the covariates on self-regulation. Each outcome variable was examined on a separate model: teacher-reported behavioral self-regulation and the direct measure of cognitive self-regulation. The second model included main effects and interaction terms between the two main dosage variables (number of years and number of hours a week) and the CLASS factors to examine how the quality of classroom experiences moderated the relation between dosage and self-regulation.

Impact of Number of Years of HS Attendance and Moderation by Teacher–Child interactions Quality

For the first model examining cognitive self-regulation as a function of the amount and quality of HS experiences, Propensity Score Matching (PMS) results showed that dosage and quality predicted 17% of the variance in the outcome. Results indicated that a larger number of years in HS was positively associated with cognitive self-regulation in kindergarten, as measured by pencil tap ($R^2 = 0.14, F(38, 350.4) = 2.42, p = 0.001$). Children’s pencil tap score increased by 0.20 points for the additional year in HS after controlling for age at assessment and baseline characteristics. Teacher-reported behavioral self-regulation was also significantly associated with the number of years in HS ($R^2 = 0.02, F(40, 405.3) = 9.94, p < 0.001$). Teachers reported children’s self-regulation increased by 0.3 standard deviations for an additional year in HS, ceteris paribus (see Table 5).

The second model examined the quality of teacher–child interactions in HS as a moderator between the amount of HS experiences (dosage) and self-regulation (cognitive and behavioral) in kindergarten. Results from PMS showed that the cognitive facilitation factor of quality of teacher–child interactions marginally moderated the relation between the number of years in HS and the teacher-reported measure of self-regulation ($p = 0.06$), ceteris paribus. No other significant interactions were found for the number of years.

Impact of Hours a Week in HS Attendance and Moderation with Teacher–Child Interactions Quality

We use OLS results to examine the relation between hours a week and self-regulation. Results showed that the number of hours a week in HS was not significantly associated with cognitive or teacher-reported behavioral self-regulation. However, there was a significant interaction between the number of hours a week and Responsive Teaching ($R^2 = 0.14, F(44, 364.7) = 2.30, p = 0.05$), indicating that the relation between hours a week and cognitive self-regulation was stronger in classrooms with a higher quality of
Table 4  Mean differences for matched samples

| Variable                                           | 1 year in HS | 2 years in HS | Differences between cohorts |
|----------------------------------------------------|--------------|---------------|-----------------------------|
|                                                   | \( (n = 772)\) | \( (n = 799)\) | \( (p)\)                    |
| **Family-level covariates**                        |              |               |                             |
| Income/poverty ratio                              | 2.8 (1.85)   | 2.78 (1.75)   | > .250                      |
| Household size                                    | 4.59 (1.60)  | 4.61 (1.60)   | > .250                      |
| Parents born in the US?                           |              |               |                             |
| Both parents born in US                           | 0.24         | 0.21          | > .250                      |
| One parent born outside US                        | 0.09         | 0.09          | > .250                      |
| Both parents born outside US                      | 0.33         | 0.32          | > .250                      |
| Home language/non-English                         | 0.34         | 0.32          | > .250                      |
| Mother’s age                                      | 29.21 (6.10) | 29.06 (5.93)  | > .250                      |
| Mother’s education                                |              |               |                             |
| Less than high school diploma                     | 0.37         | 0.36          | > .250                      |
| High school diploma                               | 0.35         | 0.36          | > .250                      |
| Some vocational/tech-associate degree             | 0.22         | 0.23          | > .250                      |
| Bachelor’s degree or higher                       | 0.06         | 0.06          | > .250                      |
| Parent depression symptoms                        |              |               |                             |
| Working full-time                                 | 0.27         | 0.26          | > .250                      |
| Working part-time                                 | 0.21         | 0.21          | > .250                      |
| Looking for work                                  | 0.21         | 0.21          | > .250                      |
| Not in labor force                                | 0.32         | 0.31          | > .250                      |
| Father’s employment status                        |              |               |                             |
| Working full-time                                 | 0.53         | 0.53          | > .250                      |
| Working part-time                                 | 0.18         | 0.18          | > .250                      |
| Looking for work                                  | 0.18         | 0.18          | > .250                      |
| Not in labor force                                | 0.11         | 0.11          | > .250                      |
| Parent depression symptoms                        | 1.63 (0.93)  | 1.61 (0.93)   | > .250                      |
| **Family activities**                             |              |               |                             |
| Parents read to the child 3 times a week or more  | 0.73         | 0.73          | > .250                      |
| Number of parent–child activities in the past week| 11.20 (2.16) | 11.26 (2.17) | > .250                      |
| Time child spent watching TV                      | 2.77 (0.84)  | 2.77 (0.84)   | > .250                      |
| Hours of sleep at night                           | 10.43 (0.89) | 10.42 (0.94) | > .250                      |
| Child care before or after HS                     | 0.39         | 0.40          | > .250                      |
| **Child characteristics**                         |              |               |                             |
| Child’s gender/male                               | 0.51         | 0.51          | > .250                      |
| Child’s race                                      |              |               |                             |
| White                                              | 0.19         | 0.19          | > .250                      |
| Black                                              | 0.31         | 0.32          | > .250                      |
| Latino                                             | 0.43         | 0.42          | > .250                      |
| American Indian or other                           | 0.07         | 0.07          | > .250                      |
| *Child’s age in month at Kindergarten assessment  | 70.76 (4.03) | 72.67 (3.64) | < .001                      |
| ECLS–B Mathematics T-score at baseline            | 47.80 (8.17) | 47.91 (7.73) | > .250                      |
| ECLS–B Letter-Sound Knowledge T-score at baseline | 43.50 (10.29)| 43.52 (10.38)| > .250                      |
| **HS program/teacher characteristics**            |              |               |                             |
| Type of curriculum                                 |              |               |                             |
| Creative curriculum                               | 0.56         | 0.54          | > .250                      |
| High scope                                        | 0.16         | 0.15          | > .250                      |
| Other (Montessori, High Reach or Scholastic)      | 0.12         | 0.12          | > .250                      |
| Locally created                                   | 0.16         | 0.17          | > .250                      |
Means for categorical variables are proportions. Standard deviations are shown in parentheses.

| Variable | 1 year in HS | 2 years in HS | Differences between cohorts |
|----------|--------------|---------------|-----------------------------|
|          | \(n = 772\) | \(n = 799\)   | \(p\)                      |
| Teacher–child ratio | 8.44 (2.28) | 8.43 (2.09) | > .250                     |
| Number of children in classroom | 17.15 (2.24) | 17.15 (2.08) | > .250                     |
| Teacher depressive symptoms | 1.50 (0.74) | 1.49 (0.74) | > .250                     |

*Predictor variables

Quality of teacher–child interactions in HS
- Responsive teaching: \(-0.01 (0.41)\) to \(0.03 (0.38)\), \(p = 0.104\)
- Positive management and routines: \(-0.01 (0.16)\) to \(-0.00 (0.15)\), \(p > .250\)
- Cognitive facilitation: \(-0.02 (0.36)\) to \(-0.02 (0.36)\), \(p > .250\)

Amount of head start
- Number of hours a week: 23.74 (10.39) to 25.87 (9.81), \(p < .001\)
- Absenteeism: 6.06 (5.14) to 6.08 (6.56), \(p > .250\)

*Child outcomes

Pencil tap: 2.08 (0.77) to 2.34 (0.74), \(p < .001\)
Teacher-reported self-regulation: \(-0.26 (0.99)\) to \(0.08 (0.92)\), \(p < .001\)

Means for categorical variables are proportions. Standard deviations are shown in parentheses.

*Not included in the matching

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Table 5  Results from OLS and PSM predictive models

| Variables | Pencil Tap | Teacher-reported self-regulation |
|-----------|------------|----------------------------------|
|           | OLS model  | PSM model                        | OLS model  | PSM model                        |
|           | \(B\) \(SE\) | \(B\) \(SE\) \(p\) | \(B\) \(SE\) | \(B\) \(SE\) | \(B\) \(SE\) | \(p\) | \(B\) \(SE\) | \(B\) \(SE\) | \(B\) \(SE\) | \(p\) |
| Dosage    |            |                                  |            |                                  |
| Number of year in HS | 0.20** 0.06 | 0.001 | 0.23* 0.06 | 0.000 | 0.30** 0.05 | 0.000 | 0.32** 0.06 | 0.000 |
| Number of hours a week | 0.00 0.00 | 0.258 | 0.00 0.00 | 0.681 | 0.00 0.00 | 0.533 | 0.00 0.00 | 0.269 |
| Days absent | 0.00 0.00 | 0.837 | 0.00 0.01 | 0.659 | 0.00 0.00 | 0.422 | 0.00 0.01 | 0.650 |
| Quality   |            |                                  |            |                                  |
| Responsive teaching | 0.09 0.07 | 0.165 | 0.06 0.09 | 0.496 | \(-0.02\) 0.05 | 0.701 | \(-0.02\) 0.09 | 0.813 |
| Positive management and routines | 0.05 0.17 | 0.753 | 0.02 0.18 | 0.922 | \(-0.08\) 0.16 | 0.612 | \(-0.03\) 0.22 | 0.895 |
| Cognitive facilitation | 0.01 0.07 | 0.885 | 0.01 0.09 | 0.874 | \(-0.07\) 0.06 | 0.270 | \(-0.08\) 0.10 | 0.441 |
| Dosage interactions |            |                                  |            |                                  |
| Number of year in HS \(\times\) days absent | 0.01 0.01 | 0.295 | 0.01 0.01 | 0.263 | 0.01 0.01 | 0.194 | 0.01 0.01 | 0.338 |
| Number of hours a week \(\times\) days absent | 0.00 0.00 | 0.079 | 0.00 0.00 | 0.217 | 0.00 0.00 | 0.956 | 0.00 0.00 | 0.833 |
| Quality interactions |            |                                  |            |                                  |
| N. of years in HS \(\times\) responsive teaching | \(-0.18\) 0.11 | 0.094 | \(-0.12\) 0.15 | 0.439 | 0.02 0.12 | 0.885 | 0.03 0.18 | 0.863 |
| N. of years in HS \(\times\) Pos. Mng. and routines | 0.08 0.36 | 0.833 | 0.07 0.46 | 0.873 | 0.15 0.30 | 0.610 | 0.09 0.42 | 0.827 |
| N. of years in HS \(\times\) Cognitive facilitation | \(-0.02\) 0.12 | 0.847 | 0.00 0.17 | 0.978 | 0.31** 0.11 | 0.008 | 0.33 0.17 | 0.057 |
| N. of Hrs. a week \(\times\) Responsive teaching | 0.01* 0.01 | 0.042 | 0.01 0.01 | 0.154 | 0.00 0.01 | 0.990 | 0.00 0.01 | 0.950 |
| N. of Hrs. A week \(\times\) Pos. Mng. and routines | \(-0.02\) 0.02 | 0.154 | \(-0.01\) 0.02 | 0.554 | 0.01 0.02 | 0.380 | 0.02 0.02 | 0.270 |
| N. of Hrs. A week \(\times\) Cognitive facilitation | 0.00 0.01 | 0.944 | 0.00 0.01 | 0.746 | 0.00 0.01 | 0.461 | 0.00 0.01 | 0.928 |

*p < .05, **p < .01
responsive teaching (see Fig. 3). Additionally, a significant interaction was found for the teacher-reported measure of behavioral self-regulation between years in HS and Cognitive Facilitation ($\beta = 0.31, p < 0.05$).

**Discussion**

The present study aimed to address the gap in understanding how preschool dosage for children from low-income families related to kindergarten self-regulation and whether quality moderated the association. Two key findings emerged. First, the number of years, but not hours a week in Head Start related to self-regulation, including cognitive and behavioral self-regulatory skills. Second, the number of hours a week in HS meaningful contributed to self-regulation when classrooms exhibited high levels of responsive teaching or cognitive facilitation, but that was not the case for the number of years in HS. Findings contribute to the growing body of evidence about how dosage and quality of early childhood education experiences relate to children’s development. Results and implications for how we support young children in families experiencing poverty will be further explored below.

**Unpacking the Complexity of Dosage and Quality with Children’s Self-Regulation**

Findings from this study are consistent with prior research that has found somewhat mixed evidence about how preschool experiences relate to outcomes (see Huston et al., 2015). Specifically, children that attended two years benefited more than those who attended only one year of HS. This result is consistent with studies that found that the number of years in preschool is associated with positive academic (Domitrovich et al., 2013; Xue et al., 2016; Youn, 2016) and behavioral outcomes (Moore et al., 2015; Wen et al., 2012). On the other hand, this study did not find an association between more hours a week and children’s self-regulation in kindergarten. This contrasts with other studies that show more hours a week of attendance in preschool associated with classroom behavior problems (Huston et al., 2015; McCartney et al., 2010; NICHD Early Child Care Research Network, 2004). Thus, the role of dosage continues to be essential but not clear-cut in how it can contribute to children’s development.

This study partially addresses this complexity by examining the moderating role of classroom quality. Specifically, there was a significant positive association between the number of hours a week (and a marginally significant relationship with years) and self-regulation when the quality of the classroom was high. Children who attended HS more hours a week have a positive and stronger association with cognitive and behavioral self-regulation in kindergarten, in classrooms with higher quality teacher–child interactions. More specifically, results revealed a significant interaction between more hours a week and Responsive Teaching, the general factor of classroom quality, for cognitive self-regulation. Children in classrooms with a higher quality of Responsive Teaching benefited more from attending more hours a week than those in low-quality classrooms.

These findings are consistent with previous research examining the relation between the number of hours a week in preschool and child outcomes. McCartney et al. (2010), for example, found that the quality of classroom experiences moderated the adverse effects of more hours of preschool on socioemotional outcomes. In other words, more hours a week in higher-quality classrooms did not relate negatively to socioemotional outcomes, while more hours in low-quality classrooms resulted in negative child outcomes.

**Considering Implications for Children in Families Experiencing Poverty**

Previous studies have emphasized the importance of quality of preschool experiences for more disadvantaged
children, as these children benefit the most from high-quality teacher–child interactions (Hamre & Pianta, 2005). Because the relation between quantity and quality of preschool experiences is largely dependent on the counterfactual experience for a particular child, high-quality interactions in disadvantaged settings are even more critical than in less underprivileged contexts.

Children living in poverty face a particular set of challenges that can harm the development of self-regulation. Children’s development of self-regulation is susceptible to toxic stress exposure, which is characteristic of poverty–living conditions due to economic hardship, food insecurity, unpredictability, and other daily hassles (Blair, 2010; Hamoudi et al., 2015). Research has shown that the relation between stress and attention takes the shape of an inverted U, where some middle-stress levels result in enhanced self-regulation and functioning. In contrast, very low or high-stress levels result in poorer self-regulation (Hamoudi et al., 2015). Chronic or prolonged stimulation of stress results in concentrations of stress hormones in the brain, which inhibit the functioning of higher-order skills.

However, evidence indicates that high-quality preschool experiences can counteract some of the negative effects described above resulting from living in chaotic and stressful household environments (Hamre & Pianta, 2005; Raver et al., 2008). For instance, Hamre and Pianta (2005) conducted a longitudinal study with children identified as at-risk by kindergarten teachers. The authors found that children in classrooms with high emotional and instructional support performed as well as their low-risk peers by the end of first grade on a series of academic and behavioral outcomes. As Obradović (2016) also describes, supportive educational contexts, like those in the classroom with supportive teacher–child interactions, may be conducive for physiologically reactive children.

Limitations

Results need to be considered in light of some limitations, such as the study’s correlational nature and the relative scarcity of information about counterfactual experiences for children who stayed at home. Moreover, the limited external validity of our findings makes this study only applicable to Head Start. Future studies examining preschool experiences should ideally include information about possible counterfactuals to Head Start and other types of early childcare settings. It is also recommended for future research to test the models presented in this study with a conventional three-factor solution of the CLASS to compare findings.

Despite the limitations, the present study provides new information regarding the relevance of more preschool experiences under the condition that they are high-quality experiences for children from low-income backgrounds. This study can provide a novel contribution to the field as research that examines the dosage of preschool experiences and quality as a moderator using rigorous methods that reduce selection bias is relatively new (Zaslow et al. 2016). As Blair and Raver (2015) have argued, self-regulation may be a primary mechanism through which poverty affects school success; thus, focusing on ways to promote self-regulation in preschool is very important. Therefore, these findings have important policy implications, suggesting the importance of starting Head Start at age three and increasing the number of hours jointly with improving the quality of experiences to support the development of self-regulation. Finally, this research contributes to the current discussion about the role of face-to-face education in early age. Recent evidence has shown an important rate of learning loss (Engzell et al. 2021) and negative consequences on the mental and developmental health of children (de Araújo et al., 2020) due to the school closures because of the coronavirus (COVID-19) pandemic. Hence, the study of the consequences of preschool dosage and the quality of teachers on self-regulation gives a relevant perspective to continue with the current educational debate.

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