Maternal Scaffolding and Home Stimulation: Key Mediators of Early Intervention Effects on Children's Cognitive Development

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This study contributes to the understanding of how early parenting interventions implemented in low- and middle-income countries during the first 2 years of children's lives are sustained longitudinally to promote cognitive skills in preschoolers. We employed path analytic procedures to examine 2 family processes—the quality of home stimulation and maternal scaffolding behaviors—as underlying mechanisms through which a responsive stimulation intervention uniquely predicted children's verbal intelligence, performance intelligence, and executive functioning. The sample included 1,302 highly disadvantaged children and their mothers living in rural Pakistan, who from birth participated in a 2-year, community-based, cluster-randomized, controlled trial designed to promote sensitive and responsive caregiving. Family processes were assessed at 2 developmental time points using parent reports, ratings of home environments, and observed parent–child interactions. Cognitive skills at age 4 were assessed using standardized tests. Controlling for socioeconomic risk (e.g., wealth, maternal education, food insecurity) and individual factors (e.g., gender, growth status), the quality of current home stimulation as well as both earlier and concurrent measures of maternal scaffolding independently mediated the intervention effects on cognitive skills at age 4. In addition, the intervention had a significant direct effect on executive functioning and performance intelligence over and above significant family processes and other covariates. We highlight implications for future program design and evaluation studies.

Keywords: cognitive development, executive functioning, early parenting intervention, low- and middle-income countries, home stimulation

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Young children in low- and middle-income countries (LMIC) face severe adversity that compromises their prenatal and early childhood development, including exposure to food insecurity, poor nutrition, infectious diseases, environmental toxins, maternal depression, and societal violence (see Fisher et al., 2012; Walker et al., 2011 for details). Many children also lack adequate stimu-

lation and learning opportunities at home (Bornstein & Putnick, 2012; Engle et al., 2011). The accumulation of these poverty-related risks may seriously undermine the development and activation of brain regions known to support emerging cognitive skills (Noble, Houston, Kan, & Sowell, 2012; Shonkoff, Boyce, & McEwen, 2009). As a result, more than 200 million children in LMIC do not reach their cognitive development potential by 5 years of age (Grantham-McGregor et al., 2007). Early childhood development (ECD) interventions have been shown to improve early cognitive outcomes in LMIC (Aboud & Yousafzai, 2015; Engle et al., 2011), yet very little is known about the mediating processes through which intervention effects operate and are maintained over time. The current study tested longitudinal effects of a responsive stimulation intervention implemented in rural Pakistan during the first 2 years of children's lives. We examined whether the quality of earlier and concurrent home stimulation and maternal scaffolding mediated intervention effects on verbal intelligence, performance intelligence, and executive functioning in 4 years-olds.

Parenting Interventions and Early Cognitive Development in LMIC

Many successful interventions in LMIC target parenting knowledge and practices as a way to bolster children's development during the first 1,000 days of life (Aboud & Yousafzai, 2015;

Engle et al., 2011; Grantham-McGregor, Fernald, Kagawa, & Walker, 2014). Programs are typically delivered by community paraprofessionals through home visits, group meetings, or both. A diverse range of family focused ECD programs have been shown to produce consistent, short-term improvements in children's cognitive outcomes (Aboud & Yousafzai, 2015; Engle et al., 2011). According to a recent meta-analysis, responsive stimulation interventions delivered in the first 2 years of life (with or without nutrition interventions) had a moderate effect on children's cognitive (average Cohen's $d = 0.420$) and language (average Cohen's $d = 0.468$) skills (Aboud & Yousafzai, 2015).

However, less is known about the sustainability of intervention effects over time. Studies in Jamaica have produced mixed evidence about the longitudinal benefits of early stimulation interventions on cognition and academic achievement in school-age children (Grantham-McGregor, Walker, Chang, & Powell, 1997; Walker, Chang, Younger, & Grantham-McGregor, 2010; Walker, Grantham-McGregor, Powell, & Chang, 2000). More research is needed to extend this work to other LMIC contexts and to examine cognitive outcomes in the preschool years. Studies show that preschool attendance promotes cognitive and preacademic skills in LMIC children (Aboud & Hossain, 2011; Engle et al., 2011; Rao, Sun, Zhou, & Zhang, 2012), but access to early education programs in rural areas can be very limited and the quality is often poor. Thus, it is crucial that we better understand the family's role in preparing children for the transition to primary school. This work would also help us determine the degree to which the early intervention benefits recede prior to school entry and subsequent exposure to variable education opportunities.

To date, evaluations of ECD interventions in LMIC have focused primarily on measures of global intelligence or language skills (Fernald, Kariger, Engle, & Raikes, 2009). Yet research from high-income countries reveals that such measures do not encompass the full set of skills that children need to transition successfully to school settings. School transition and readiness are crucially supported by executive functions (EFs), the higher order cognitive skills that enable self-regulation of attention, behavior, and emotions through the use of inhibitory control, working memory, and cognitive flexibility (Diamond, 2013; Zelazo, 2015). Moreover, the contribution of EFs to adaptive classroom behaviors and early childhood academic achievement is independent of language and general intelligence (McClelland & Cameron, 2012; Obradović, Portilla, & Boyce, 2012). In a rural LMIC context, EF assessments provide an especially useful index of early cognitive capacities, since they can be designed to minimize measurement biases that are due to limited exposure to educational programming, media, and modern technology (Obradović et al., 2016). Further, prior impact evaluation studies have failed to statistically account for significant covariation in child outcomes, limiting our understanding of how early interventions may uniquely affect different aspects of early cognitive development. Identifying the distinct and shared pathways through which ECD programs affect children's intelligence and EF skills could improve intervention design.

Mediating Family Processes

Although most program evaluations focus on children's developmental outcomes, some have examined changes in the quality of the home stimulation as a function of intervention exposure. The HOME Inventory total score (Caldwell & Bradley, 2003), especially the infant/toddler version, has been used widely in LMIC to assess the opportunities for stimulation in the home. It represents a simple count of resources (e.g., toys, learning materials), physical characteristics (e.g., child's play environment is safe), family routines (e.g., child eats at least one meal a day with mother and father or other siblings), parents' behaviors (e.g., mother responds verbally to child's vocalizations or verbalizations), and child experiences (e.g., child is taken to shop or market store at least once a week), based on a combination of parent report and brief observations during a home visit. Improvements in the total HOME score following the completion of an ECD intervention have been documented in Jamaica (Walker, Chang, Powell, & Grantham-McGregor, 2004), rural Bangladesh (Aboud & Akhter, 2011; Aboud, Singla, Nahil, & Borisova, 2013), rural Paraguay (Peairson, Austin, de Aquino, & de Burró, 2008), Uganda (Boivin et al., 2013), and rural Pakistan (Yousafzai, Rasheed, Rizvi, Armstrong, & Bhutta, 2015). Although the HOME inventory has emerged as a pervasive marker of posttreatment effects on global environment, it has several limitations. First, it does not capture the quality or frequency of parenting practices or children's experiences. Second, it partially relies on the caregiver's interpretation and recall, which could be further biased by low adult literacy and education rates in some LMIC. Third, it can be influenced by idiosyncratic experiences during a home visit. Fourth, many items reflect family socioeconomic status (Nadeem, Rafique, Khowaja, & Yameen, 2014), which is not directly targeted or altered by the intervention efforts.

To address these limitations, some LMIC studies have employed standardized observational protocols to examine changes in specific parenting behaviors that are less dependent on family wealth and resources, akin to play-based assessments of parental sensitivity and cognitive stimulation conducted in the United States (Tamis-LeMonda, Shannon, Cabrera, & Lamb, 2004). In Jamaica, Powell and colleagues (2004) found that a yearlong home visitation program had a positive effect on the frequency of maternal interaction with the child, including singing, drawing, and looking at a book. In rural Bangladesh, mothers who participated in a responsive caregiving program used a significantly higher number of responsive utterances (e.g., expanding on child's verbalization, encouraging conversation, praising) during an observed picture book activity when compared with a control group (Aboud & Akhter, 2011). In a peri-urban South African settlement, Cooper and colleagues (2009) observed that mothers who participated in a parenting intervention engaged in more sensitive and less intrusive behaviors during play interactions when children were 6 and 12 months old. In rural Pakistan, a responsive stimulation intervention improved the quality of mother−child interaction, as indexed by positive affect, maternal scaffolding, and child engagement during an observed picture book activity when children were 12 and 24 months of age (Yousafzai et al., 2015). Given that most evaluation studies examine changes in family processes during or shortly after the intervention, it is unclear whether these effects persist over time and whether parents can adapt lessons learned in the first few years of the child's life to later parenting.

Despite the documented direct intervention effects on family context and child outcomes, very few LMIC studies have examined whether changes in home stimulation and caregiving practices are related to improvements in child functioning following an

intervention. Aboud and colleagues (2013) provide an exception by reporting that home stimulation and maternal knowledge were significantly associated with children's cognitive and language outcomes following the completion of a parenting program. By linking posttreatment measures of family context and child outcomes, researchers can identify which family processes mediate intervention effects. For example, Walker and colleagues (2004) showed that the effect of a psychosocial intervention on an index of global development in low-birth weight Jamaican infants was partially mediated by improvements in home stimulation. The quality of home stimulation needs to be further studied as a potential mediator, as correlational studies show that it mediates socioeconomic adversity effects on preschoolers' cognitive development in both high-income and low-income countries (Hackman, Gallop, Evans, & Farah, 2015; Hamadani et al., 2014; Patel et al., 2013). For example, both early and concurrent home stimulation partially mediated the effect of family wealth and maternal education on the general intelligence of impoverished Bangladeshi 5-year-olds (Hamadani et al., 2014).

Given the broad nature of the home stimulation construct, our understanding of intervention effects on early cognitive development would be improved by identification of specific parental behaviors as potential mediators. Parental scaffolding behaviors such as prompts, praise, elaboration, and redirection have been shown to foster early language and EF skills in children from high-income countries (Fay-Stammbach, Hawes, & Meredith, 2014; Guttentag et al., 2014; Weisleder & Fernald, 2013). And recent work in the United States revealed that maternal sensitivity and scaffolding mediates both ECD intervention effects and socioeconomic adversity effects on early cognitive development (Guttentag et al., 2014; Lengua et al., 2014; Raviv, Kessenich, & Morrison, 2004).

Yet maternal scaffolding behaviors are not frequently observed in LMIC. Aboud and Akhter (2011) found that Bangladeshi mothers are much more likely to issue commands, pose questions, and simply name objects during a picture book activity than they are to praise, answer questions, and expand on the child's verbalization. A recent cross-sectional study revealed that reading activities and the presence of books at home mediated the effects of family wealth and parental education on Zambian 6-year-old children's EFs, language, and nonverbal reasoning skills (McCoy, Zuilkowski, & Fink, 2015). Although this study does not evaluate ECD intervention effects, it identifies specific experiences that mediate broad measures of family socioeconomic status. No study to date has examined how specific maternal behaviors or practices mediate ECD intervention effects on children's cognition in LMIC. More work is needed to uncover the unique aspects of both family environment and parenting behaviors that serve as underlying mechanisms through which ECD interventions may foster early cognitive skills in children from LMIC.

The Pakistan Early Child Development Scale-Up Trial

The experience of Pakistani children is generally representative of other disadvantaged children growing up in LMIC. Pakistan is the sixth most populous country in the world, with 21% of the population living below the international poverty line of $1.25 USD a day (UNDP, 2014). Exposure to infectious diseases, food insecurity, and lack of micronutrients in diet contribute to high rates of infant mortality (74 per 1,000) and underfive mortality (89

per 1,000; NIPS & ICF International, 2013). The majority of Pakistan's population (64%) lives in agricultural areas, and striking health disparities have been noted between children in rural and urban districts (NIPS & ICF International, 2013). For example, 56% of children from poor, rural families experience stunting, compared with 24% of children from wealthy, urban families (Di Cesare et al., 2015). To address the developmental needs of children growing up in such disadvantaged environments, the Pakistan Early Child Development Scale-Up (PEDS) yrial was designed to evaluate the feasibility and effectiveness of integrating early responsive stimulation (RS) and enhanced nutrition (EN) interventions within routine government health services delivered by community-based health workers (Yousafzai, Rasheed, Rizvi, Armstrong, & Bhutta, 2014).

A birth-cohort from a predominantly agricultural district was recruited to participate in this 2-year, community-based, cluster-randomized, controlled trial with a 2×2 factorial design. The Lady Health Workers (LHW), typically married women between ages 18 and 45 with at least 8 years of education and 15 months of national program training, received specialized instruction, and supervision in administering the RS and EN interventions. A cluster was defined as the LHW catchment, and 80 clusters were sampled using a two-stage stratified random sampling strategy. The RS intervention aimed to promote sensitive and responsive caregiving using the adapted United Nations Children's Fund and World's Health Organization's Care for Child Development curriculum (UNICEF, 2011). During monthly community group meetings, primary caregivers discussed various early child development topics (e.g., attachment, praise and discipline, maternal well-being), interacted with their children, received constructive feedback, and participated in peer-to-peer problem solving. In addition, caregivers received individualized coaching, support, and feedback during routine monthly home visits. They were taught how to interpret and respond to children's signals while engaging in developmentally appropriate play and communication activities. In addition, the RS intervention focused on improving the quality of home stimulation by teaching mothers how to make low-cost toys and provide a safe environment for learning. The focus of the EN intervention was to expand on existing health, hygiene, and basic nutrition education. It drew linkages between nutrition and health and promoted responsive feeding practices and feeding-related problem-solving skills in caregivers. The EN intervention also included delivery of multiple micronutrient powder between 6 and 24 months of age. Both interventions ended at 24 months of age. For a more detailed description of the intervention design and implementation, see Yousafzai et al. (2014).

The RS intervention, alone or in combination with the EN intervention, was successful at improving children's cognition, language, and motor development at both 12 and 24 months of age, producing a moderate to large treatment effect (Yousafzai et al., 2014). There was no additive effect of the two interventions on child outcomes. Yousafzai and colleagues (2015) also reported a large treatment effect on the quality of the observed mother−child interaction, stimulation opportunities at home, and parenting knowledge and practices during the second year of children's lives. Two years after the completion of the intervention, we found small effects of the RS intervention on 4-year-old children's executive function skills, general intelligence, and pro-social behavior (Yousafzai et al., 2016). In addition, the RS intervention had a

small effect on the quality of mother–child interactions, whereas both interventions had a small effect on the quality of home stimulation (Yousafzai et al., 2016).

Current Study

The main goal of the current study was to identify underlying mechanisms that explain longitudinal effects of the RS intervention on children's cognitive skills at age 4. We examined two family processes, the quality of home stimulation and maternal scaffolding behaviors, as potential mediators of the RS intervention effects on verbal intelligence, performance intelligence, and EF skills. To determine how intervention effects are maintained over time, we tested the strength of these mediators when children were both two and four years of age. Based on the limited empirical evidence reviewed above, we hypothesized that (a) the RS intervention would predict change in the quality of home stimulation and maternal scaffolding from age 2 to age 4, (b) both earlier and concurrent measures of the home stimulation and maternal scaffolding would emerge as unique predictors of preschoolers' cognitive skills, and (c) family processes would mediate the effects of the RS intervention on three cognitive outcomes. We used a series of path analytic models that enabled us to control for (a) covariation of two family processes within each time point, (b) the 2-year continuity of each family process, and (c) covariation among related measures of cognitive skills. We controlled for known family risk factors (i.e., family wealth, food insecurity, maternal education, family size) and children's gender, linear growth, and exposure to the EN intervention.

Method

Participants

Participants included 1,302 children (46% girls) and primary caregivers (99% mothers) who were enrolled in the original PEDS trial from birth to 24 months of age and were included in the longitudinal follow-up at age 4. Attrition at the follow-up ($N = 187$, 12.56%) was predominantly due to disabilities, deaths, and migration (see below for a more detailed description of missing data). The attrited group had a significantly higher share of children who received the EN intervention compared to the group of children who were retained in the study, $t(1,487) = 3.029$, $p = .003$, but otherwise the two groups did not differ in terms of RS exposure or any study variables from the baseline, 18-month, and 24-month assessments.

Participants resided in the predominantly agricultural Naushero Feroze District in Sindh Province, Pakistan and were exposed to high levels of poverty. Monthly household income averaged $100 USD ($SD = 140 USD). Primary school attendance in the region is low, and in this sample 68% of mothers and 31% of fathers reported not being able to read and write. At baseline, mothers were 28.20 years of age ($SD = 5.88$ years) and reported completing an average of 2.26 grades of education ($SD = 3.77$). At the completion of the interventions, when children were 24 months old, approximately one third of families reported food insecurity (33%), and a substantial proportion of children were underweight (43%) or exhibited stunting (61%) or wasting (27%). At the 48-month follow-up, a similar number reported food insecurity (37%), other measures were lower but still considerable: underweight (11%), stunting (16%), and wasting (4%).

Procedures

A birth-cohort of children, born between April 1, 2009 and March 31, 2010 was invited to enroll in the PEDS trial with their primary caregivers. The current study employs data collected at the baseline enrollment (between birth and 2.5 months of age) and at the 18-month, 24-month, and 48-month assessments. Most children were assessed within a month of the designated assessment age. The assessment team received extensive training on interacting with families, understanding the evaluation constructs, administering measures, and dealing with assessment barriers. Throughout the PEDS trial (0 to 24 months), data were collected during home visits. At age 4, comprehensive child assessments were conducted during a 3-hr center visit and a separate 3-hr home visit. Participants' burden and fatigue were minimized by (a) alternating between child and maternal assessments, (b) scheduling performance measures at the beginning of the visit, (c) including set breaks and providing designated resting/napping spaces at the center, and (d) training assessors to identify when participants needed an impromptu refreshment, nap, playing, or bathroom break. All questionnaires and child assessments were administered in the local language (Sindhi).

Measures

Descriptive statistics and bivariate correlations among all study variables can be found in Table S.1 in the online supplemental material.

Intervention exposure. A dummy variable represented children's exposure to the RS intervention ($N = 660$), and a separate dummy variable was created to control for children's exposure to the EN intervention ($N = 626$). Because the EN intervention targeted both maternal behaviors and children's nutrition, the effect of EN was estimated on both family processes and child outcomes (see the analytic plan).

Maternal scaffolding. Maternal scaffolding behaviors were observed during a 5-min interaction in which mothers were instructed to play with their children using a picture book. They were rated using the Observation of Mother and Child Interaction protocol (OMCI; Rasheed & Yousafzai, 2015). Scoring was based on the frequency of the observed behavior, with a higher score denoting more frequent demonstration of behaviors (0 = *never*; 1 = *very few, one to two times*; 2 = *sometimes, three to four times*; 3 = *often, five or more times*). A maternal scaffolding at 24 months ($N = 1,301$; $M = 1.602$, $SD = 0.804$, $\alpha = .86$) score was created by averaging six ratings of maternal behaviors: (a) sensitivity and contingent responding (e.g., guiding the activity while also enabling independent exploration), (b) expanding on the child's speech, (c) pointing and naming objects in the book, (d) posing questions to the child, (e) responding to the child's questions or requests, and (f) helping the child maintain interest. Maternal scaffolding at 48 months ($N = 1,289$; $M = 1.408$, $SD = 0.745$, $\alpha = .67$) was created by averaging four ratings: (a) sensitivity and contingent responding, (b) scaffolding by expanding on the child's speech, (c) posing simple and complex questions to the child, and (d) helping the child to focus and maintain interest. Typical be-

haviors that mothers used to maintain the child's interest included variable vocalizations, encouraging facial expressions, active comments on the child's actions, and helping the child explore the book.

Home stimulation quality. Home stimulation quality was measured with the Home Observation for Measurement of the Environment Inventory (Caldwell & Bradley, 2003). The infant/toddler version was used at 18 months and the early childhood version at 48 months. In this study, the original items were slightly adapted following extensive piloting, such as the addition of culturally relevant examples and definitions (e.g., number of toys the child had access to did not need to include shop bought toys; everyday items such as spoons and cups could also be used as toys), and the exclusion of an item focused on magazine subscription in the early childhood version. There were six dimensions at 18 months: (a) responsivity, (b) acceptance, (c) organization, (d) learning materials, (e) involvement, and (f) variety; and there were eight dimensions at 48 months: (a) learning materials, (b) language stimulation, (c) physical environment, (d) responsivity, (e) academic stimulation, (f) modeling, (g) variety, and (h) acceptance. Each item was scored as 0 (*absent*) or 1 (*present*), on the basis of mothers' report of family living patterns and habits, observation of spontaneous mother−child interactions, and orderliness and enrichment potential of the physical home environment. The full list of adapted items from both versions of the HOME inventory can be found in the online supplement. A total HOME score was generated by summing all 45 items at 18 months ($\alpha = .82$, $N = 1273$, $M = 30.811$, $SD = 5.444$) and 54 items at 48 months ($\alpha = .94$, $N = 1295$, $M = 32.071$, $SD = 6.741$).

Child intelligence. Children's intelligence was assessed using the Wechsler Preschool and Primary Scale of Intelligence−III (WPPSI-III; Wechsler, 2002). Items were culturally adapted by replacing unfamiliar words and pictures with alternates that are more representative of the local community. The test was administered in Sindhi, and assessors were instructed to simplify instructions and include examples when they believed the child did not understand the instructions; see Rasheed, Memon, Siyal, Obradović, and Yousafzai (2016) for adaptation details. Individual items were culturally adapted by replacing unfamiliar words and pictures with those that are more representative of the local community. Scale scores from the Information, Vocabulary, and Word Reasoning subtests were summed to create a verbal IQ (VIQ) composite ($\alpha = .92$, $M = 77.125$, $SD = 9.962$). Scale scores from the block design, matrix reasoning, and picture concepts subtests were summed to create a performance IQ (PIQ) composite ($\alpha = .73$, $M = 79.479$, $SD = 9.356$).

Executive function composite. Because there was no existing EF battery for preschoolers in rural LMIC, we completed an extensive process of task selection, adaptation, and evaluation (see Obradović et al., 2016). Six tasks were deemed developmentally and culturally appropriate. These assessed children's inhibitory control (IC; ability to suppress a dominant response in favor of a subdominant response), working memory (WM; ability to hold, update, and manipulate information in the mind over short periods of time), and cognitive flexibility (CF; ability to switch flexibly between two different dimensions).

The Fruit Stroop (IC task) assessed the child's ability to focus on a subdominant perceptual feature of an image, rather than on a dominant feature (Carlson, 2005). Children were shown three new pictures, each depicting a small fruit embedded within a different larger fruit (e.g., a small apple inside a large banana) and were asked to point to the small fruit, which requires suppressing the inclination to choose the large, more salient fruit. The total score reflected the percentage correct across three test trials ($\alpha = .50$). The Knock-Tap Game (IC task) assessed children's ability to implement a set of rules and suppress an imitation of the assessor's actions (Molfese et al., 2010). Using their hand, children were asked to tap on the table after the assessor knocked on it, and, conversely, to knock after the assessor tapped. The total score reflected the percentage correct across 16 test trials ($\alpha = .79$). The Big/Little Game (IC task; Carlson, 2005) assessed children's ability to state a contradictory rather than a salient perceptual feature of an image. Children were asked to say "little" when presented with a picture of a big cat and to say "big" when presented with a picture of a little cat. The total score reflected the percent correct across 16 test trials ($\alpha = .88$). The Go/NoGo Game (IC task) assessed children's ability to perform an action following a frequent "go" stimulus and to inhibit that same action following a less frequent "no-go" stimulus (Willoughby, Blair, Wirth, & Greenberg, 2010). Children were asked to press a desk bell when presented with an image of a cat and not to press the bell when presented with an image of a dog. The total score reflected the percentage of correct "no-go" trials ($\alpha = .82$) for children who demonstrated at least 76% accuracy on "go" trials. During the Forward Word Span (WM task), children were asked to repeat verbally presented word sequences of increasing length. The total score represented the longest span for which at least two test trials were repeated correctly, plus 0.5 if one longer sequence was correctly repeated at the next level (Noël, 2009). Children who could not repeat any words, or only one word, were given a score of 1 ($\alpha = .66$). The Separated Dimensional Change Card Sort (S-DCCS; CF task) measured children's ability to switch attention between two different dimensions, using a set of colored cards (green or yellow) featuring the black silhouette of a common shape (star or truck) (Carlson, 2005). Children were asked to complete six color trials, and then, after a rule switch, six shape trials. The total score reflected the percentage of correct postswitch trials ($\alpha = .79$).

Comprehension of task rules was determined by performance on practice trials. Children who did not pass task-specific comprehension criteria did not receive a valid test score. A final composite score was created by averaging valid test scores across six EF tasks (Cronbach's $\alpha = .64$, $M = -0.027$, $SD = 0.611$). Given the recent finding that a three-task battery provides a reliable measure of overall EF skills (Willoughby, Pek, Blair, & Family Life Project Investigators, 2013), the final EF composite was created for children who passed comprehension criteria for three or more tasks (91% of children who completed the EF battery). For more on EF task adaptation, passing criteria, and the final composite, see Obradović et al. (2016).

Covariates. The following covariates were assessed by primary caregiver's report: (a) Family wealth was assessed at baseline using 44 items reflecting ownership of property, livestock, and household assets (e.g., TV, bicycle, car), dwelling characteristics (e.g., access to water, sanitation facilities, type of flooring material), and number of bedrooms in the home. Principal components analysis was used to generate a single standardized factor score representing cumulative family wealth ($N = 1,294$; $M = -0.002$,

SD = 0.988). (b) Maternal education (N = 1,302; M = 2.192, SD = 3.686) measured the number of grades the mother completed in formal schooling at baseline. (c) Food insecurity (N = 1,301; M = 1.600, SD = 0.963), a measure of the availability of safe and nutritionally adequate food, was assessed at 24 months on a 4-point Likert-scale (1 = *food secure*, 2 = *mildly food insecure*, 3 = *moderately food insecure*, 4 = *severely food insecure*; Coates, Swindale, & Bilinsky, 2007). (d) Family size as indexed by the total number of children (N = 1302, M = 4.158, SD = 2.253). (e) Child's gender (1 = male, 0 = female). In addition, trained assessors measured child's height at 24 months of age using a ShorrBoard to the nearest 0.1 cm. In accordance with standardized guidelines (Cogill, 2003), height was converted into a standardized height-for-age index using WHO Anthro software V3.2.2 (M = −.87, SD = 1.17, range = −4.96–3.63). HAZ values, an index of linear growth as well as chronic malnutrition or stunting, were used in the analyses.

Analytic Plan

The main analyses were conducted in Mplus (Version 7.3; Muthén & Muthén, 2014). The percentage of missing data was small, ranging from 0.00% to 4.92%, except for the EF composite measure (12.14%) where inability to understand task rules accounted for most missingness (9%). Other reasons for missing data, in order of frequency, included external interruptions that resulted in an abbreviated assessment procedure (e.g., no electricity in the assessment room), lack of permission from the head household to stay for the duration of the full assessment, challenging behavior, and obvious disabilities (e.g., unable to walk or speak). We used robust maximum-likelihood estimators to account for missing data and non-normality of some variables.

We tested our main hypotheses using a series of nested path analytic models: Model 1 estimated the direct pathways of the intervention on the four mediators and on the three outcome variables; Model 2 estimated an additional six pathways from the age two mediators to the outcome variables; and Model 3 estimated an additional six pathways from the age four mediators to the outcome variables. All models estimated covariation of mediators within each time point, the 2-year continuity of each mediator, and covariation of the three outcomes. Because the RS intervention was cluster-randomized at the level of the LHW catchment, we used robust Huber-White standard errors and CLUSTER command to account for the nonindependence of observations arising from the clustering of children into 80 catchments. We controlled for the effect of six covariates (family wealth, maternal education, food insecurity, total number of children, and child's gender and exposure to EN intervention) on each endogenous variable. In addition, we accounted for the effect of the child's HAZ on cognitive outcomes in the model.

To evaluate acceptable absolute fit of the models, we used the following fit indices: comparative fit index (CFI; values ≥ .95 indicate good model fit), Tucker–Lewis index (TLI; values ≥ .95), and root mean square error of approximation (RMSEA; values ≤0.06). Relative model fit was evaluated using a scaled chi-square difference test for nested models. Each model was compared to the next most parsimonious model in order to evaluate if the additional parameters resulted in better fit. A significant chi-square difference test indicated that the additional pathways

improved model fit, and thus the more complex model was selected (Satorra, 2000). We tested the strength of indirect effects of the RS intervention using the MODEL INDIRECT function in Mplus. We calculated the indirect effects through each mediator individually and via continuity of each mediator across both age points. Significant differences in pathway estimates were further examined using the MODEL CONSTRAINT function in Mplus. Finally, we used biased-corrected (BC) bootstrapping procedure with 5,000 draws (Preacher & Hayes, 2008) to generate the most accurate confidence intervals for the indirect effects and examine statistical difference in the magnitude of contrasting direct and indirect effects.

Results

Main Effects Model

Model 1 (CFI = 0.966, TLI = 0.897, RMSEA = 0.051) revealed significant direct effects of the RS intervention on the quality of home stimulation at 18 months (β = 0.387, p < .001), as well as maternal scaffolding at 24 months (β = 0.300, p < .001) and 48 months of (β = .077, p = .019). The effect of the RS intervention on the quality of home stimulation at 18 months was stronger than the effect on maternal scaffolding at 24 months (B = 2.903, BC bootstrap CI [3.087 to 4.330]). Further, the effect of the RS intervention on maternal scaffolding was stronger at 24 months than at 48 months (B = 0.192, BC bootstrap CI [0.232 to 0.504]). In addition, the RS intervention had a significant unique longitudinal effect on EFs (β = 0.129, SE = 0.027, p < .001), VIQ (β = 0.070, SE = 0.034, p = .046), and PIQ (β = 0.096, SE = 0.029, p = .002) at 48 months.

Comparison of Model 1 with Model 2 (CFI = 0.978, TLI = 0.910, RMSEA = 0.047) revealed that the addition of six pathways from the age two mediators to the outcome variables significantly improved the relative model fit, as indicated by a significant chi-square difference test, $\Delta\chi^2(6) = 34.27$, p < .001. Further comparison showed that Model 3, with an additional six pathways from the age four mediators to outcome variables, fit the data significantly better than Model 2, $\Delta\chi^2(6) = 54.79$, p < .001. Thus, Model 3 with excellent absolute model fit (CFI = 0.990, TLI = 0.939, RMSEA = 0.039) was adopted as our final mediation model. Significant standardized path estimates and latent variable R^2 values for Model 3 are presented in Figure 1.

Mediation Model

Direct paths. Table 1 presents standardized estimates for all direct pathways. The quality of home stimulation at 24 months did not predict any cognitive outcomes, whereas home stimulation at 48 months significantly predicted concurrent measures of children's EFs (β = 0.116, p = .001), VIQ (β = 0.196, p < .001), and PIQ (β = 0.132, p < .001). Maternal scaffolding at 24 months significantly predicted EFs (β = 0.076, p = .001), VIQ (β = 0.079, p = .006), and PIQ (β = 0.063, p = .038), whereas maternal scaffolding at 48 months significantly predicted EFs (β = 0.094, p = .003) and VIQ (β = 0.092, p = .006). Statistical comparisons of the effect estimates revealed that maternal scaffolding at 24 and 48 month had a similar effect on EFs (B = −0.020, BC bootstrap CI [−0.084 to 0.042]) and VIQ
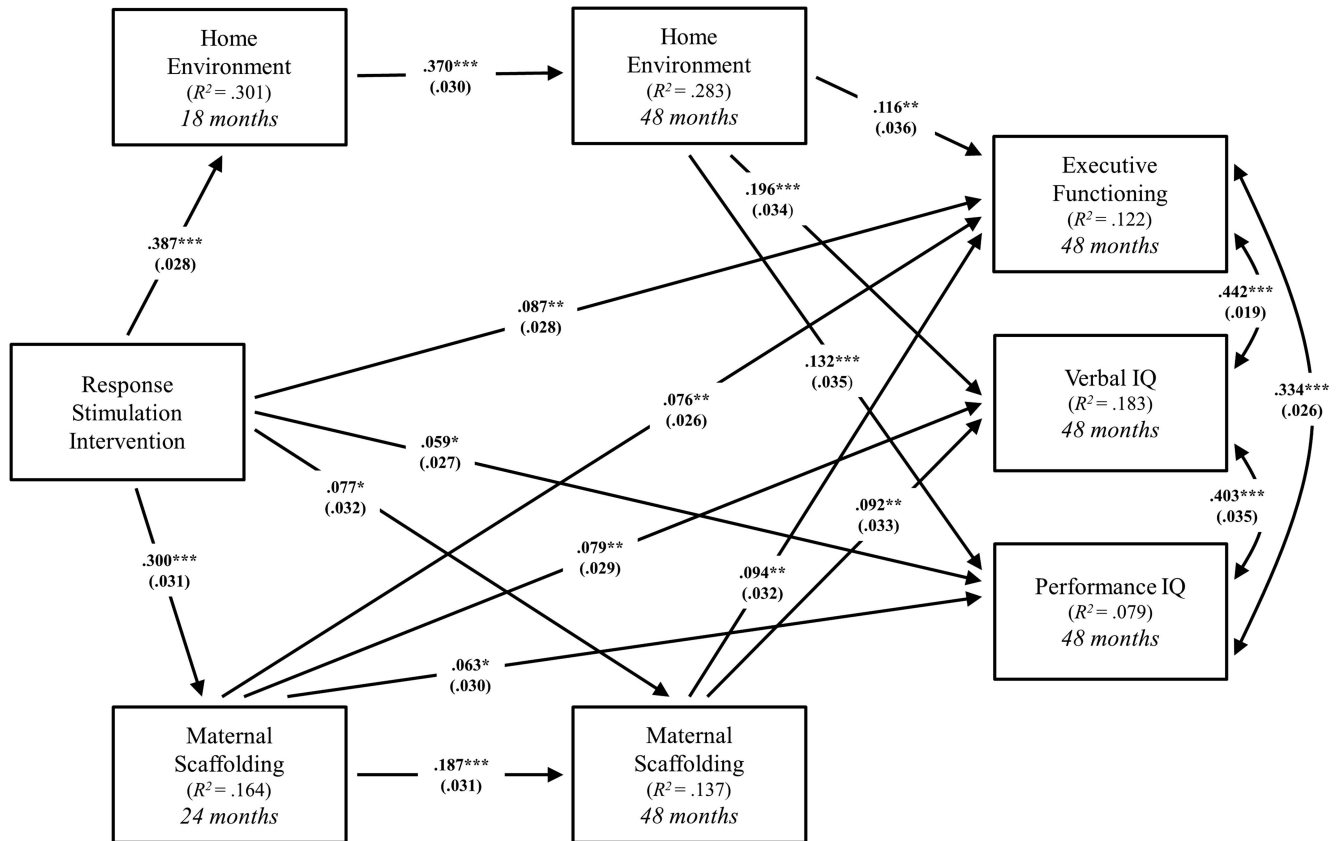
Figure 1. Path modeling show the effects of a Responsive Stimulation intervention on children's executive function skills and IQ, as mediated by the intervention's effects on the home stimulation quality and maternal scaffolding. Covariation between home stimulation and maternal scaffolding is .205, $p < .001$ (at age 2) and .149, $p < .001$ (at age 4)

$(B = -0.254$, BC bootstrap CI $[-1.331$ to $0.777])$. Home stimulation at 48 months had a stronger effect than the concurrent measure of maternal scaffolding on VIQ $(B = -0.934$, BC bootstrap CI $[-1.820$ to $-0.018])$, and on EFs $(B = -0.067$, BC bootstrap CI $[-0.120$ to $-0.013])$. After the inclusion of mediating pathways, exposure to the RS intervention continued to predicted EFs $(\beta = 0.087, p = .002)$ and PIQ $(\beta = 0.059, p = .028)$ at 48 months, although to a lesser degree. Direct effect of the RS intervention on VIQ was fully mediated.

As expected, home stimulation quality at 18 months significantly predicted home stimulation quality at 48 months $(\beta = 0.370, p < .001)$, and maternal scaffolding at 24 months significantly predicted maternal scaffolding at 48 months $(\beta = 0.187, p < .001)$. Longitudinal stability of the home stimulation was statistically stronger than stability of maternal scaffolding $(B = 0.283$, BC bootstrap CI $[0.195$ to $0.737])$. Further there was significant covariation of these processes within time points. Home stimulation quality at 18 months was significantly covaried with maternal scaffolding at 24 months $(\beta = 0.205, p < .001)$, and, similarly, home stimulation quality at 48 months was significantly covaried with maternal scaffolding at 48 months $(\beta = 0.149, p < .001)$. VIQ and PIQ were significantly correlated with each other $(\beta = 0.403, p < .001)$, and with EF skills $(\beta = 0.442, p < .001; \beta = 0.334, p < .001$, respectively).

Covariates. Standardized estimates of the covariate effects are shown in Table 2. Greater family wealth, lower food insecurity, higher maternal education, and smaller number of children were associated with higher quality of home stimulation at both 18 and 48 months. Greater family wealth, lower food insecurity, and higher maternal education were also associated with higher levels of maternal scaffolding at 24 months, whereas only higher maternal education predicted higher levels of maternal scaffolding at 48 months. Family wealth was positively associated with child VIQ, food insecurity was negatively associated with child PIQ, and maternal education was positively associated with child EF skills. Child HAZ at 24 months was positively associated with all cognitive outcomes.

Having a higher number of children in the family predicted lower quality of home stimulation at 18 months, but greater improvements in the quality of home stimulation by 48 months. However, the number of children in the family was not related to maternal scaffolding. Child gender did not emerge as a significant covariate. Lastly, exposure to the EN intervention predicted higher quality of home stimulation at both 18 and 48 months as well as maternal scaffolding at 24 months. Over and above other covariates, exposure to the EN intervention was negatively associated with child PIQ, in contrast to a nonsignificant bivariate correlation.

Table 1
Direct Effects of Main Pathways From Final Model

Pathway	β (*SE*)	*p*
Direct RS effects		
RS → Home (18 months)	.387 (.028)	<.001
RS → Scaff (24 months)	.300 (.031)	<.001
RS → Home (48 months)	−.067 (.034)	.052
RS → Scaff (48 months)	.077 (.032)	.018
RS → EF	.087 (.028)	.002
RS → VIQ	−.001 (.032)	.977
RS → PIQ	.059 (.027)	.028
Family effects (Age 2)		
Home (18 months) → EF	−.005 (.040)	.896
Home (18 months) → VIQ	.052 (.031)	.091
Home (18 months) → PIQ	.006 (.030)	.844
Scaff (24 months) → EF	.076 (.026)	.003
Scaff (24 months) → VIQ	.079 (.029)	.006
Scaff (24 months) → PIQ	.063 (.030)	.038
Longitudinal continuity		
Home (18 months) → Home (48 months)	.370 (.030)	<.001
Scaff (24 months) → Scaff (48 months)	.187 (.031)	<.001
Family effects (Age 4)		
Home (48 months) → EF	.116 (.036)	.001
Home (48 months) → VIQ	.196 (.034)	<.001
Home (48 months) → PIQ	.132 (.035)	<.001
Scaff (48 months) → EF	.094 (.032)	.003
Scaff (48 months) → VIQ	.092 (.033)	.006
Scaff (48 months) → PIQ	.039 (.033)	.237
Within-time covariation		
Home (18 months) with Scaff (24 months)	.205 (.028)	<.001
Home (48 months) with Scaff (48 months)	.149 (.030)	<.001
EF with VIQ	.442 (.019)	<.001
EF with PIQ	.334 (.026)	<.001
VIQ with PIQ	.403 (.035)	<.001

Note. RS = responsive stimulation intervention; Home = quality of the home stimulation; Scaff = maternal scaffolding; EF = executive function composite; VIQ = verbal IQ; PIQ = performance IQ.

As expected, we found significant associations among covariates. Child's HAZ was positively associated with family wealth (β = 0.277, *p* < .001) and maternal education (β = 0.227, *p* < .001), and negatively associated with food insecurity (β = −0.159, *p* < .001) and family size (β = −0.101, *p* = .001). Wealth was positively associated with maternal education (β = 0.367, *p* < .001) and negatively associated with food insecurity (β = −0.253, *p* < .001) and number of children (β = −0.113, *p* < .001). Food insecurity was positively associated with number of children (β = 0.106, *p* < .001) and negatively associated with maternal education (β = −0.211, *p* < .001) and exposure to the EN intervention (β = −0.128, *p* < .001). Finally, maternal education was positively associated with the EN intervention (β = 0.090, *p* = .048) and negatively associated with number of children (β = −0.176, *p* < .001).

Indirect paths. Table 3 presents standardized estimates for all indirect pathways linking the RS intervention and cognitive outcomes via two family mediators at two developmental points. Maternal scaffolding at 24 months significantly mediated the RS effects on all three outcomes (RS → Scaff [24 months] → VIQ/ PIQ/EF), whereas home stimulation at 18 months did not emerge as a significant mediator. The indirect pathway from the RS intervention via both measures of home stimulation predicted all three cognitive outcomes (RS → Home [18 months] → Home [48 months] → VIQ/PIQ/EF). Similarly, the indirect pathway from the

RS intervention via both measures of maternal scaffolding was predictive of VIQ and EFs (RS → Scaff [24 months] → Scaff [48 months] → VIQ/EF). Statistical comparisons of the contrasting indirect effects revealed that the significant indirect effect on VIQ via longitudinal stability of home stimulation (RS → Home [18 months] → Home [48 months] → VIQ) was stronger in magnitude (*B* = 0.452, BC bootstrap CI [0.172 to 0.752]) than a significant pathway through longitudinal stability of maternal scaffolding (RS → Scaff [24 months] → Scaff [48 months] → VIQ).

Discussion

The current study extends our limited understanding of how parenting interventions implemented in LMIC during the first two years of children's lives are sustained longitudinally to promote emerging cognitive skills of 4-year-old children. Specifically, we examined two family processes—the quality of home stimulation and maternal scaffolding—as underlying mechanisms through which the RS intervention predicted preschoolers' verbal intelligence, performance intelligence, and EF skills. By accounting for shared variance between the two family processes as well as their longitudinal continuity, the study revealed (a) unique longitudinal effects of the RS intervention on the targeted family processes across the two time periods, (b) relative importance of family processes for preschool cognition, and (c) independent and shared mediating pathways through which the intervention operated over time.

Unique Intervention Effects on Family Processes Over Time

Consistent with the previous evaluation study (Yousafzai et al., 2015), the RS intervention significantly predicted higher levels of both home stimulation and observed maternal scaffolding during the second year of children's lives after controlling for the significant covariation of the two family processes. However, by age four, the RS intervention was predictive of 2-year change only in the quality of maternal scaffolding. This finding offers preliminary evidence that mothers in the intervention group were able to adapt some of the original ECD messages to the cognitive scaffolding of preschool children. In other words, participation in the RS intervention continued to predict improvements in maternal scaffolding skills 2 years after the intervention ended. In contrast, the RS intervention did not predict the change in the quality of home stimulation between ages 2 and 4. The lack of a direct effect of the RS intervention on changes in home stimulation could be explained partially by the stronger 2-year continuity of home stimulation, the greater impact of socioeconomic covariates (i.e., wealth, food insecurity, family size) on the quality of home stimulation, and greater demands on family resources in comparison to maternal scaffolding behaviors.

These findings extend existing evaluation studies in LMIC (Aboud & Akhter, 2011; Aboud et al., 2013; Boivin et al., 2013; Cooper et al., 2009; Peairson et al., 2008; Walker et al., 2004) by separating the unique effects of the ECD intervention on maternal behaviors from the broader measure of home stimulation. We observed distinct effects of the RS intervention on two-family processes as well as a longitudinal decoupling of home stimulation and maternal scaffolding, marked by a decrease in their within-

Table 2
Final Model Covariate Direct Effects

Pathway	β (SE)	p-value	Pathway	β (SE)	p-value
Wealth (base) → Home (24 m)	.180 (.028)	<.001	Male → Home (24 m)	−.029 (.021)	<.151
Wealth (base) → Scaff (24 m)	.120 (.034)	<.001	Male → Scaff (24 m)	−.008 (.023)	.739
Wealth (base) → Home (48 m)	.119 (.033)	<.001	Male → Home (48 m)	.011 (.025)	.671
Wealth (base) → Scaff (48 m)	.036 (.032)	.258	Male → Scaff (48 m)	.019 (.027)	.475
Wealth (base) → EF	.000 (.029)	.991	Male → EF	−.012 (.027)	.657
Wealth (base) → Verbal IQ	.042 (.029)	.148	Male → Verbal IQ	.042 (.025)	.093
Wealth (base) → Perf IQ	.004 (.030)	.904	Male → Perf IQ	.016 (.026)	.535
Mat Edu (base) → Home (24 m)	.172 (.025)	<.001	EN (0-24 m) → Home (24 m)	.072 (.031)	.021
Mat Edu (base) → Scaff (24 m)	.127 (.030)	<.001	EN (0-24 m) → Scaff (24 m)	.119 (.033)	<.001
Mat Edu (base) → Home (48 m)	.178 (.024)	<.001	EN (0-24 m) → Home (48 m)	.070 (.033)	.032
Mat Edu (base) → Scaff (48 m)	.231 (.034)	<.001	EN (0-24 m) → Scaff (48 m)	−.019 (.033)	.571
Mat Edu (base) → EF	.074 (.032)	.022	EN (0-24 m) → EF	−.029 (.027)	.294
Mat Edu (base) → Verbal IQ	.032 (.023)	.164	EN (0-24 m) → Verbal IQ	−.065 (.034)	.057
Mat Edu (base) → Perf IQ	.020 (.035)	.558	EN (0-24 m) → Perf IQ	−.077 (.031)	.013
Fam Size (base) → Home (24 m)	−.114 (.025)	<.001	Food Ins (24 m) → Home (24 m)	−.107 (.030)	<.001
Fam Size (base) → Scaff (24 m)	−.032 (.025)	.190	Food Ins (24 m) → Scaff (24 m)	−.056 (.024)	.018
Fam Size (base) → Home (48 m)	.059 (.026)	.025	Food Ins (24 m) → Home (48 m)	−.090 (.028)	.002
Fam Size (base) → Scaff (48 m)	−.011 (.023)	.628	Food Ins (24 m) → Scaff (48 m)	−.031 (.033)	.339
Fam Size (base) → EF	.065 (.032)	.041	Food Ins (24 m) → EF	−.022 (.026)	.392
Fam Size (base) → Verbal IQ	−.013 (.028)	.645	Food Ins (24 m) → Verbal IQ	−.048 (.025)	.050
Fam Size (base) → Perf IQ	−.009 (.029)	.749	Food Ins (24 m) → Perf IQ	−.042 (.026)	.113
			HAZ (24 m) → EF	.182 (.030)	<.001
			HAZ (24 m) → Verbal IQ	.187 (.032)	<.001
			HAZ (24 m) → Perf IQ	.138 (.028)	<.001

Note. Home = Quality of the home environment; Scaff = Maternal scaffolding; EF = executive function composite; Perf= Performance; Mat Educ = maternal education; Fam = Family; EN = enhanced nutrition intervention; Food Ins = Food insecurity; HAZ= height-for-Age.

time covariation and changes in the contribution of family socioeconomic factors. These findings highlight the importance of studying specific parenting behaviors in addition to measuring the overall quality of family context via the ubiquitous HOME assessment tool. Standardized observation parent–child interaction protocols that are quick and easy to administer in the field and can be reliably coded in the moment (Rasheed & Yousafzai, 2015) offer promising new ways to objectively assess specific targets of the intervention curricula in developmentally and culturally appropriate ways. The waning effect of the RS intervention over time, together with the modest continuity of both family processes, suggests a need for future programs that explicitly address how to adapt and transfer ECD knowledge and skills to later developmental periods. Future evaluation studies should systematically examine the effect of booster sessions in bolstering the longitudinal intervention effects on family processes.

Family Determinants of Early Cognitive Development

By measuring the distinct aspects of family context and accounting for their covariation over time, we were able to identify differences in the longitudinal contributions of overall home stimulation and specific maternal scaffolding behaviors to preschoolers' cognitive development. We found that only the concurrent measure of home stimulation emerged as a significant predictor of children's verbal intelligence, performance intelligence, and EF skills. This finding contributes to a growing empirical literature that demonstrates the significance of early childhood home enrichment for children's early cognitive development in LMIC (Bornstein & Putnick, 2012; Hamadani et al., 2014; McCoy et al., 2015; Patel et al., 2013). However, it contrasts with a study of Bangla-

deshi children where both 18-month and 64-month measures of home stimulation separately contributed to a global measure of intelligence (Hamadani et al., 2014). This discrepancy could be due to the shorter interval between the two assessment points in our study, as the effects of earlier home stimulation were carried forward via significant 2-year continuity.

Consistent with the notion that linguistic stimulation in the home plays a critical role in promoting development of early language development (Raviv et al., 2004; Weisleder & Fernald, 2013), we found that both earlier and concurrent measures of maternal scaffolding behaviors exerted independent effects on children's verbal intelligence. The current study also extended previous work on the importance of maternal scaffolding for children's early EF skills in high-income countries (Fay-Stammbach et al., 2014; Lengua et al., 2014) by showing that both early and concurrent measures of maternal scaffolding uniquely contributed to EF skills in preschoolers from LMIC. Scaffolding behaviors rated during a picture book activity, such as expanding on the child's prior talk and helping the child stay focused and maintain interest, were more directly relevant to developing verbal intelligence (e.g., vocabulary, verbal comprehension, knowledge about the world) and EF skills (e.g., response inhibition and interference suppression) than to indices of performance intelligence (e.g., fluid reasoning, spatial processing, perceptual-organization, and visual-motor integration). Consequently, preschoolers' performance intelligence was only predicted by the earlier measure of scaffolding, possibly reflecting the domain-general significance of early contingent responding. Although researchers are starting to employ observational measures of specific maternal behaviors in evaluating ECD interventions in LMIC

Table 3
Final Model Indirect Pathways

Pathway	Point estimate	Product of coefficients			Bootstrapping BC 95% CI	
		SE	p		Lower	Upper
RS → Home (18 months) → Home (48 months) → EF	.017	(.006)	.003		.006	.028
RS → Home (18 months) → EF	−.002	(.016)	.895		−.033	.029
RS → Home (48 months) → EF	−.008	(.005)	.127		−.018	.003
RS → Scaff (24 months) → Scaff (48 months) → EF	.005	(.002)	.012		.001	.009
RS → Scaff (24 months) → EF	.023	(.008)	.004		.007	.039
RS → Scaff (48 months) → EF	.007	(.004)	.065		−.001	.015
RS → Home (18 months) → Home (48 months) → VIQ	.028	(.006)	<.001		.016	.040
RS → Home (18 months) → VIQ	.020	(.012)	.092		−.004	.044
RS → Home (48 months) → VIQ	−.013	(.007)	.078		−.028	.002
RS → Scaff (24 months) → Scaff (48 months) → VIQ	.005	(.002)	.019		.001	.010
RS → Scaff (24 months) → VIQ	.024	(.009)	.008		.006	.042
RS → Scaff (48 months) → VIQ	.007	(.004)	.066		−.001	.015
RS → Home (18 months) → Home (48 months) → PIQ	.019	(.005)	<.001		.008	.029
RS → Home (18 months) → PIQ	.002	(.012)	.844		−.021	.026
RS → Home (48 months) → PIQ	−.009	(.005)	.070		−.019	.001
RS → Scaff (24 months) → Scaff (48 months) → PIQ	.002	(.002)	.250		−.002	.006
RS → Scaff (24 months) → PIQ	.019	(.009)	.044		.000	.038
RS → Scaff (48 months) → PIQ	.003	(.003)	.259		−.003	.009
RS → Home (18 months) → Home (48 months)	.143	(.016)	<.001		.112	.174
RS → Scaff (18 months) → Scaff (48 months)	.056	(.011)	<.001		.034	.078

Note. RS = responsive stimulation intervention; Home = quality of the home stimulation; EF = executive function composite; Scaff = maternal scaffolding; VIQ = verbal IQ; PIQ = performance IQ.

(Cooper et al., 2009; Rasheed & Yousafzai, 2015), more work is needed to establish the relevance of these behaviors for child adaptation. Such analyses can in turn inform better design of observational protocols that more accurately reflect the intervention targets as well as intended effects on different developmental outcomes.

Direct and Indirect Effects of the ECD Intervention on Cognitive Development

Corroborating the longitudinal impact evaluation study, which shows small effects of the RS intervention on general intelligence and EF skills (Yousafzai et al., 2016), the current study revealed the unique direct effect of the RS intervention on EF skills and verbal and performance intelligence. The current findings also contribute to our understanding of family processes as underlying mechanisms linking the ECD intervention to child development in LMIC. By using path analytic procedures and the repeated measures of home stimulation and maternal behaviors, we were able to identify the independent effects and specific timing of different mediating processes. Our results revealed that maternal scaffolding assessed at the completion of the RS intervention, when children were two years of age, mediated the RS intervention effect through its longitudinal effect on all three cognitive outcomes, and via a 2-year continuity and concurrent maternal scaffolding effect on verbal intelligence and EF skills. The RS intervention was successful at promoting long-term cognitive development by fostering both short- and long-term improvements in maternal scaffolding, an aspect of responsive and contingent caregiving.

The results also demonstrated that the RS effect on preschoolers' cognitive development was significantly mediated through a 2-year continuity and concurrent home stimulation effect on all

three cognitive outcomes. Moreover, this longitudinal indirect pathway was stronger than that of the analogous longitudinal indirect effect of maternal scaffolding on preschoolers' verbal intelligence. When it comes to the broader measure of home stimulation, it appears that the RS intervention was critical in instigating initial improvements, which in turn predicted the quality of concurrent home stimulation, which was more relevant for preschoolers' cognition. The finding extends the work of Walker and colleagues (2004), who found that total HOME score partially mediated a psychosocial intervention on the development of Jamaican infants. The findings also corroborate the work of McCoy and colleagues (2015), who revealed that parental investment in learning, as indexed by presence of books in home and caregivers' reading practices, mediated the effect of socioeconomic resources on concurrent measures of 6-year-old children's language skills, performance reasoning, and EF skills.

Finally, it is important to note that while the two-family processes fully explained the effect of the RS intervention on measures of preschoolers' verbal intelligence, exposure to the RS intervention continued to have a significant direct effect on EF skills and performance intelligence. Given the earlier developmental trajectory of language skills compared to other cognitive skills, both family measures predominately focused on various forms of language stimulation. It is feasible that other aspects of home stimulation or parenting may further explain the effect of the RS intervention on developing nonverbal reasoning skills. Future studies should also examine measures of earlier child competences as well as indices of health as alternative mediating processes. The final model also highlights the need to bolster the longitudinal effect of the RS intervention, in that only modest amounts of variance in each cognitive outcome were explained.

Limitations and Future Directions

The current study represents an important initial effort to examine the longitudinal effect of an ECD intervention implemented in LMIC via repeated measures of family processes on multiple cognitive outcomes. Nevertheless, it has several limitations that need to be addressed by future studies. First, several measures employed in the current study, including the EF task battery and the early childhood version of the HOME inventory, have not been widely used with preschool samples in LMIC studies. Although we conducted rigorous adaptation procedures and validation studies of our instruments (e.g., Obradović et al., 2016), the generalizability of these measures in other LMIC contexts is limited. Second, we used the total HOME score in our analyses in order to demonstrate the unique contribution of the standardized assessment of maternal scaffolding over and above this broad measure of family environment that is frequently employed in LMIC. However, there is a conceptual overlap between indices of maternal scaffolding and some HOME items. Future research should investigate the unique contribution of the HOME items that are influenced by family socioeconomic status in LMIC and those that represent processes more directly targeted by intervention programs. Third, our measure of maternal scaffolding could be enhanced by expanding observation protocol to include other interaction activities and by including more nuanced markers of scaffolding quality (e.g., sensitivity, contingency, persistence). Fourth, there is a need to employ direct measures of parenting in a naturalistic context (e.g., analyses of language recordings in the home) as well as develop measures of specific activities and experiences that promote different dimensions of early cognitive development. Finally, assessment of home stimulation at 18 months (i.e., 6 months before the completion of the RS intervention) limits the direct comparison with the measure of maternal scaffolding at 24 months and precludes the tests of causal mediation.

We focused our study on direct comparisons of two related mediating family processes that were primary targets of the RS intervention. Future studies should extend this work by examining whether the RS effects are also mediated by earlier measures of the child's competences. Such analysis would further shed light on the timing and mechanisms of the intervention effects and help identify developmental antecedents of preschoolers' cognitive skills. In addition, future studies should examine how nutrition as well as child's health and growth relate to early cognitive development and processes that support it. Last, there is a need to replicate our findings using samples from other LMIC contexts.

Conclusion

Identifying the longitudinal effects and mediating pathways through which an ECD intervention operates and affects developmental outcomes over time has great implications for future program design and scale-up efforts. Maternal scaffolding behaviors in toddlerhood were a significant longitudinal predictor and mediator of the intervention effects on verbal intelligence, performance intelligence, and EF skills of 4-year-old children. During the sensitive period of rapid cognitive development between ages two and four, maternal scaffolding behaviors also increased as a result of the intervention exposure and showed declining association with a broader measure of home context and family socioeconomic factors. Given limited access to and poor quality of early education opportunities outside the home (UNICEF, 2013, 2014), more programs should be designed to explicitly promote caregivers' scaffolding skills as a way to foster school readiness of disadvantaged children living in rural areas of LMIC.

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