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RCT of a reading aloud intervention in Brazil: Do impacts differ depending on parent literacy?

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ABSTRACT

Children in low- and middle-income countries (LMICs) are at risk for adverse early development and school readiness outcomes; low parent literacy is common and an important contributing factor. While prevention programs have sought to improve child outcomes by promoting positive parenting practices such as reading aloud, there has been limited evidence of whether such programs have impacts for parents with low literacy in LMICs. This study investigated: (1) whether parent literacy is associated with parent–child reading aloud interactions, the overall cognitive home environment, and child language and cognitive outcomes; and (2) whether impacts of a toddler/preschool reading aloud program differ depending on parent literacy among low-income families in northern Brazil. We performed a secondary analysis of a single-blind cluster randomized controlled trial (RCT) of a parenting intervention (*Universidade do Bebê* [UBB]) implemented in educational childcare centers in Boa Vista, Brazil. UBB consisted of: (1) a lending library in which children's books were borrowed weekly; and (2) monthly parent workshops focused on reading aloud. Control families received usual care without the reading aloud program. Five hundred and six mother-infant dyads (279 intervention; 287 control) were enrolled at mean (SD) child age 37.4 (6.5) months. Parents and children were evaluated at baseline/enrollment and approximately 6–9 months later. Measures: (1) Predictor/moderator: parent literacy; (2) Parent outcomes: parent–child interaction during shared storybook reading; cognitive home environment; (3) Child outcomes: expressive and receptive vocabulary; IQ; working memory and short-term phonological memory. Analyses accounted for baseline performance, sociodemographics, and clustering within centers and sites. Parent literacy was positively associated with parent–child verbal/reading interactions and child developmental outcomes, supporting our first hypothesis, that low parent literacy would be associated with lower quantity and quality of parent–child reading and lower scores on assessments of child development. UBB had positive impacts on parent–child interaction, cognitive stimulation, IQ, and receptive vocabulary for both high and low literacy parents, contrary to our second hypothesis, that low parent literacy would be associated with reductions in impacts of the reading aloud intervention. The comparable impacts of a reading aloud program on parent–child verbal/reading interactions and child cognitive outcomes regardless of parent literacy level suggest that preventive interventions in LMICs should consider promotion of shared reading even for low-literacy families.

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1. Introduction

More than 21% of children under four years of age in low- and middle-income countries (LMIC) live in extreme poverty (Newhouse, Suarez-Becerra, & Evans, 2016). These children are at risk for adverse early development, school readiness, and long-term educational, health, and economic outcomes (Grantham-McGregor et al., 2007; Hamadani et al., 2014; Lu, Black, & Richter, 2016; Wagner, 2017). Reduced quantity and quality of language exposure in the home (home language environment) is a common consequence of living in disadvantaged socioeconomic backgrounds and an important risk factor for developmental delays in language and cognitive domains in both high-income countries (HICs) (Hamilton, Hayiou-Thomas, Hulme, & Snowling, 2016; Malhi, Menon, Bharti, & Sidhu, 2018) and in LMICs (Nag, Vagh, Dulay, & Snowling, 2018; Piccolo, Arteche, Fonseca, Grassi-Oliveira, & Salles, 2016; Roopnarine & Dede Yildirim, 2018; Zuilkowski, McCoy, Jonason, & Dowd, 2019).

A large body of research has established that parent–child reading aloud provides significant and specific opportunities to promote the development of child language and emergent literacy skills, particularly for children growing up in poverty (Cates, Weisleder, & Mendelsohn, 2016; Cates, Weisleder, Dreyer et al., 2016; Cates et al., 2018; Dowdall et al., 2019; Mendelsohn et al., 2018; Roopnarine & Dede Yildirim, 2018). Programs focused on promoting reading aloud in HICs, such as Reach Out and Read (ROR), Video Interaction Project (VIP), Raising a Reader, and the Parent–Child Home Program (PCHP), have been shown to have significant positive impacts on the home language and literacy environment by providing resources (e.g., children's books), guidance, and encouragement for parents to engage in interactive reading with their infants (Anthony, Williams, Zhang, Landry, & Dunkelberger, 2014; Cates et al., 2018; Dowdall et al., 2019; Klass, Dreyer, & Mendelsohn, 2009; Levenstein, O'Hara, & Maden, 1983; Levenstein & O'Hara, 1993; Mendelsohn et al., 2007, 2011, 2001; Needlman, Toker, Dreyer, Klass, & Mendelsohn, 2005; Zuckerman, 2009). There are many reasons to hypothesize that programs developed in HICs might have similar impacts in LMICs.

First, many programs developed in HICs that support parent–child book reading in the context of poverty and low parental education address barriers to parent–child reading that are faced by low-income parents in HICs and LMICs alike, such as limited access to children's books, low literacy or comfort with reading, stress/exhaustion, and limited knowledge about why and how to read with young children. As in HICs, studies in LMICs, including Brazil (Eickmann et al., 2003; Weisleder et al., 2018), have shown benefits of parent–child shared reading programs on language and cognitive outcomes in early childhood (Dowdall et al., 2019; Jeong, Pitchik, & Yousafzai, 2018; Kim, Lee, & Zuilkowski, 2020; Murray et al., 2016; Roopnarine & Dede Yildirim, 2018; Vally, Murray, Tomlinson, & Cooper, 2015; Worku et al., 2018).

Second, theoretical frameworks such as the family investment and stress models that have been developed to explain the effects of poverty on child development in the US (Masarik & Conger, 2017) have also been shown to be applicable to families living in LMICs (Wolf & McCoy, 2019). The investment pathway would suggest that low-income families in LMICs may provide fewer literacy-rich experiences to their children due to material barriers such as limited access to books at home (Nag et al., 2018), similar to what has been found in HICs (Malhi et al., 2018; Peterson, Bruce, Patel, & Chamberlain, 2018; Van Bergen, van Zuijen, Bishop, & de Jong, 2017). The family stress pathway would suggest that family stressors, such as maternal depression and parenting stress, can be barriers to supportive parent–child relationships in LMICs (Herba, Glover, Ramchandani, & Rondon, 2016; Piccolo et al., 2016), similar to HICs (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005; McLoyd, 1998; Shaw, Connell, Dishion, Wilson, & Gardner, 2009). These stressors have also been associated with socioemotional and cognitive disparities in both LMICs (Gelaye, Rondon, Araya, & Williams, 2016; Netsi et al., 2018; Piccolo, Salles, Falceto, Fernandes, & Grassi-Oliveira, 2016) and HICs (Asbury, Wachs, & Plomin, 2005; Chazan-Cohen et al., 2009; Hughes, Roman, Hart, & Ensor, 2013; Weisleder et al., 2019). Further, stressors are associated with reduced retention in preventive programs in both HICs and LMICs, although some recent data has also suggested that families with higher social risk may have greater retention to such programs (Ingoldsby, 2010; Miller et al., 2019).

On the other hand, the degree to which certain family factors that play a role in these explanatory models represent barriers to parent–child reading may be greater in LMICs than in HICs. For example, while low-income parents in HICs face challenges purchasing and accessing children's books (Dickinson, Griffith, Golinkoff, & Hirsh-Pasek, 2012), they nonetheless have greater access to such books (e.g., through libraries and book-lending programs) than low-income parents in LMICs, where there is limited availability of children's books overall. Similarly, while low parental literacy is a significant barrier for some parents in HICs, it is much more prevalent in LMICs (Roser & Ortiz-Ospina, 2016) –16% of the adult population in LMICs and 8% in Brazil are functionally illiterate (World Bank, 2017).

Low parental literacy poses specific challenges to engaging in reading aloud activities and programs (Zuckerman, Elansary, & Needlman, 2019). Studies in HICs have shown that parents with low literacy have limited knowledge about early literacy development (Peterson et al., 2018), low motivation for reading books with their children (Jimenez et al., 2019; Peterson et al., 2018), and negative beliefs about literacy (Skibbe, Justice, Zucker, & McGinty, 2008). Consistent with these attitudes, parents with low literacy levels have been found to provide fewer books and read less with their children than parents with higher literacy levels, (Duursma, Pan, & Raikes, 2008; Green et al., 2009; Mendelsohn et al., 2011; Puglisi, Hulme, Hamilton, & Snowling, 2017). Given these challenges, it is possible that parents with low literacy may benefit less from programs that focus on shared reading. On the other hand, reading aloud programs may be able to address these challenges by teaching parents ways of using books as a tool for interaction with their child that do not require reading, e.g., telling stories, naming pictures, and talking about characters' feelings (Zuckerman et al., 2019).

In sum, while programs developed in HICs may be effective in promoting parent–child book-sharing interactions in LMICs, it is important to (1) consider making adaptations to these programs that address the local socioeconomic and cultural context, and (2) assess the efficacy of these programs while considering relevant moderators, such as parental literacy.

A number of prior programs have utilized early childcare and education to promote shared book reading and play. While some programs have focused on child care providers, e.g., the Mexican daycare dialogic-reading intervention (Valdez-Menchaca & Whitehurst, 1992) and its extensions (Opel, Ameer, & Aboud, 2009), others have used this setting to provide parent education regarding these activities (e.g., the Turkish Early Enrichment Project - TEEP) (Kagitcibasi, Sunar, Bekman, Baydar, & Cemalcilar, 2009). Alternatively, one of the best documented programs, the Jamaica Home Visit (JHV) program, has utilized home visiting to support play through homemade toys and reading using age-appropriate books (Grantham-Mcgregor & Smith, 2016; Grantham-McGregor, Powell, Walker, & Himes, 1991); this program has undergone significant scaling efforts through the Reach Up Early Childhood Parenting Program (Walker, Chang, Smith, Baker-Henningham, & the Reach Up Team, 2018). Further, several programs have utilized the health care setting either in pediatric primary care (e.g., JHV adaptation) (Chang et al., 2015; Walker, Baker-Henningham et al., 2018) and Reach Out and Read (Philippine Ambulatory Pediatrics Association,

2020; San Augustin, Ramos-Bonoan, Lorenzana, Klass, & Needlman, 2019) or in other health care settings (Nahar et al., 2012). Other programs have utilized varying degrees of home visiting and parent groups in community centers (for example, Knauer, Jakiela, Ozier, Aboud, & Fernald, 2019; Murray et al., 2016; Vally et al., 2015).

Research on parent literacy and parent–child reading aloud is sparse in LMICs (Dowdall et al., 2019; Knauer et al., 2019; Nag et al., 2018; Zuilkowski et al., 2019) and even more limited about book-reading interventions. A recent study in Kenya (Knauer et al., 2019) showed impacts of a brief dialogic reading training program on parent–child shared book reading and child vocabulary both for parents that were deemed literate and those that were deemed illiterate. That study, which was conducted with preschool to early school-age children in a multilingual environment, suggests that LMICs interventions to promote book reading might have positive impacts regardless of parent literacy. Additional study is needed to better understand the relationship between parent literacy and parent–child book reading generally and the degree to which low literacy parents benefit from book-reading interventions.

Given the paucity of research on reading aloud in the context of low parental literacy, the overarching goal of this study is to determine the relationship between parent literacy and parent–child reading in the context of a parent–child book-reading intervention in an LMIC. We address this by performing a secondary analysis of baseline and follow-up data of a Cluster Randomized Controlled Trial (RCT) of a reading aloud intervention (*Universidade do Bebê* [UBB]) (Weisleder et al., 2018). UBB is a community-based group model set in early childcare, one of several platforms previously used in LMICs to promote cognitive stimulation more broadly.

The RCT of UBB included blinded assessments of parent–child verbal/reading interactions, child developmental outcomes, and maternal literacy. A prior publication presented results of the RCT's primary aims and outcomes (Weisleder et al., 2018), showing significant impacts of UBB on parent provision of cognitive stimulation (Cohen's d = 0.43), quality of interactive reading (d = 0.52–0.57) and child cognitive outcomes (i.e., receptive vocabulary, working memory and IQ) (d = 0.33–0.46). The current study seeks to further understand how parent literacy level might moderate the impacts of early literacy interventions by examining: (1) associations between parent literacy and parent–child interactive reading, the cognitive home environment and child cognitive and language development; and (2) whether the effects of a book-reading intervention on parent–child verbal/reading interactions and child outcomes vary by parent literacy level.

Based on theoretical considerations and limited existing data, we hypothesized that (1) low parent literacy would be associated with lower quantity and quality of parent–child reading and lower scores on assessments of child development, and (2) low parent literacy would be associated with reductions in impacts of the reading aloud intervention. Ultimately, findings from this study will inform refinement of early childhood programs in LMICs given the high prevalence of low adult literacy in these countries.

2. Methods

2.1. Context and study design

This study is a secondary analysis of a cluster RCT of a parenting intervention called *Universidade do Bebê* (UBB) implemented in low-income neighborhoods in Boa Vista, a medium-sized city in northern Brazil with a high poverty rate. In the state of Roraima, where Boa Vista is located, almost 60% of children live in families making less than 5.50 US dollars ($) per day, and 25% with less than $1.90 per day; in addition, 27% of the adult population is functionally illiterate (IBGE, 2018).

In the cluster RCT, 22 educational childcare centers (*Casas-Mãe,* literally "Mother-home" in English but *loosely translated to "Feels Like Home"*) in low-income neighborhoods in Boa Vista were randomized to receive UBB or Control (usual services, including an early learning curriculum developed by the Instituto Alfa e Beto (IAB) and implemented at both intervention and control *Casas-Mãe*). The unit of randomization was the childcare centers, such that only families with children registered in one of the 22 childcare centers were eligible to participate in the study. Childcare centers sharing playgrounds were considered a single cluster to avoid contamination, resulting in 12 randomization clusters with 1–3 childcare centers per cluster. Six clusters (11 childcare centers) were randomly assigned to the intervention group, and the other 6 clusters (11 childcare centers) were assigned to the control group. Details about the randomization, enrollment process and intervention are provided in Weisleder et al. (2018) and will be briefly summarized in this publication.

2.2. Intervention

The book-reading intervention (UBB) consisted of monthly parent workshops and a book-lending program that took place in the educational childcare centers. The parent workshops were collaboratively developed by IAB and investigators at the NYU Grossman School of Medicine, and incorporated strategies from Reach Out and Read (Klass et al., 2009; Mendelsohn et al., 2001; Needlman, Fried, Morley, Taylor, & Zuckerman, 1991; Zuckerman, 2009) and the Video Interaction Project (Cates et al., 2018; Mendelsohn et al., 2007, 2011; Weisleder et al., 2016). A bachelor's level facilitator (early child educator, psychologist, or social worker) led ten monthly, 1-hour workshops with up to 30 parents and their children, approximately every four weeks during the 2015 school year. Each session consisted of a brief presentation on reading aloud (strategies, challenges), followed by a discussion of parents' experiences reading with their child at home, a real-time opportunity to practice reading developmentally appropriated books with the child, a debriefing to discuss the experience, and development of plans for the home. Facilitators were trained and supervised to maintain fidelity based on protocols developed by IAB. In addition, UBB included a lending library in which children were able to borrow two elementary school level books from the childcare center and exchange them for new ones each week. We estimate the intervention annual cost at approximately $750 per Casa-Mãe, which is comparable or less than other reading aloud and parenting interventions with low-income families in LMICs (Knauer et al., 2019; Walker et al., 2015).

2.3. Sampling/Participants

All children registered in the 22 childcare centers were eligible for the study. At the beginning of the school year, 660 children were registered for childcare in one of the 22 centers. Of those, 566 (86%) biological parents who gave consent to participate in the research were assessed together with their children at baseline (279 intervention and 287 control). At follow-up, 484 (86%) dyads (232 intervention and 252 control) completed the evaluation. Sample size ranged from 429 to 475 because not all parents and children completed all measures. Children were 37.4 months old on average (SD = 6.5) at baseline and 45.16 (SD = 6.6) at follow-up evaluation. Sample demographics at baseline are presented in Table 1.

2.4. Assessments

After providing informed consent, parents and children were evaluated at enrollment (baseline: March–June 2015) and at the

Table 1
Unadjusted mean comparison tests for sample sociodemographic characteristics at baseline by literacy level (for the overall sample and by randomization status).

	Overall sample			Low literacy			High literacy		
	Low literacy (n = 235)	High literacy (n = 240)	p[a]	Control (n = 121)	Intervention (n = 114)	p[b]	Control (n = 128)	Intervention (n = 112)	p[b]
Children									
Age in months, mean (SD)	37.70 (6.49)	37.18 (6.51)	.35	38.17 (6.52)	37.18 (6.45)	.39	37.30 (6.54)	37.05 (6.51)	.83
Sex - Male (%)	51.72	51.68	.93	53.3	50	.62	53.2	50	.65
First-born child (%)	29.74	36.13	.14	30.83	28.57	.73	38.10	33.93	.58
Race, indigenous (%)	1.30	2.52	.34	.84	1.8	.69	2.4	2.7	.86
Parents/family									
Age (>21 years old) (%)	10.76	10.21	.83	13.91	12.10	.12	8.11	7.41	.35
High school graduate (%)	48	74	<.001	50	47	.93	77	71	.31
Income (R$), mean (SD)	1002.40 (519)	1235.10 (736)	<.001	969.70 (462)	1037.10 (573)	.33	1225.60 (673)	1245.90 (462)	.72
Food insecurity, mean (SD)	1.53 (1.27)	1.39 (1.25)	.24	1.60 (1.28)	1.45 (1.27)	.38	1.48 (1.25)	1.29 (1.25)	.27
Financial hardship, mean (SD)	.89 (1.03)	.89 (.99)	.94	1.02 (1.10)	.99 (1.01)	.06	.77 (.96)	.75 (.95)	.82
Depression (%)	37.50	29.29	.08	39.17	35.71	.59	35.43	22.32	.04
Married or living with a partner (%)	61.90	71.73	.02	64.71	58.93	.45	70.63	72.97	.81

[a] = comparison between low- and high-literacy groups based on Cloze test median split adjusted for clusters, *for the overall sample.*
[b] = comparison between low- and high-literacy groups based on Cloze test median split adjusted for clusters, *by randomization status.*

end of the school year (follow-up: December 2015, approximately 6–9 months later). The assessments measured the quality of interaction between parents and their children, as well as children's language and cognitive skills, and were conducted by research assistants (blind to study hypotheses) in the childcare centers.

2.5. Measures

Except for the Cloze test, which was analyzed at follow-up only, all variables analyzed in this study were measured at baseline and follow-up. Instruments were selected based on availability and validation in Brazilian Portuguese. For measures without an available adaptation, instruments were reviewed by two bilingual authors to assess relevance for families in Brazil and translated/back-translated between English and Portuguese.

2.5.1. Predictor/Moderator

Parent literacy: The Cloze test, validated for Brazilian Portuguese (Santos, Primi, Taxa, & Vendramini, 2002), was used to evaluate parent reading comprehension at follow-up only. In this task, 14 words were removed from a passage with 103 words and replaced with blank spaces. Participants were asked to fill in each blank, writing down the answer on the sheet provided by the examiner. A list of possible words was developed through agreement between evaluators. Each response was scored using a 5-point scale as follows: 0 = incorrect answer; 1 = plausible answer with orthographic or grammatical error; 2 = plausible answer without orthographic or grammatical error; 3 = correct word with orthographic or grammatical error; 4 = correct word with no orthographic or grammatical error (total scores: 0–56). The Flesch-Kincaid grade level test was calculated using Coh-Metrix-Port (Scarton & Aluısio, 2010) and indicated an easy level of readability (index score = 88.02), equivalent to 6th school grade. Reliability was established by two educators and two experts, who reviewed tests in blocks of 10, comparing and discussing the responses until complete agreement was established. The Cloze test has demonstrated adequate psychometric indexes in other studies, including internal consistency (Cronbach's α = 0.83; (Santos, 2005), criterion validity by contrasting groups (Santos & Oliveira, 2010), and validity by response process (Cunha & Santos, 2010). For the present study, literacy was defined as high and low based on a median split (Median = 26; Minimum = 0, Maximum = 48).

Of note, parent literacy did not follow a normal distribution. The Cloze test distribution had two peaks, one near zero and one higher, and was found to be non-normal (W = .98, $p < .001$). As there is no consensus regarding cut points defining low and high literacy, we chose a median split as a commonly used approach in such circumstances (Christian, Morrison, & Bryant, 1998; Friedman & Hoffman-Goetz, 2007). In addition to using a median split for primary analyses, we performed sensitivity analyses testing alternative cut points, i.e., terciles, quartiles and found comparable effect sizes (albeit with loss of power to show statistical significance).

2.5.2. Parent–child verbal/reading interactions

2.5.2.1. Interactive reading. The Adult/Child Interactive Reading Inventory (ACIRI) (DeBruin-Parecki, 1999) consists of observations of parent–child interactions behaviors real-time coded during shared storybook reading. Interaction frequencies were rated from never to most of the time (0–3 scale; raw scores: 0–36) by blind coders (using a checklist) on 12 parent literacy behaviors related to: (1) "Enhancing Attention to Text" (e.g., sharing the book with the child and promoting physical proximity, using child-adjusted language, positive affect, and reinforcement), (2) P̈romoting Interactive Reading and/or Supporting Comprehension(̈e.g., promoting a c̈onversationẅith the child, asking questions, pointing and nam-

ing pictures and words and waiting for child's responses), and (3) "Using Literacy Strategies" (e.g., asking questions about the story, elaborating on the child's ideas). Coders were trained by one of the authors (ASL) to achieve reliability. Reading interactions used for the ACIRI were also video recorded. After study completion, one of the authors recoded 5% of the videos to establish a gold standard for interrater reliability, with intra-class correlation coefficient (ICC) = .64 for parent literacy behaviors. The instrument has shown good internal consistency in the US ($\alpha \geq .8$) and in Brazil's current sample ($\alpha \geq .86$).

2.5.2.2. Cognitive home environment. StimQ (Dreyer, Mendelsohn, & Tamis-Lemonda, 1996), a structured interview with the caregiver, was used to assess parent–child interactions in play, shared reading, and daily routines. Parent interview included three subscales: (1) The READ subscale was used to assess frequency and quality of reading interactions (scores 0–13); (2) Parental Verbal Responsivity (PVR) was used to assess caregiver-child verbal interactions (scores 0–14); and (3) Parent Involvement in Developmental Advance (PIDA) was used to assess caregiver teaching and play activities (scores 0–10). In US populations, the instrument has shown good internal consistency (Cronbach's α = .88), test-retest reliability (ICC = .93), and was correlated with the Home Observation for Measurement of the Environment Inventory (r = .5–.6). The survey was first translated and back-translated in Brazil, with final translations based on consensus review by educators and experts. Good internal consistency (α = .82) was found for StimQ for the current sample in Brazil. Test-retest reliabilities among control families were calculated based on administration at baseline and follow-up; these were somewhat lower than expected (r = .45 for StimQ Total, r = .32 for READ, r = .45 for PVR, and r = .35 for PIDA; all $p < .001$), possibly due to the interval between administrations.

2.5.3. Child outcomes

2.5.3.1. Expressive vocabulary. Teste Infantil de Nomeação (Dias, Tortella, & Seabra, 2012) is a Brazilian adaptation of the Boston Naming Test (BNT) (Ferraro & Lowell, 2010). In this test, the child was asked to label a series of pictures, one at a time. Each correct response corresponded to 1 point (total score: 0–60). Raw scores were used because standard scores were only available for three years and older. The Brazilian version has shown high internal consistency (α = .97; split-half reliability = .96) and concurrent validity with child receptive vocabulary (r = .73).

2.5.3.2. Receptive vocabulary. Teste de Vocabulário por Imagens Peabody (TVIP) (Ferracini, Capovilla, Dias, & Capovilla, 2006) is an adaptation of the Peabody Picture Vocabulary Test to the Brazilian population (Dunn & Dunn, 1997). In the TVIP, words are read to the child, and the child is asked to identify the corresponding picture out of four possible choices; each correct answer corresponded to 1 point (total score: 0–125). Raw scores were used, as standard scores were only available for three years and older. The instrument has shown high internal consistency (α = .89; split-half reliability = .41) and concurrent validity with the Language Development Survey (Rescorla, 1989) (r = .36).

2.5.3.3. IQ. Two subscales, Categories and Situations, from the Brazilian version of the Snijders-Oomen nonverbal intelligence test (SON-R) were used (Tellegen, Winkel, Wijnberg-Williams, & Laros, 1998). In the Categories subscale, the child had to match pictures to create categories (e.g., place all the flowers together). In the Situations subscale, the child saw an incomplete picture and had to fill in the missing part (e.g., place the head that belongs to each animal). One point was given for each correct response and testing stopped after two incorrect responses. The scores on each subscale were summed to obtain a total IQ score. Standard scores were available for children 2.5 years and older. The instrument has shown high concurrent validity with the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler, 2002) (r = .78) and the Columbia Mental Maturity Scales (Burgemeister, Blum, & Lorge, 1972) (r = .56).

2.5.3.4. Working memory. Teste Infantil de Memória (TIMT; now called TIME-R) (Mecca, Duarte, & Macedo, 2019; Morais & Macedo, 2011) is a non-verbal working memory task developed by Morais and Macedo (2011). In this test, items were scored as correct if the child pointed to and named objects in the presented order (total score: 0–48). The test has shown concurrent validity with forward (r = .54) and backward digit span tasks (r = .55), and with forward (r = .65) and backward Corsi block-tapping tasks (r = .61).

2.5.3.4.1. Phonological short-term memory. Teste de Repetição de Palavras e Pseudopalavras (TRPP) is a phonological short-term memory task validated for the Brazilian population by Brazilian investigators (Trevisan, 2012). Series of 20 words/nonwords are presented and scored based upon repetition in the correct order (total score 0–40). The test has shown high internal consistency (α = .83; split-half = .83), test-retest reliability (r = .73), and concurrent validity with tests of auditory (r = .60) and visual working memory (r = .49).

2.5.3.5. Covariates. Sociodemographic characteristics were assessed via interviews with the parent. The set of covariates included was chosen a priori based on research documenting associations between these variables and study outcomes, including research in Brazil (Anselmi et al., 2008; Piccolo, Salles et al., 2016; Walker et al., 2011). Child variables included age, sex, race (dichotomized as indigenous or not indigenous), and birth order. Family characteristics included the parent's age (dichotomized as <21 years or older), marital status, family income (with mean imputation performed for 55 missing cases), food insecurity, and financial hardship. Parental depressive symptoms were assessed by the Edinburgh Postnatal Depression Scale (met criteria if $\geq$ 10 depressive symptoms) (Cox, Chapman, Murray, & Jones, 1996) validated for the Brazilian population (Santos et al., 2007).

2.6. Data analysis

Power calculations were described in the previous report (Weisleder et al., 2018). All of the analyses were performed using multilevel models to account for clustering, which included three levels: clusters (level 3), centers within clusters (level 2), and dyads within centers (level 1) (conducted using the STATA software version 15). Sociodemographic and covariate data at baseline were compared (adjusting for cluster) by parent literacy (median split) overall and by intervention status (Table 1). Bivariate correlations between covariates and outcome measures at baseline are presented in Table 2.

To investigate the association between parenting and child outcomes (for Aim 1), we performed cross-sectional analysis, utilizing baseline data (prior to initiation of interventions) for both predictor (Cloze test dichotomized by median split) and outcome variables (parent–child verbal/reading interactions and child). Table 3 presents these analyses, performed using models adjusted by clusters (three levels) and all the covariates mentioned above.

To investigate whether the effects of a book-reading intervention on parent–child verbal/reading interactions and child outcomes vary by parent literacy level (Aim 2), we analyzed data from the assessments performed at follow-up and accounted for baseline performance, clustering (three levels) and the covariates mentioned above. Table 4 presents the results. To investigate differences in the effects of UBB on the 13 outcomes variables and

Table 2
Bivariate correlations between covariates and outcome variables for the overall sample at baseline.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Child's age	–																		
2. Child's sex	−.05	–																	
3. First-born child	−.05	.01	–																
4. Race, indigenous	−.05	−.02	.08*	–															
5. Maternal age	−0.1*	−.02	.26**	.11*	–														
6. High school graduate	−.01	.08	.07	−.05	−.17**	–													
7. Family income	.03	−.03	.07	.04	−.07	.18**	–												
8. Food insecurity	.05	.03	−.11*	0	−.03	−.17**	−.19**	–											
9. Financial hardship	.05	.01	−.08*	.01	−.02	−.07	−.05	.43**	–										
10. Depression	.02	.06	−.02	.10*	.08*	−.16**	−.19	.42**	.24**	–									
11. Marital status	−.01	−.11*	.01	.02	−.02	−.01	.30**	−.13**	−.03	−.15**	–								
12. Literacy total score	−.03	.01	.11*	.05	.02	.28**	.21**	−.02	−.06	−.10*	.07	–							
13. ACIRI	−.02	.04	.03	−.07	−.11*	.21**	.05	−.03	−.07	−.12*	−.04	.22**	–						
14. StimQ	.07	.10*	.17**	.04	−.03	.13**	.08*	−.03	0	−.10*	.09*	.11*	.18**	–					
15. TIN	.55**	−.07	−.03	.02	−.08*	.11*	.10*	−.04	−.05	−.12*	.09*	.13*	.11**	.11	–				
16. Peabody	.51**	.01	−.01	−.02	−.07	.07	.04	−.01	−.04	−.08*	.03*	.05	.09**	.12*	.67**	–			
17. SON-R	.01	.04	.02	.03	−.03	.07	0	−.02	−.02	−.07	.04	.15**	.11**	.10*	.45**	.41**	–		
18. TIME-R	.48**	0	.03	−.02	−.09*	−.05	.03	0.02	−.03	.01	.02	.06	.10**	.11	.53**	.47**	.34**	–	
19. TRPP	.47**	.06	.02	−.02	−.05	−.02	.06	.03	.01	−.03	.05	.07	.10**	.11*	.54**	.51**	.29**	.59**	–

1 = Child's age; 2 = Child's sex; 3 = First-born child; 4 = Race, indigenous; 5 = Maternal age; 6 = High school graduate; 7 = Income (R$); 8 = Food insecurity; 9 = Financial hardship; 10 = Depression; 11 = Marital status (married or living with a partner); 12 = Literacy total score; 13 = Interactive reading (ACIRI)3; 14 = Cognitive home environment (StimQ); 15 = Expressive vocabulary (TIN); 16 = Receptive vocabulary (Peabody); 17 = IQ (SON-R); 18 = Working memory (TIME-R); 19 = Phonological short-term memory (TRPP).

* $p < .05$.

** $p < .005$.

Table 3
Associations between literacy and parenting/child outcomes at baseline (standardized coefficients - beta).

Outcomes		Literacy level[a]		β	z	p
		Low literacy (n = 235)	High literacy (n = 240)			
Parent–child verbal/reading interactions	Interactive reading (ACIRI adult scores)	13.28 (6.46)	15.76 (6.36)	.37	4.54	<.001
	ACIRI - Enhancing Attention to Text	6.62 (2.43)	7.56 (2.42)	.38	4.95	<.001
	ACIRI – Promoting interactive reading and supporting comprehension	3.78 (3.14)	4.79 (3.08)	.31	3.44	.001
	ACIRI - Using Literacy Strategies	2.89 (1.95)	3.41 (1.93)	.24	3.11	.002
	Cognitive home environment (StimQ)	19.81 (7.81)	21.96 (7.14)	.22	1.96	.023
	StimQ READ	4.70 (4.12)	5.56 (3.87)	.13	1.40	.163
	StimQ PVR	8.06 (2.91)	9.07 (2.84)	.29	3.24	.001
	StimQ PIDA	6.97 (2.54)	7.44 (2.21)	.17	1.82	.069
Child	Expressive vocabulary (TIN)	3.29 (4.06)	4.51 (4.94)	.27	3.36	.001
	Receptive vocabulary (Peabody)	7.35 (6.13)	8.08 (7.05)	.16	1.89	.059
	Nonverbal intelligence (SON-R)	89.72 (12.41)	94.19 (14.33)	.32	3.41	.001
	Working memory (TIME-R)	4.13 (3.73)	4.44 (4.26)	.07	.88	.378
	Phonological short-term memory (TRPP)	1.6 (1.87)	1.83 (1.95)	.11	1.31	.189

StimQ PVR = Parental Verbal Responsivity.
StimQ PIDA = Parent Involvement in Developmental Advance.
Multilevel modeling was used to account for clustering (22 childcare centers within 12 sites).
Separate models were performed for each outcome, adjusted for children's age, sex, race (dichotomized as indigenous or not indigenous), and birth order; and parent age, marital status, family income, food insecurity, financial hardship, and depressive symptoms.
[a] Parent literacy dichotomized by median split. β = standardized coefficient (beta).

potential moderation, separate models for each outcome (13) were analyzed for low- and high-literacy parents; moderation between parent literacy and intervention status was analyzed by multiplying dummy-coded literacy level and randomization status. Multiple comparisons were controlled through the Benjamini and Hochberg (Benjamini & Hochberg, 1995) procedure using a false discovery rate (FDR) of 10%. Table 4 shows the means and standard deviations by groups defined by intervention status and literacy level (median split). The intervention effects by literacy groups were analyzed using multilevel models adjusted for cluster, baseline, and covariates. We measured effect sizes by calculating a baseline-corrected Cohen's *d*, based on analyses of covariance (ANCOVAs). In addition, because depression and children's cognitive deficits have the potential to affect program engagement, and because we found differences between low- and high-literacy parents for maternal depression, we performed exploratory analyses removing mothers who met criteria ≥10 in the Edinburgh Postnatal Depression Scale and children with IQ ≤ 70 (SON-R standard scores).

3. Results

3.1. Descriptive statistics

Sample sociodemographic characteristics at baseline are presented by parent literacy level and randomization status in Table 1. Unadjusted mean comparison tests showed that, overall, low-literacy parents had lower parental education and income (both $p < .001$), were less likely to be married/living with a partner ($p = .02$) and had a nonsignificant trend towards having more depressive symptoms ($p = .08$). In comparisons of intervention and control parents for low- and high-literacy subgroups considered separately, intervention and control parents were comparable for the majority of sociodemographic characteristics. However, low-literacy controls showed a trend towards significant higher financial hardship compared to low-literacy intervention parents ($p = .06$), and high-literacy controls showed more depressive symptoms than high-literacy intervention parents ($p = .04$). Table 2

Table 4
Outcomes' mean performance at follow-up by parent literacy level and intervention status, impacts of UBB intervention (Cohen's d), and interaction significance (p-value).

Outcomes		Low literacy[3]			High literacy			p^2
		Control Mean (SD)	Intervention Mean (SD)	Cohen's d[1]	Control Mean (SD)	Intervention Mean (SD)	Cohen's d[1]	
Parent–child verbal/reading interactions	Interactive reading (ACIRI)	10.40 (4.71)	13.47 (5.97)	.59**	13.08 (5.26)	16.09 (4.77)	.60**	.59
	ACIRI - Enhancing Attention to Text	5.48 (2.56)	5.92 (2.68)	.16	6.52 (2.45)	7.21 (2.42)	.22*	.23
	ACIRI – Promoting interactive reading and supporting comprehension	2.94 (2.34)	4.52 (2.42)	.70**	3.88 (2.73)	5.55 (2.36)	.59**	.89
	ACIRI - Using Literacy Strategies	1.98 (1.51)	3.02 (2.25)	.57*	2.69 (1.70)	3.33 (1.73)	.41*	.23
	Cognitive home environment (StimQ)	21.24 (7.84)	24.52 (7.10)	.49*	24.76 (6.81)	27.18 (6.05)	.43*	.32
	StimQ READ	5.32 (4.05)	7.78 (3.51)	.67**	6.85 (3.75)	8.61 (3.49)	.41*	.12
	StimQ PVR	8.28 (3.26)	8.92 (2.96)	.25	9.46 (2.93)	10.21 (2.42)	.38*	.58
	StimQ PIDA	7.72 (2.14)	7.90 (2.27)	.06	8.38 (1.87)	8.53 (1.67)	.14	.83
Child	Expressive vocabulary (TIN)	6.74 (5.60)	8.34 (6.61)	.33[t]	8.25 (5.69)	9.18 (6.59)	.11	.17
	Receptive vocabulary (Peabody)	12.27 (8.41)	14.31 (9.46)	.31*	13.36 (9.21)	15.5 (10.22)	.42*	.73
	IQ (SON-R)	91.19 (12.72)	97.49 (14.43)	.39*	95.65 (14.45)	100.54 (14.62)	.36*	.49
	Working memory (TIME-R)	7.26 (4.61)	8.98 (5.72)	.41**	7.17 (4.32)	9.72 (5.94)	.49**	.51
	Phonological short-term memory (TRPP)	3.21 (2.44)	3.32 (2.39)	.07	3.25 (2.65)	3.56 (2.36)	.08	.42

[3]Parent literacy dichotomized by median split.
* $p < .01$.
** $p < .001$.
[1] Cohen's d estimates are baseline-corrected.
[2] Interaction between intervention status and literacy level p-value.
[t] Non-significant trend (p = .07).

shows bivariate correlations between covariates for the overall sample at baseline. As previously showed (Weisleder et al., 2018), parents from the intervention group overall (without regard to literacy) were less likely to report financial hardship (p = .07) and to meet criteria for depression (p = .09), but those differences were not statistically significant.

In terms of engagement, 97% of both high and low literacy families attended at least one workshop out of 10 [$\chi^2(1, N = 226) = 0.001$, p = .98] and a t-test for mean number of workshops indicated no differences between low- and high-literacy groups in number of visits (5.38 [SD = 2.20] vs. 5.26 [SD = 2.10]; t = .77, p = .44). Additionally, 81% of the high-literacy parents and 87% of the low-literacy group borrowed at least one book [$\chi^2(1, N = 226) = 0.92$, p = .34] and there were no differences for number of books borrowed by low- and high-literacy parents (20 [SD = 11.6] vs. 18 [SD = 11.7]; t = 1.13, p = .26).

3.2. Aim 1 analyses: Associations between parent literacy and baseline *parent–child verbal/reading interactions and child outcomes*

Table 3 shows the results for the associations between parent literacy and baseline parent–child verbal/reading interactions and child outcomes. Parent literacy was positively associated with *baseline* interactive reading (ACIRI total score: β = .37, p < .001; ACIRI attention: β = .38, p < .001; ACIRI comprehension: β = .31, p < .001; ACIRI strategy: β = .24, p = .01) and the cognitive home environment (StimQ total score: β = .22, p = .02; StimQ PVR: β = .29, p = .001; StimQ PIDA: β = .17, p = .07).

We observed a high frequency of parents who did not read to their child at all in their homes (n = 181; 34%), i.e., StimQ READ score = 0. We performed an exploratory analysis to investigate whether literacy (median split) was associated with the proportion of parents not reading at baseline. Parents with lower literacy were less likely to read in their homes than parents with higher literacy [40% vs. 60%, $\chi^2(1, N = 450) = 5.01$, p = .02]. This relationship persisted after adjustment for clusters (AOR = 1.57, p = .02), and as a non-significant trend after adjustment for both clusters and covariates (AOR = 1.35, p = .10).

Parent literacy was positively associated with child expressive vocabulary (β = .27, p < .001) and IQ (β = .32, p = .002). There was a nonsignificant trend for the association between literacy and receptive vocabulary (β = .16, p = .06). There were no significant associations between parent literacy and working memory or phonological short-term memory. Similar findings were observed after applying FDR corrections.

3.3. Aim 2 analyses: Tests for variation in the impact of the book-reading intervention on parent–child verbal/reading interactions and child outcomes by literacy level

Multilevel models showed comparable benefit of UBB on parent–child verbal/reading interactions and children's outcomes regardless of parent literacy level (see Table 4). For example, among parent–child verbal/reading interactions outcomes, effect size (Cohen's d) for overall interactive reading as .59 (p = .001) for low-literacy parents and .60 (p = .001) for high-literacy parents. Among child outcomes, effect size for IQ was .30 (p = .008) for children of low-literacy parents and .36 (p = .007) for children of high-literacy parents. The interaction between parent literacy and intervention status was not statically significant for any of the parent–child verbal/reading interactions or child developmental outcomes. Similar findings were found after applying FDR corrections.

In separate within-group models, workshops attended (dichotomized by median split) predicted ACIRI comprehension (β = .31, p = .04), StimQ total (β = .44, p = .01), and StimQ PVR (β = .41, p = .01), for low-literacy families only. The number of books borrowed predicted ACIRI comprehension for both low- and high-literacy groups (low: β = −.34, p = .04; high: β = −.48, p = .007). The number of books borrowed (dichotomized by median split) also predicted ACIRI strategy (β = −.57, p = .01), StimQ total (β = .52, p = .004), StimQ READ (β = .41, p = .017), StimQ PVR (β = .51, p = .003), for low-literacy parents only.

Finally, we performed exploratory analyses excluding 157 mothers who had scored -≥ 10- on the Edinburgh Postnatal Depression Scale. In these analyses, the effect sizes and statistical significance were comparable to the original findings for all measures for low- and high-literacy parents. In terms of child cognitive disabilities, we performed exploratory analysis excluding the 15 cases that child IQ (SON-R) ≤ 70. Similarly, the effect sizes and statistical significance for all measures for both literacy levels were comparable to the original findings.

4. Discussion

In this study, we first examined associations between parent literacy and parent–child verbal/reading interactions and child outcomes. Consistent with our hypothesis, parent literacy was positively associated with parent–child verbal/reading interactions and child cognitive and language outcomes (child's expressive and receptive vocabulary and IQ) at baseline. Next, we investigated whether the effects of a book-reading intervention on parent–child interactive reading, overall cognitive home environment, and child cognitive outcomes varied by parent literacy among low-income families. Contrary to our hypothesis, findings showed comparable benefit of the intervention regardless of parent literacy level.

The observed associations between parents' literacy level and reading activities at home are consistent with limited prior studies in LMICs (Dowdall et al., 2019; Knauer et al., 2019; Nag et al., 2018; Zuilkowski et al., 2019). Based on theoretical frameworks such as the family investment and stress models, and similar to what has been observed in HICs (Duursma, Pan, et al., 2008; Green et al., 2009; Jimenez et al., 2019; Peterson et al., 2018; Puglisi et al., 2017; Zuckerman et al., 2019), it is possible that low-literacy parents in LMICs engage in fewer literacy activities with their children due to lower self-efficacy and motivation to read and to having fewer books at home (Nag et al., 2018). Although shared book reading is an activity that can involve storytelling and conversations rather than reading per se, parents with low literacy may nonetheless perceive their limited literacy skills as a barrier to sharing books with their children. Our study extended those findings by showing that low literacy was also associated with reading aloud outcomes. Of note, exploratory analyses suggested that low-literacy parents were more likely to not read to their children at all.

Given these relations between low literacy and reading aloud, we expected to see reduced program impacts for parents with low literacy. In addition, because low levels of education and literacy are associated with exposure to multiple socioeconomic adversities and with parents' beliefs and knowledge about early childhood development, we expected that low parental literacy might impact engagement in parenting programs (Whittaker & Cowley, 2012). Importantly, we observed similar engagement in and impacts of a reading aloud intervention for low- and high-literacy parents. Although there has been very limited prior study of the degree to which literacy might moderate reading aloud interventions, a recent study documented similar findings in the context of a short-term intervention with families in Kenya (Knauer et al., 2019). The current study extends these findings to a population in a second LMICs with different characteristics (e.g., urban, monolingual). Generalization of findings across contexts and methodologies supports utilization of reading aloud programs across different LMICs.

Interestingly, we found similar impacts of the intervention for low-literacy parents on reading aloud interactions but not on verbal interactions more broadly (i.e., StimQ PVR and StimQ PIDA). It is possible that low-literacy parents were less likely to generalize from their experiences with reading-aloud to other verbal interactions (Duursma, Augustyn, & Zuckerman, 2008). Programs that promote play and other broad verbal interactions have been shown to have cross-domain impacts (Hassinger-Das et al., 2017) and may have additional benefits for families with low literacy.

A key question relates to why families with low literacy nonetheless benefit from interventions focused on reading aloud. One possible explanation is that parents in the UBB program learned strategies for using the pictures in the book to engage in verbal interactions with their child, such as labeling, describing, and telling stories. These behaviors have been observed in book-sharing interactions in low-income populations (Ninio & Bruner, 1978; Valdez-Menchaca & Whitehurst, 1992). This strategy has also been proposed to explain impacts of reading aloud interventions in HICs (Mahoney, McConnell, Larson, Becklenberg, & Stapel-Wax, 2020), which emphasize discussion rather than reading the book text per se (Fletcher & Reese, 2005; Ninio & Bruner, 1978; Valdez-Menchaca & Whitehurst, 1992; Whitehurst et al., 1994). In addition, parents in the UBB workshops discussed perceived barriers and solutions to reading aloud and had opportunities to engage in and receive feedback about book reading with their child, which may have increased their self-efficacy and motivation to read. Although this study cannot identify which of these program components are necessary to achieve the observed impacts, it suggests that a program that provides moderate support for reading aloud can increase parent–child reading interactions and child outcomes even for families with low literacy. Additional study is needed to better understand these processes in the context of reading aloud interventions in both HICs and LMICs.

A strength of this study was its successful implementation across multiple neighborhoods in Boa Vista, supporting validity across diverse, high-risk contexts, and in contrast to many prior studies showing reduced engagement and impact in families experiencing adversity (Gadsden, Ford, & Breiner, 2016). Furthermore, group models for intervention have been commonly used in research in LMICs (Chang et al., 2015; Hamadani, Huda, Khatun, & Grantham-McGregor, 2006; Yousafzai, Rasheed, Rizvi, Armstrong, & Bhutta, 2015), supporting their potential for applicability in other settings. A limitation of this study is that it was performed in a single city, Boa Vista, in one country, Brazil. Additional study is needed to determine whether findings are generalizable to other LMICs or HICs. A second limitation is the availability of instruments to evaluate young children and parent–child interactions during book reading in Brazil, although we observed impacts on key measures developed (TIME-R) or validated (Boston Naming test, Peabody, and SON-R) in Brazil. Given that the Cloze test is not a standardized measure, we performed sensitivity analyses with different cut points and found similar results. Further, the Cloze test provides a general estimate of reading comprehension, but it does not assess specific components such as word reading. Therefore, we do not know whether similar results would be obtained among parents with more specific limitations with word reading. A third limitation is that randomization took place only for families already attending childcare centers, and it is possible that childcare center attendance could have amplified impacts. Such impacts might be especially important for children whose parents have lower literacy levels, given that educational childcare can provide additional opportunities for children to experience book sharing with adults. Although the current analyses do not address the potential role of the childcare centers in supporting child outcomes, they suggest that interventions that support parent–child book sharing can enhance child development for children already attending educational childcare regardless of parental literacy level. Finally, a limitation of this analysis is that it did not address whether there were sustained impacts beyond completion of one year of the program. Parental literacy level might moderate the intervention's impacts in the longer term, even if no effect was found on immediate impacts. While our findings of early impact are nonetheless relevant, ongoing support for parenting and high-quality education may be necessary to sustain impacts beyond program completion and across children's schooling (Pages, Lukes, Bailey, & Duncan, 2019). Furthermore, a higher level of support may be needed to sustain impacts among children whose parents have lower literacy levels.

5. Conclusion

Our results suggest that reading aloud programs can increase the quantity and quality of parent–child book-sharing interactions and enhance child outcomes for families in which parents have low

literacy. This finding is important because of the high prevalence of low parental literacy in LMICs, but also has relevance for initiatives seeking to promote early literacy in HICs. Given the low cost of many reading aloud programs (such as ROR, VIP, and the Kenyan Study of Knauer et al., 2019), including the group model studied here, consideration should be given to population-level scaling of such programs in Brazil and across LMICs more broadly.

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Declarations of interest

None.

CRediT authorship contribution statement

Alan L. Mendelsohn: Conceptualization, Methodology, Validation, Formal analysis, Writing - review & editing, Supervision. **Luciane da Rosa Piccolo:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **João Batista Araujo Oliveira:** Conceptualization, Methodology, Resources, Writing - review & editing, Supervision. **Denise S.R. Mazzuchelli:** Project administration. **Aline Sá Lopez:** Project administration. **Carolyn Brockmeyer Cates:** Conceptualization, Methodology, Validation, Writing - review & editing, Supervision. **Adriana Weisleder:** Conceptualization, Methodology, Validation, Data curation, Writing - review & editing, Supervision, Project administration.

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