Breastfeeding, Physical Growth, and Cognitive Development

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abstract

BACKGROUND AND OBJECTIVES: Breastfeeding is an evidence-based recommendation for all countries, but breastfeeding rates have been declining in many middle-income settings. One reason behind this decline is the perception that breastfeeding may not be necessary in modern urban settings, where clean water is available and alternative foods are abundant. We investigate the importance of breastfeeding for early childhood development in the modern urban context of São Paulo, Brazil.

METHODS: In our study, we used data from the ongoing prospective Western Region Birth cohort in São Paulo, Brazil. Children were recruited at birth and managed for 3 years. Durations of exclusive and mixed breastfeeding were our primary independent variables. Our secondary independent variable was an indicator for compliance with World Health Organization (WHO) breastfeeding recommendations. Our primary outcomes of interest were indicators of children's physical, cognitive, language, and social-emotional development at 3 years of age. Adjusted estimates and 95% confidence intervals were calculated by using linear and logistic regression.

RESULTS: Complying with WHO recommendations to exclusively breastfeed for 6 months followed by complementary feeding until 2 years of age was associated with a 0.4-SD increase in overall child development (β: .38; confidence limit = 0.23 to 0.53), a 0.6-SD increase in height-for-age *z* score (β: .55; confidence limit = 0.31 to 0.79), and a 67% decrease in the odds of stunting (odds ratio = 0.33; 95% confidence interval = 0.20 to 0.54).

CONCLUSIONS: Our results suggest that even in settings with easy access to complementary foods, complying with WHO breastfeeding recommendations is important for healthy physical growth and cognitive development.

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Dr Wallenborn conceptualized and designed the study, conducted the initial analyses, and drafted the initial manuscript; Dr Fink conceptualized and designed the study, designed data collection instruments, and coordinated and supervised data collection; Dr Levine and Dr Carreira dos Santos reviewed the manuscript for important intellectual content; Dr Brentani conceptualized the cohort design, designed data collection instruments, coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content; Dr Grisi coordinated and supervised data collection and critically reviewed the manuscript for important intellectual content; and all authors reviewed and revised the manuscript, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.

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WHAT'S KNOWN ON THIS SUBJECT: As countries develop economically and reach middle-income levels, breastfeeding often becomes more challenging, and rates of breastfeeding significantly drop. Evidence on the importance of continued breastfeeding for child development in upper middle-income countries with abundant food access is limited.

WHAT THIS STUDY ADDS: Our results suggest that in the upper-middle–income settings of Brazil, complying with the World Health Organization breastfeeding recommendations is likely beneficial for children's physical and cognitive development.

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Currently, >250 million children worldwide do not reach their full developmental potential.[1] Two *Lancet* series on early childhood development highlighted critical consequences of delayed childhood development and identified risk and protective factors that help children reach their full potential.[2] Breastfeeding is among the factors that help children's healthy physical and cognitive development[3] and is actively promoted by the World Health Organization (WHO) worldwide.[4] In a recent systematic review, authors found breastfeeding to be consistently associated with improved intelligence tests, schooling performance, and adult income earnings[5]; for social-emotional functioning, evidence appears more mixed.[6] For physical growth, the majority of studies from high-income countries reveal leaner growth and slower weight gain trajectories in exclusively breastfed infants compared with formula-fed infants,[7–11] implying that breastfeeding could also be a key protective factor for obesity and cardiovascular diseases.[12,13]

Today, the extent to which mothers engage in breastfeeding varies widely across country income groups.[14] In most low-income countries, breastfeeding is almost universal.[15] However, as countries develop economically and reach middle-income levels, breastfeeding often becomes more challenging or is perceived as less necessary, and rates of breastfeeding drop significantly.[15–18] Although the critical importance of breastfeeding for early childhood development seems obvious in low-income settings where safe alternative foods are scarce,[19] this is not necessarily true in higher-income settings where alternative feeding choices are abundant, affordable, relatively safe, and easily accessible. A lack of regulatory frameworks for sales and marketing of breast milk substitutes, such as the WHO Code of Marketing of Breast-milk Substitutes, may also lead to lower breastfeeding rates and higher rates of complementary feeding with infant formula.[20]

In Brazil, the prevalence of breastfeeding decreased drastically during the 1970s.[21] Factors contributing to these declines included increasingly affordable alternative feeding options, changing social norms, and a rise in mothers' formal labor commitments without sufficient parental leave or breastfeeding support.[22] The Brazilian National Breastfeeding Program was a major turning point for the prevalence of exclusive breastfeeding in infants <6 months of age, increasing rates from 5% in 1986 to 37% in 2013.[21] However, the prevalence of exclusive breastfeeding varies, with the highest rates seen in capital cities and higher socioeconomic groups.[23]

In this study, we aim to investigate the association between breastfeeding and children's physical, cognitive, language, and social-emotional development in this setting. Our study population of mothers living in a large metropolitan area of Brazil, a dynamic and rapidly growing modern middle-income country, represents large urban environments that are home to a growing share of families in low- and middle-income countries.[24] Our research directly responds to a previous *Pediatrics* study in which authors called for research on a dose-response relationship between breastfeeding and infant development that could adequately control for confounders.[25] We respond to this call by using a prospective cohort of children growing up in poor urban neighborhoods of São Paulo, Brazil, while controlling for essential confounding factors overlooked in previous studies (ie, home stimulation). On the basis of our a priori data analysis plan, we hypothesized that (1) breastfeeding duration is associated with a higher level of cognitive and social-emotional development, (2) this association will be more apparent in exclusively breastfed children, with smaller estimates seen in children who had mixed feeding, and (3) height-for-age *z* score (HAZ) will be smaller among exclusively breastfed children compared with nonbreastfed or mixed-fed children. Post hoc, we added childhood obesity, which had been omitted in the original preanalysis plan but was deemed an important outcome by local coinvestigators given the rising rates of child obesity in this setting.[26]

METHODS

Data Source

Data used for our prospective cohort study were collected as part of the São Paulo Western Region Birth Cohort (ROC) located in the Butantã-Jaguaré region of São Paulo municipality, Brazil. The cohort comprises all resident children born at São Paulo's university hospital between April 1, 2012, and March 31, 2014. Birth outcomes were obtained from electronic medical records. Additional information on mother-infant dyads was collected at 36 months postpartum by study staff at the child's home through structured interviews. Data were collected on socioeconomic status, health standing, breastfeeding practices and other infant feeding behaviors, and childhood development indicators. Additional details on the ROC can be found elsewhere.[27]

The original study population included 3620 mothers that were interviewed at 3 years postpartum. Our study excluded mother-infant dyads who were not selected for the 3-year breastfeeding module (n = 1239), had a multiple birth (ie, twins) (n = 21), or had a child with a malformation or disability (n = 72) (Fig 1). Our final study population consisted of 2288 mother-infant dyads. The breastfeeding module that consisted of 5 breastfeeding

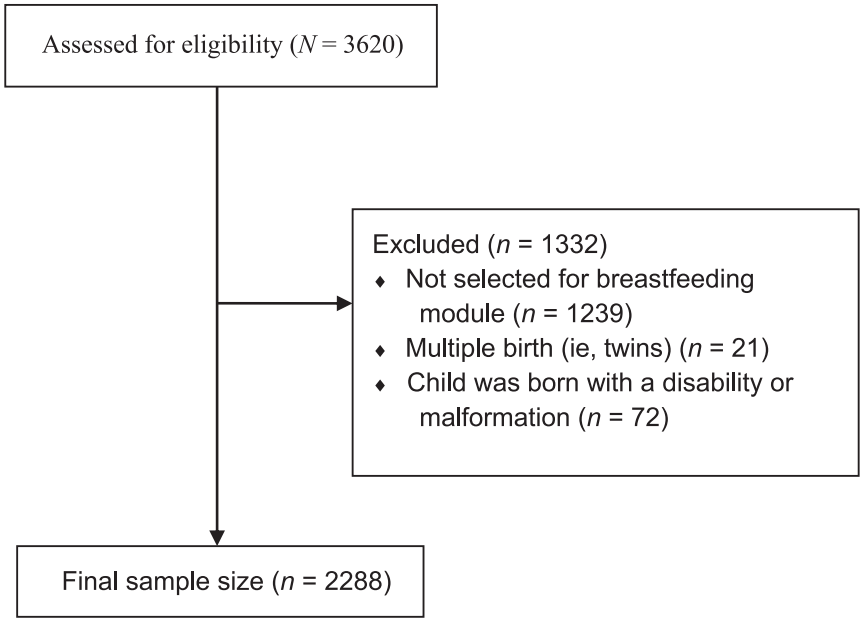

FIGURE 1
Consolidated Standards of Reporting Trials flow diagram for sample population.

questions was added ~6 months after launching the 36-month follow-up. As a result, ~1000 mother-infant dyads were not administered the breastfeeding module.

Breastfeeding

Our primary exposure of interest, breastfeeding duration, was parameterized multiple ways to explore the mechanisms between breastfeeding and our outcomes of interest. We investigated both exclusive breastfeeding duration and total breastfeeding duration in months. Mothers self-reported breastfeeding duration by answering the following questions: "For how many months did the child exclusively receive breast milk?" and "For how many months did the child receive any breast milk?" In addition to the continuous measure, exclusive breastfeeding was also categorized as follows: exclusive breastfeeding for ≤3 months, 4 to 5 months, and at least 6 months. Lastly, we combined exclusive breastfeeding and any breastfeeding duration to create an indicator that signifies accordance with WHO international breastfeeding recommendations, defined as follows: does not comply with recommendations, only complies with exclusive breastfeeding for at least 6 months, only complies with providing breast milk for at least 24 months, and complies with both (at least 6 months of exclusive breastfeeding and total breastfeeding duration of at least 24 months).[28]

Childhood Development Outcomes

Our primary outcomes for cognitive and physical development were children's overall development as assessed by the Regional Project on Child Development Indicators (PRIDI) (Engle scale) and HAZ. PRIDI is a tool used to collect high-quality and regionally comparable data on the overall development of children aged 2 to 5 years in Latin America, capturing cognitive, language, social-emotional, and motor development.[29] We also analyzed a dichotomous (yes or no) indicator of child stunting (HAZ <-2) and child weight status using BMI *z* scores, categorized into underweight (less than the fifth percentile), normal weight (fifth percentile to less than the 85th percentile), overweight (85th to less than the 95th percentile), and obese (≥95th percentile). The total PRIDI score (range: 0–61) was normalized within the study sample to a mean of 0 and SD of 1. At 36 months, both the mother and trained interviewer measured the child's height in centimeters. Weight was measured by trained staff only. HAZ and weight-for-height *z* score were computed by using the WHO's Anthro software package.[30]

Our secondary outcomes for social-emotional development included *z* scores on the Early Childhood Behavior Questionnaire (ECBQ) and the Strengths and Difficulties Questionnaire (SDQ). The ECBQ is a parent report of toddler (1.5–3 years) temperament consisting of 18 items, with higher scores representing better social-emotional development.[31] The SDQ is an emotional and behavioral screening tool for children, comprising 25 questions for caregivers. Scores range from 0 to 30, with lower scores representing fewer behavioral difficulties. We reversed the SDQ scale so higher scores represent better outcomes to facilitate comparability with the PRIDI estimates. In our a priori data analysis plan, we specified an additional secondary outcome: the Caregiver Reported Early Development Instruments (CREDI). However, CREDI was dropped as a secondary outcome because of the high rate of missing information (67.4%; n = 1542) and potential biases created by parents reporting on their own children. All cognitive and social-emotional development indicators, including PRIDI, ECBQ, and SDQ, are indicators for overall child development and do not directly identify children with developmental difficulties. These indicators were normalized to a mean of 0 and SD of 1 to facilitate interpretation of estimated group differences.

Potential Confounding Factors

A literature search was conducted to identify the following potential confounding factors[32–35]: household food insecurity score, social support score, caregiver's highest educational attainment, income (in Brazilian real), Multiple Indicator Cluster Surveys (MICS) (home stimulation score), preterm birth, low birth weight, presence of father or father figure at home, hours per week the caregiver works outside of the home, maternal age at birth, age at child assessment, child care attendance, child sex, couples conflict, and the Edinburgh Postnatal Depression score. Couples conflict is the sum score of 4 domains (eg, assault, sexual coercion, injury, and psychological aggression) from a revised couples conflict tactics scale. Respondents could answer between 0 and 3, from none of the time to all of the time. The social support score consists of 4 domains aimed at quantifying the level of support for companionship, assistance, or other support systems: (1) someone to confide in or talk to about problems, (2) someone to take them to the doctor, (3) someone to help with daily chores if they are sick, and (4) some to loan small amounts of money if needed. We calculated a sum score for the social support scores (from 0, being no social support, to 16, being the highest level of social support). Categorization schematics are found in Table 1.

Statistical Analysis

Descriptive statistics were used to describe the study population by using frequencies and percentages for categorical variables and means and SDs for continuous variables. Characteristics were also described by exclusive breastfeeding duration category coupled with a χ^2 or *t* test to identify significant differences between groups. Because of the high attrition rate from baseline to 36 months, we examined differences in maternal-infant characteristics to evaluate the risk of potential selection bias. We also examined differences between mothers who completed the breastfeeding module and those who did not. Kernel density plots were created to display the empirical distribution of PRIDI and HAZ by exclusive breastfeeding duration.

To investigate associations between breastfeeding and physical growth and childhood development indicators, linear regression was used to obtain β estimates and 95% confidence limits (CLs) for PRIDI, ECBQ, SDQ, and HAZ. Logistic regression was used to obtain odds ratios (OR) and 95% confidence intervals (CIs) for childhood stunting and obesity. Logistic regression was also used in an additional analysis focusing on children with a PRIDI score >1 SD below the sample mean. Child sex and the Edinburgh Postnatal Depression score were tested for effect modification by using an interaction term in the initial analysis. After finding no evidence of effect modification, we included both variables as confounders in our empirical models. Additionally, all models investigating mixed breastfeeding controlled for preceding exclusive breastfeeding duration. A *P* value of .05 signified statistical significance. SAS version 9.4 (SAS Institute, Inc, Cary, NC) was used for all analyses. This study was approved by the Faculdade de Medicina da Universidade de São Paulo Institutional Review Board (9 01604312.1.0000.0065).

RESULTS

From the ROC data, we identified 2288 mother-infant dyads for our study. As shown in Supplemental Table 5, overall, children not assessed in the 3-year survey had a slightly higher prevalence of low birth weight (9.1% vs 6.1%) and preterm birth (10.7% vs 8.9%) as well as slightly more supportive home environments compared with children managed until 3 years of age. Similarly, among all participants at 3 years postpartum, those who did not complete the breastfeeding module had slightly higher levels of caregiver educational attainment, MICS home stimulation scores, low birth weight, stunting, and HAZ scores (Supplemental Table 6).

Among study participants (*N* = 2288), 4.9% of children were born low birth weight (<2500 g) and 8.1% were born prematurely (<37 weeks' gestation). At 3 years of age, almost 1 in 4 children were stunted (23.9%). The majority of children attended child care at least once a week (82.6%) and had a father or father figure in the household (85.2%) (Table 1). Characteristics stratified by reported exclusive breastfeeding duration categories are also displayed in Table 1. We found significant differences between exclusive breastfeeding duration categories and HAZ, stunted growth, PRIDI, postnatal depression score, child age at development assessment, levels of caregiver educational attainment, social support score, MICS home stimulation score, house presence of father or father figure, and preterm birth.

Supplemental Figures 2 and 3 display the distribution of exclusive and total breastfeeding duration. A quarter of mothers exclusively breastfed 3 to 5 months. Almost half of women exclusively breastfed 6 months or more (Supplemental Fig 2). The majority (~55%) of mothers provided at least some breast milk for at least 6 months (Supplemental Fig 3).

The relationship between child development indicators and exclusive breastfeeding duration categories is shown in Table 2. Compared with mother-infant dyads who exclusively breastfed ≤3 months, infants exclusively breastfed at least 6 months had a 0.3-SD higher PRIDI score (CL = 0.16 to 0.34) and 0.4 higher HAZ score (CL = 0.16 to 0.54).

TABLE 1 Description of Sample Population Overall and By Exclusive Breastfeeding Duration

	Overall (N = 2288)	Exclusively Breastfed ≤3 mo (n = 769)	Exclusively Breastfed 4–5 mo (n = 531)	Exclusively Breastfed ≥6 mo (n = 973)	P
Dependent variables					
HAZ[a]	−0.7 (1.7)	−1.0 (1.7)	−0.8 (1.7)	−0.5 (1.7)	<.0001[b]
Weight status					.29
Underweight	251 (11.6)	71 (9.7)	71 (14.0)	108 (11.9)	—
Normal weight	1173 (54.3)	416 (56.6)	267 (52.5)	483 (53.3)	—
Overweight	350 (16.2)	121 (16.5)	85 (16.7)	143 (15.8)	—
Obese	388 (18.0)	127 (17.3)	86 (16.9)	172 (19.0)	—
Stunted growth					<.0001[b]
Yes	524 (23.9)	227 (30.8)	121 (23.5)	175 (18.8)	—
PRIDI[a]	0.1 (1.0)	−0.1 (1.0)	0.1 (1.0)	0.2 (1.0)	<.0001[b]
ECBQ[a]	−0.03 (1.0)	−0.1 (1.0)	−0.03 (1.0)	0.02 (1.0)	.14
SDQ[a]	0.03 (1.0)	−0.02 (1.0)	0.05 (1.0)	0.1 (1.0)	.16
Potential effect modifiers					
Edinburgh Postnatal Depression score[a]	6.9 (5.2)	7.4 (5.5)	7.1 (5.1)	6.5 (5.1)	.01[b]
Child sex					.16
Female	1220 (53.3)	390 (50.7)	286 (53.9)	538 (55.3)	—
Male	1068 (46.7)	379 (49.3)	245 (46.1)	435 (44.7)	—
Potential confounders					
Maternal age at delivery, y					.24
13–20	502 (21.9)	176 (22.9)	116 (21.9)	207 (21.3)	—
21–25	643 (28.1)	233 (30.3)	155 (29.2)	250 (25.7)	—
26–30	553 (24.2)	175 (22.8)	121 (22.8)	253 (26.0)	—
>30	590 (25.8)	185 (24.1)	139 (26.2)	263 (27.0)	—
Child age at assessment[a]	3.5 (0.7)	3.5 (0.6)	3.5 (0.7)	3.4 (0.7)	<.01[b]
Caregiver highest grade completed					<.01[b]
None	67 (3.0)	27 (3.6)	16 (3.1)	24 (2.5)	—
Elementary	967 (43.3)	367 (48.5)	232 (45.0)	367 (38.8)	—
Middle	1086 (48.6)	333 (44.1)	249 (48.3)	493 (52.1)	—
Upper	113 (5.1)	29 (3.8)	19 (3.7)	63 (6.7)	—
Hours caregiver works outside the home[a]	17.9 (20.2)	17.6 (20.0)	18.3 (20.1)	17.9 (20.6)	.83
Income, R$					.34
0–1000	523 (26.5)	196 (29.4)	109 (24.2)	217 (25.7)	—
1001–1600	473 (4.0)	146 (21.9)	105 (23.3)	216 (25.6)	—
1601–2250	471 (23.9)	161 (24.1)	111 (24.6)	197 (23.3)	—
>2250	507 (25.7)	164 (24.6)	126 (27.9)	215 (25.4)	—
Household food insecurity score[a]	0.9 (1.6)	1.0 (1.7)	1.0 (1.6)	0.9 (1.6)	.22
Social support score[a]	12.6 (3.9)	12.6 (4.1)	12.5 (3.9)	12.6 (3.8)	.91
MICS home stimulation score[a]	4.9 (1.4)	4.8 (1.5)	5.0 (1.3)	5.0 (1.4)	.01[b]
Maternal BMI					.04[b]
Underweight, <18.5	60 (2.8)	24 (3.3)	11 (2.2)	25 (2.7)	—
Normal wt, 18.5–24.9	963 (44.4)	348 (48.1)	220 (43.5)	388 (41.7)	—
Overweight, 25–30	738 (34.0)	213 (29.4)	185 (36.6)	339 (36.5)	—
Obese, >30	410 (18.9)	139 (19.2)	90 (17.8)	178 (19.1)	—
Low birth wt, <2500 g					.80
Yes	111 (4.9)	39 (5.1)	26 (4.9)	43 (4.4)	—
Preterm birth, <37 wk' gestation					.01[b]
Yes	186 (8.1)	80 (10.4)	43 (8.1)	62 (6.4)	—
Child care attendance					.05
Never attends	372 (17.4)	130 (18.2)	70 (13.9)	172 (18.9)	—
Attends at least once per week	1768 (82.6)	584 (81.8)	432 (86.1)	738 (81.1)	—
House presence of father or father figure					.04[b]
Yes	1948 (85.2)	638 (83.1)	447 (84.3)	849 (87.3)	—
Couples conflict score[a]	1.9 (2.0)	2.0 (1.9)	1.8 (1.9)	1.8 (2.0)	.14

Categorical variables are presented as n (column %). Because of rounding, percentages may not add to 100. R$, Brazilian real; —, not applicable.

[a] Continuous variable. Data are presented as mean (SD).

[b] Significant P value.

Similarly, the odds of child stunting at 36 months were 38% lower with exclusive breastfeeding for at least 6 months (OR = 0.62; 95% CI = 0.45 to 0.84). Our exploratory analysis confirms that children who were exclusively breastfed ≥6 months had 44% lower odds (OR = 0.56; 95% CI = 0.39 to 0.81) of having a PRIDI score

>1 SD below the sample mean compared with children exclusively breastfed ≤3 months (results not shown). We did not find evidence of a relationship between childhood weight status, ECBQ, or SDQ. Density plots of PRIDI (Supplemental Fig 4) and HAZ (Supplemental Fig 5) suggest that the improvements in these 2 outcomes affect all parts of the distribution (ie, that average improvements are not driven by children with extremely positive or negative outcomes).

The association between current WHO breastfeeding recommendations and child development indicators is shown in Table 3. Compared with maternal-infant pairs who did not comply with WHO recommendations, maternal-infant pairs only complying with the recommendation to exclusively breastfeed for at least 6 months were associated with a 0.4-SD increase in PRIDI score (β: .41; CL = 0.23 to 0.58). Results were largely the same for compliance with exclusive breastfeeding for the first 6 months followed by complementary feeding until 2 years of age (β = .38; CL = 0.23 to 0.53) and only providing complementary breast milk for at least 24 months (β = .30; CL = 0.03 to 0.58). All other behavioral indicators revealed weaker associations with breastfeeding ($P > .05$). For physical growth, complying with the recommendation to exclusively breastfed for 6 months only was associated with a 0.7-SD increase (CL = 0.44 to 0.99) in HAZ. Similar associations were found for complying with both exclusive and complementary feeding guidelines (β = .55, CL = 0.31 to 0.79) or only providing complementary breast milk for at least 24 months (β = .54; CL = 0.10 to 0.99). The odds of child stunting were lowest for children who were exclusively breastfed for 6 months and received breast milk for at least 24 months (OR = 0.33; 95% CI = 0.20 to 0.54); however, exclusive breastfeeding for at least 6 months was also associated with reduced odds of child stunting (OR = 0.49; 95% CI = 0.28 to 0.85). No associations were found between WHO breastfeeding recommendations and childhood weight status.

The adjusted associations between months of exclusive and mixed breastfeeding duration and child development indicators are shown in Table 4. Our fully adjusted models revealed an increase of 0.03 in the PRIDI standardized score for every month increase in exclusive breastfeeding (CL = 0.02 to 0.04). For mixed breastfeeding, the estimate remained significant but slightly attenuated (β = .01; CL = 0.002 to 0.01). The same trend can be seen in physical growth outcomes. A 1-month increase in exclusive breastfeeding resulted in a significant increase of 0.04 in our HAZ standardized score (CL = 0.02 to 0.05), whereas a 1-month increase in any breastfeeding duration increased the HAZ standardized score by 0.01 (CL = 0.01 to 0.02). The odds of child stunting were lowest for exclusive breastfeeding (OR = 0.93; 95% CI = 0.89 to 0.97) but attenuated for mixed breastfeeding (OR = 0.96; 95% CI = 0.95 to 0.98). We did not find evidence to support a relationship between breastfeeding duration and SDQ or childhood weight status. Supplemental Table 7 provides support that each additional month of mixed breastfeeding after cessation of exclusive breastfeeding increased PRIDI, ECBQ, SDQ, and HAZ scores

TABLE 2 Adjusted Associations Between Exclusive Breastfeeding and Child Outcomes

	Exclusive Breastfeeding Duration, mo		
	≤3	4–5	≥6
Fully adjusted β (95% CL)			
Cognitive and social-emotional development			
PRIDI (continuous)	Referent	0.12 (−0.02 to 0.26)	0.28 (0.16 to 0.34)***
ECBQ	Referent	−0.01 (−0.14 to 0.12)	−0.02 (−0.14 to 0.01)
SDQ	Referent	0.02 (−0.11 to 0.16)	0.04 (−0.08 to 0.15)
Physical growth			
HAZ	Referent	0.10 (−0.11 to 0.32)	0.35 (0.16 to 0.54)***
Fully adjusted OR (95% CI)			
PRIDI *z* score <−1	Referent	0.76 (0.51 to 1.14)	0.56 (0.39 to 0.81)**
Weight status[a]			
Underweight	Referent	0.89 (0.53 to 1.49)	1.13 (0.74 to 1.73)
Normal weight	Referent	Referent	Referent
Overweight	Referent	1.07 (0.72 to 1.59)	0.81 (0.57 to 1.16)
Obese	Referent	1.21 (0.82 to 1.79)	1.38 (0.99 to 1.93)
Stunted	Referent	0.80 (0.56 to 1.13)	0.62 (0.45 to 0.84)*

All models adjusted for child sex, maternal age at birth, caregiver highest educational attainment, income, presence of the father or father figure at home, preterm birth, low birth wt, child care attendance, age at child assessment, household food insecurity score, social support score, couples conflict, hours caregiver works away from the home, and depression and MICS stimulation score. —, not applicable.

[a] Adjusted also for maternal BMI.

* $P < .05$; *** $P < .0001$.

TABLE 3 Relationship Between WHO Breastfeeding Recommendations and Child Outcomes

	Does Not Comply With Recommendations	Only Complies With Exclusive Breastfeeding for At Least 6 mo	Only Complies With Providing Breast Milk for At Least 24 mo	Complies With Both Exclusive Breastfeeding for At Least 6 mo and Providing Breast Milk Until At Least 24 mo
Fully adjusted β (95% CL)				
Cognitive and social-emotional development				
PRIDI	Referent	0.41 (0.23 to 0.58)***	0.30 (0.03 to 0.58)*	0.38 (0.23 to 0.53)***
ECBQ	Referent	0.14 (−0.03 to 0.31)	0.12 (−0.15 to 0.39)	−0.01 (−0.16 to 0.13)
SDQ	Referent	0.12 (−0.05 to 0.29)	0.13 (−0.14 to 0.40)	0.09 (−0.05 to 0.24)
Physical growth				
HAZ	Referent	0.71 (0.44 to 0.99)***	0.54 (0.10 to 0.99)*	0.55 (0.31 to 0.79)***
Fully adjusted OR (95% CI)				
Weight status[a]				
Underweight	Referent	1.12 (0.59 to 2.14)	2.02 (0.84 to 4.87)	1.48 (0.86 to 2.55)
Normal weight	Referent	Referent	Referent	Referent
Overweight	Referent	0.77 (0.45 to 1.33)	1.17 (0.51 to 2.65)	0.63 (0.37 to 1.07)
Obese	Referent	1.30 (0.80 to 2.09)	0.95 (0.41 to 2.22)	1.50 (0.99 to 2.28)
Stunted	Referent	0.49 (0.28 to 0.85)*	0.49 (0.20 to 1.19)	0.33 (0.20 to 0.54)**

All models were adjusted for child sex, maternal age at birth, caregiver highest educational attainment, income, presence of the father or father figure at home, preterm birth, low birth wt, child care attendance, age at child assessment, household food insecurity score, social support score, couples conflict, hours caregiver works away from the home, depression, and MICS stimulation score.

[a] Adjusting for the additional confounder of maternal BMI.

* $P < .05$; ** $P < .01$; *** $P < .0001$.

and decreased the odds of child stunting. No association was found between mixed breastfeeding duration and childhood weight status.

DISCUSSION

The first 1000 days of life are fundamental for cognitive, social-emotional, and physical development.[36] Our results support existing evidence that exclusive and mixed breastfeeding is a critical component in ensuring healthy cognitive development and physical growth, even in a middle-income country. We investigated breastfeeding and early childhood development indicators in a region that, like many middle-income countries, has been struggling to improve breastfeeding rates. We provide evidence that exclusively breastfeeding for 6 months alone or in combination with complementary feeding for at least 24 months is important for physical and cognitive development. In addition, each additional month of exclusive or mixed breastfeeding appears to have a positive impact on early childhood development.

Our findings that breastfeeding is associated with better child development could be partially explained through maternal-infant bonding rather than the nutritional influence of breast milk alone. Research has revealed that children with strong maternal-infant bonding have better cognitive and social-emotional development.[37] In fact, an infant's brain development has been linked to the parental attachment relationship,[38] which may be promoted by breastfeeding. Research suggests that breastfeeding lowers maternal levels of stress,[39] increases bonding,[40] and increases mother-infant relationships more generally.[41] However, it is also plausible that lower stress levels enable women to breastfeed longer and reach their breastfeeding goals.[42]

Our evidence on increased breastfeeding duration and better child development outcomes may also be explained through responsive feeding and parenting behavior. A systematic review found a consistent relationship between prolonged breastfeeding and responsive feeding, which is an indicator for responsive caregiving[43] (ie, the ability to properly respond to situations that promote child development).[44] In several studies, researchers also report that breastfeeding duration is linked to positive parenting practices in later childhood.[43] Authors of a study based in the United Kingdom reported that formula use or short breastfeeding duration was associated with low levels of nurturance,[45] which is a critical component of parental care that helps children achieve their full developmental potential.[46]

We also found evidence that breastfeeding is associated with physical growth at 3 years of age. Specifically, we found lower odds of child stunting (ie, higher HAZ score) among breastfed infants. Research has revealed a direct relationship between hormones and growth factors found in breast milk and healthy infant body composition,[47] which could help explain our findings. The method of breast milk feeding may also relate to physical growth. Emerging evidence suggests that feeding infants breast milk from a bottle has a weaker association with healthy weight compared with exclusive direct breastfeeding.[48]

TABLE 4 Fully Adjusted Associations Between Months of Exclusive and Mixed Breastfeeding and Child Development Indicators

	Exclusive Breastfeeding	Mixed Breastfeeding[a]
Fully adjusted β (95% CL)		
Cognitive and social-emotional development		
PRIDI	.03 (0.02 to 0.04)***	.01 (0.002 to 0.01)**
ECBQ	.01 (−0.001 to 0.01)	−.001 (−0.01 to 0.004)
SDQ	−.001 (−0.01 to 0.01)	.01 (−0.001 to 0.01)
Physical growth		
HAZ	.04 (0.02 to 0.05)***	.01 (0.01 to 0.02)**
Fully adjusted OR (95% CI)		
Weight status[b]		
Underweight	1.01 (0.98 to 1.04)	1.02 (1.00 to 1.05)
Normal weight	Referent	Referent
Overweight	.97 (0.93 to 1.01)	1.00 (0.98 to 1.02)
Obese	1.00 (0.97 to 1.03)	1.02 (1.00 to 1.04)
Stunted	.93 (0.89 to 0.97)**	.96 (0.95 to 0.98)**

All models were adjusted for child sex, maternal age at birth, caregiver highest educational attainment, income, presence of the father or father figure at home, preterm birth, low birth wt, child care attendance, age at child assessment, household food insecurity score, social support score, couples conflict, hours caregiver works away from the home, depression, and MICS stimulation score.

[a] All mixed breastfeeding models control for preceding exclusive breastfeeding duration.

[b] Also adjusting for the additional confounder of maternal BMI.

* $P < .05$; ** $P < .01$; *** $P < .0001$.

We found no association between breastfeeding duration and child obesity. Yet, the estimates trended toward increased odds of overweight or obesity for children who were breastfed longer. This counterintuitive trend could be explained through the high prevalence of overweight and obesity in our study population. It is estimated that >50% of Brazilian populations are overweight or obese.[49] Our trends between breastfeeding and child overweight or obesity may be a reflection of parental preference for heavier infants[50,51] in a setting with rapidly growing obesity rates[52] but are concerning from a public health perspective and warrant further research.

To our knowledge, this study is the first used to investigate breastfeeding and early childhood development indicators among a unique population in which middle- and high-income characteristics are blended. The prospective birth cohort enabled extensive data collection and allowed us to control for important confounding factors, such as parent-child interactions and home stimulation, which are likely to confound the general associations between breastfeeding and child outcomes. However, our study may suffer from selection bias because not all participants completed the 3-year breastfeeding module. Our study is also not representative of the entire Brazilian population or other middle-income countries, although large urban areas have become home to the majority of children in many low- and middle-income countries. Additionally, as with any breastfeeding measure, report of breastfeeding is prone to recall and social desirability bias; nevertheless, recall of breastfeeding duration has been shown to be reliable.[53] Albeit relying on a recall at 36 months, the families were managed since the child's birth, which may result in a trusting relationship with research staff and, consequently, less biased responses during the interview. Emerging evidence suggests that feeding infants breast milk from a bottle has a weaker association with healthy weight compared with exclusive direct breastfeeding.[48] With our study, we could not consider direct breastfeeding compared with bottle-feeding of human milk, a food frequency list for complementary breastfeeding including vitamin supplementation, parental height, the role of maternal-infant bonding, responsive feeding, or parenting behavior as possible confounders or mediating factors because these variables were not collected; future research can hopefully address these. In our study, we did however control for an extensive set of variables capturing home environments, which may at least partially capture these aspects.

CONCLUSIONS

The results of this article suggest large and robust associations between both exclusive and nonexclusive breastfeeding and children's cognitive and physical development. Further efforts are needed to increase breastfeeding rates to support children's healthy development.

ABBREVIATIONS

CI: confidence interval
CL: confidence limit
ECBQ: Early Childhood Behavior Questionnaire
HAZ: height-for-age *z* score
MICS: Multiple Indicator Cluster Surveys
OR: odds ratio
PRIDI: Regional Project on Child Development Indicators
ROC: São Paulo Western Region Birth Cohort
SDQ: Strengths and Difficulties Questionnaire
WHO: World Health Organization

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