Public Health Nutrition: 24(13), 4080–4090 doi:10.1017/S1368980020002542

Association between iron deficiency anaemia and complementary feeding in children under 2 years assisted by a Conditional Cash Transfer programme

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Submitted 6 January 2020: Final revision received 11 June 2020: Accepted 30 June 2020: First published online 18 August 2020

Abstract

Objective: To evaluate the association between Fe deficiency anaemia (IDA) and complementary feeding in children under 2 years old assisted by the Conditional Cash Transfer programme, Bolsa Família (BFP).
Design: Cross-sectional study. Data were obtained through a standardised form, questionnaire to assess the eating habits of children under 2 years of age, capillary Hb (HemoCue®) and the Brazilian Household Food Insecurity Measurement Scale. Associations were calculated using hierarchical Poisson regression, adjusted at the last level by socio-economic, demographic and environmental variables from previous hierarchical levels.
Setting: Six municipalities from the State of Alagoas, Brazil.
Participants: Children aged 6–24 months assisted by BFP.
Results: A total of 1604 children were evaluated, among whom 58·1 % had anaemia. A higher number of food groups consumed (prevalence ratio (PR) = 0·97; 95 % CI 0·95, 0·99; $P = 0·009$), the consumption of dairy (PR = 0·86; 95 % CI 0·79, 0·84; $P = 0·001$) and meat (PR = 0·90; 95 % CI 0·83, 0·99; $P = 0·030$) in addition to bottle feeding (PR = 0·88; 95 % CI 0·82, 0·96; $P = 0·004$) were associated with a lower prevalence of IDA.
Conclusions: IDA is still a serious public health problem in children under 2 years old assisted by BFP in Alagoas. We highlight the importance of promoting complementary feeding based on a diversified dietary intake, as well strengthening prophylactic supplementation programmes to increase children's adherence in conjunction with the implementation of food and nutrition education to help reduce the prevalence of this condition.

Keywords
Child
Iron deficiency
Social vulnerability
Complementary feeding

The first 1000 d, from conception to the second year of a child's life, is marked by the fastest growth and development phase of humans. In this period, inadequate complementary feeding, with discontinuity or absence of breast-feeding up to 2 years of age, intake of food with low levels of bioavailable Fe and reduced Fe absorption due to chronic infections, can lead to the development of Fe deficiency anaemia (IDA)[1]. This condition can cause irreversible delays in linear growth and cognitive and motor development, as well as increase the risk of morbidity and mortality, a lower intelligence and educational level, and reduced income and productivity in adulthood[1–4]. The most severe damage to child development occurs in the early years of life during the complementary feeding phase. Some authors have identified an inadequate complementary diet as a major cause of malnutrition and child mortality[3,5–7].

IDA remains the most common nutritional deficiency in the world[1,7]. Worldwide, the WHO[8] estimates that anaemia affects 41·7 % of children under 5 years. In Brazil, according to the latest national data from the Brazil National Demographic and Health Survey of Children and Women[9], the prevalence of anaemia in children under the age of 5 years was 20·9 %, with a higher prevalence among children aged 6–24 months (24·1 %) living in the northeast region of the country (25·5 %). In Alagoas, a

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state located in the northeast region of Brazil with the lowest Human Development Index in the country and the location where this study was conducted, IDA was found to affect 27·4 % of children aged 6 months to 5 years, being more prevalent among children under 2 years of age (40·7 %)[10].

In accordance with the United States Agency for International Development[11] anaemia casual pathway, the basic determinants of this condition include insufficient household food security, inadequate maternal and child care, insufficient health services and an unhealthy environment. Children living with low incomes with poor access to health care and insufficient knowledge of the importance of food diversity are at greater risk of household food insecurity (FI) and low diet quality, resulting in micronutrient deficiencies and malnutrition[12–14]. In this context, Conditional Cash Transfer programmes have been recommended worldwide to reduce poverty and hunger by making welfare programmes conditional upon the receivers' actions. That is, the government only transfers the income to persons who achieve certain criteria[15]. Researchers have shown the impact of Conditional Cash Transfer programmes on food availability among families with low income, which they result in a higher food expenditure and increase in the diet's quality and diversity, along with improvement in food security among young children[16,17]. Segura-Pérez *et al.*[17] found that children 12–36 months old receiving Conditional Cash Transfer programmes were 25·5 % less likely to have anaemia when compared with their non-assisted peers. Eradication of poverty, hunger and FI is United Nations' Sustainable Development Goals priorities to be reached by 2030[18].

Given that adequate nutrition is essential for growth and development of children, and IDA impairs children to reach their full potential[1–4,19], this study aimed to assess complementary feeding practices among anaemic and non-anaemic children assisted by the Brazilian Conditional Cash Transfer programme to help providers as well as policymakers to reduce prevalence of this disease.

Methods

Design

Cross-sectional study. The current study is part of a larger project entitled *Evaluation of the management and operationalization of the National Program for Iron and Vitamin A Supplementation and their relationship with the nutritional status of children aged 6 to 24 months in municipalities of Alagoas state*, which was performed in accordance with the guidelines set out in the Declaration of Helsinki. The study was approved by the local institutional review board (CAAE 80416617.0.0000.5013), and the caregiver of each child gave written informed consent.

Setting and sample selection

Children aged 6–24 months, assisted by the Bolsa Família Program, and residents of six municipalities in the State of Alagoas, located in the northeast region of Brazil, were eligible for enrolment. The six municipalities cover all physiographic regions of the State of Alagoas – Pilar (Metropolitan Region), Murici (Zona da Mata), Teotônio Vilela (South Region), São Luís do Quitunde (Northern Region), Pão de Açúcar (Sertão) and Batalha (Agreste) – and were included in the study because they were participating in the Early Childhood Program of the State of Alagoas, which has as selection criteria to have total coverage of the Brazilian primary care, Family Health Strategy, and at least one team from the Family Health Support Centers (NASF). The state early childhood programme aims to contribute to improving the quality of life of pregnant women, nursing mothers and children through intersectoral actions developed in the areas of health, nutrition, education and social assistance. The main sociodemographic characteristics of all municipalities are reported in the online supplementary material (Supplemental Table S1).

The study sample size was calculated using an expected relative risk for 1·1 of children aged 6–24 months with anaemia and an inadequate minimum dietary diversity, according to the study by Saaka and Galaa[20], with 73·2 % of unexposed, 95 % CI and 80 % power. The ratio between the number of children assisted by Bolsa Família (BFP) per municipality and the total number of children assisted by BFP in all six municipalities was calculated to define the sample size in each municipality of the study, so each ratio was individually multiplied by the total sample size. Therefore, the total sample size calculated was 1132 children in all six municipalities (Supplemental Fig. S1). The number of children assisted by BFP was obtained through the Single Registry system database provided by the State of Alagoas Secretariat of Social Assistance and Development. The sample size was calculated using the StatCalc EpiInfo version 7.2.2.2 software (Center for Diseases Control and Prevention, Atlanta, EUA).

The identification of eligible children was performed through the health monitoring map of the BFP-assisted children by municipality, which invited their caregiver to attend the Community Health Center for participation in the study. All families of eligible children were invited by community health workers and through wide dissemination in local media such as community radio stations or during appointments with health professionals at the Community Health Center. The flow chart for the selection of study participants and the main sociodemographic characteristics between the children participating and not participating in the study are reported in the online supplementary material (Supplemental Fig. S1 and Table S1). Despite the efforts, a non-probabilistic convenience sampling approach was used, since only those children that attended the Community Health Center scheduled for data collection were included. The research in the

https://doi.org/10.1017/S1368980020002542 Published online by Cambridge University Press

municipalities had the consent and partnership of the Municipal and State Health Departments.

Children whose parents reported a diagnosis of genetic or autoimmune haematological diseases (sickle cell disease, haemolytic, sideroblastic and aplastic anaemia, Fanconi anaemia and thalassaemia) or had previously been diagnosed with a non-IDA nutritionally related type of anaemia (megaloblastic and pernicious anaemia) and those whose mothers had mental health conditions were excluded from the study. In families with more than one child within the inclusion criteria, only the oldest was selected to participate. In cases of twin siblings, the included child was randomly selected.

Data collection

Data were collected between May and December 2018 by trained staff composed of four nutritionists and ten technical assistants. The children's caregivers were interviewed using a structured form asking about sociodemographic, health and environmental issues. Information on family income, sanitation, housing location and number of residents per household were obtained from secondary data through the Consultation, Selection and Information Extraction database of the Unified Registry for Social Programs of the Brazilian government (Cadastro Único) using the social registration number (NIS) of each individual provided by the state government.

Dependent variable

The dependent variable was IDA, diagnosed when Hb <11 g/dl[21]. Hb concentration was measured by taking a finger-prick blood using a portable hemoglobinometer HemoCue® Hb 201 + (HemoCue Inc.). Data collectors were trained to clean the finger with 70 % alcohol and allow it to dry before pricking it with a sterile lancet. The first two drops of blood were wiped away using a clean gauze, and the third drop of blood was collected to fill the microcuvette. The blood sample in the microcuvette was loaded in the calibrated HemoCue® to measure the Hb concentration. Children identified with anaemia were referred for treatment and follow-up at the referral health service of the municipality where they were evaluated.

Independent variables

The complementary feeding characteristics evaluation was in accordance with the WHO indicators for assessing infant and young child feeding practices[22], which will be described in another topic later on. As covariates, the following characteristics of the household were investigated: per capita household income, number of residents per household, housing location (urban/rural), source of drinking water (adequate: mineral or public/inadequate: well water, river or cistern)[23], sanitation (adequate: general sewage system or septic tank/inadequate: rudimentary cesspit or open sewer)[23] and FI. In addition, the characteristics of the children's caregivers were collected: age and education and the children's characteristics: gender, age, length-for-age, type of delivery, diarrhoea in the last 15 d prior to the interview and being enrolled in day care; and enrolment in supplementation programmes (National Program for Iron (PNSF) and Vitamin A (PNSA) Supplementation) in the previous semester.

Complementary feeding and micronutrient supplementation

For the assessment of food consumption, an adaptation of the questionnaire to assess eating habits of children under 2 years of age, proposed by Oliveira *et al.*[24], adapted for regional foods and based on the WHO indicators for assessing infant and young child feeding practices[22], was used. The questionnaire is composed of forty-nine defined questions in which the children's caregivers were asked to recall all food and drink their children had consumed in the previous 24 h. Among the fifteen indicators proposed by the WHO, eleven that fit the study age group were evaluated: children ever breastfed; early initiation of breast-feeding; continued breast-feeding at 1 year; continued breast-feeding at 2 years; introduction of solid, semisolid or soft foods; minimum dietary diversity; minimum meal frequency; minimum acceptable diet; consumption of Fe-rich or Fe-fortified foods; bottle feeding; and milk feeding frequency for non-breastfed children.

The questionnaire responses were organised into the seven food groups recommended by WHO[22]: (1) grains/roots/tubers; (2) legumes/nuts; (3) dairy; (4) meats; (5) eggs; (6) vitamin-A-rich fruits/vegetables and (7) other fruits/vegetables. Minimum dietary diversity was defined when the child consumed in the previous day ≥ 4 food groups out of the seven food groups listed above. Minimum meal frequency as intake of solid/semisolid foods ≥2 times/d for breastfed infants aged 6–8 months, ≥3 times/d for breastfed children aged 9–24 months and ≥4 times/d for non-breastfed children aged 6–24 months. A minimum acceptable diet was defined as minimum dietary diversity and minimum meal frequency in the previous 24 h for children who were breastfed; for children who were not breastfed, it was defined as minimum meal frequency, minimum dietary diversity (four out of six food groups excluding dairy based on the seven food groups above) and at least two milk feedings per d.

The indicator of early initiation of breast-feeding was calculated through the proportion of children born in the last 24 months who were put to the breast within 1 h of birth. Continued breast-feeding at 1 and 2 years was calculated using the proportion of children 12–15 months and 20–23 months of age, respectively, who were fed breast milk. Introduction of solid, semisolid or soft foods was obtained by the proportion of infants 6–8 months of age who received solid, semisolid or soft foods.

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The consumption of Fe-rich or Fe-fortified foods was calculated using the proportion of children 6–23 months of age who received an Fe-rich food or Fe-fortified food that is specially designed for infants and young children, or that is fortified in the home. Last, the indicator of milk feeding frequency for non-breastfed children was assessed through the proportion of non-breastfed children 6–23 months of age who received at least 2 milk feedings in the previous day.

The children's adherence to the National Program of Iron (PNSF) and Vitamin A (PNSA) Supplementation was verified through medical records in the Child Health Handbook, together with questioning of the caregiver to determine if the children were using ferrous sulphate or if they had already been supplemented with the megadoses of vitamin A in the last semester. PNSF and PNSA act through the prophylactic supplementation of ferrous sulphate and vitamin A megadoses for children from 6 to 24 months and children up to 5 years, respectively, together with food and nutrition education[25,26].

Anthropometry

Length was measured in a recumbent position using the Alturexata® portable infantometer (Alturexata Ltd) placed on a flat and stable surface. The children were measured with no clothes, shoes, socks or hair ornaments, and their caregivers were requested to hold the children's head while the researcher held the knees and took the measurement. Children with *Z*-score of length-for-age <−2 were considered as stunted[27].

Household food security

FI was assessed through the Brazilian Household Food Insecurity Measurement Scale (EBIA), with fourteen questions (yes or no) about the food access situation experienced at home in the last 90 d before the interview. Its analysis is based on the sum of the affirmative answers, being classified as: Household Food Security and mild, moderate and severe Household FI[28].

Statistical analysis

Independent variables were divided into hierarchical levels according to the adaptation of the theoretical model proposed by Cotta *et al.*[29]. The first level includes the socio-economic characteristics of the caregivers. The second level relates to the environment in which the child lives. The third level comprises the family's FI situation. The fourth level includes the individual characteristics of the child. The fifth and last level is the child's consumption of complementary foods (Fig. 1).

Data were tabulated by double independent typing and analysed using the statistical package SPSS 20.0 (IBM Inc.) with a significance level set at 5 %. To identify factors associated with IDA, hierarchical Poisson regression with robust variance estimation was used to calculate the prevalence ratio (PR) according to the theoretical model shown in Fig. 1. A bivariate analysis was performed between the independent variables and the outcome (IDA) within each hierarchical level, and only variables with unadjusted $P < 0{\cdot}20$ were maintained in the multivariable model. For each hierarchical level, variables within the same level were entered simultaneously and variables from previous levels that were $P < 0{\cdot}20$ were also included.

Results

The study evaluated 1604 children aged 6–24 months. Table 1 shows the characteristics of the study participants. Among the children, 58·1 % had IDA and 9·7 % were stunted. Approximately 40 % of households had inadequate sanitation, 41·5 % of the caregivers had <9 years of education, and 66·5 % of households assessed were mild, moderate or severe FI.

In regard to food intake, 92·8 % of the children were ever breastfeed and over 81 % of the children had solid, semi-solid or soft foods introduced at the appropriate time, between the sixth and eighth months. In contrast, 43 % did not have a minimum acceptable diet, which includes indicators of minimum dietary diversity and meal frequency. In addition, there was low adherence of the children to the national supplementation programmes, with coverage of only 29·5 % by PNSA and lower than 7 % by PNSF. Other dietary characteristics are presented in Table 2.

Regarding the hierarchical analysis of the child feeding practices indicators, the final model was adjusted by the age and education level of the caregiver, per capita household income, housing location, drinking water, household FI, children's age, HAZ, adherence to PNSF and PNSA, and day care enrolment. In this model, IDA was inversely associated with the highest number of food groups consumed (PR = 0·97; 95 % CI 0·95–0·99; $P = 0{\cdot}009$), the consumption of dairy (PR = 0·86; 95 % CI 0·79–0·84; $P = 0{\cdot}001$) and meat (PR = 0·91; 95 % CI 0·83–0·99; $P = 0{\cdot}030$), in addition to the use of bottle feeding (PR = 0·88; 95 % CI 0·82–0·96; $P = 0{\cdot}004$) (Table 3).

Discussion

The present study demonstrates that IDA persists as a serious public health problem among children aged 6–24 months assisted by BFP in Alagoas with a prevalence of 58·1 %, which is above the 40 % level reported by WHO[30]. In addition, 66·5 % of households assessed were FI and among these families, almost 72·5 % of the children were anaemic ($P < 0{\cdot}001$). This needs to be highlighted since it is known that poverty and FI are some of the main determinants of poor diet quality and diversity, which leads

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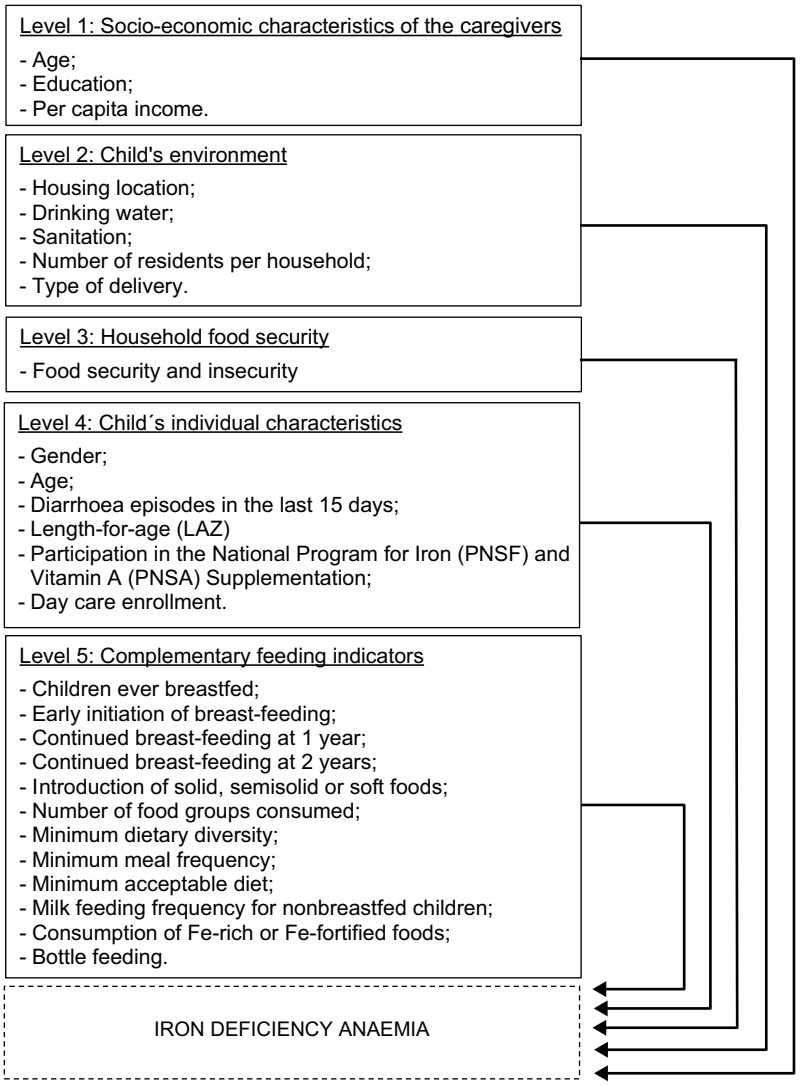

Fig. 1 Hierarchical model proposed to evaluate the association between iron deficiency anemia (IDA) and the socio-economic, demographic, environmental, health and complementary feeding characteristics of children aged 6–24 months, assisted by the Bolsa Família Program and their families in the State of Alagoas, Brazil, 2018

to an eating pattern based on unhealthy choices and IDA development[11,31–33].

However, Martins and Monteiro[16] observed that the BFP has contributed a higher per capita expenditure on food and a higher availability of *in natura* or minimally processed foods to low-income households when compared those assisted with non-assisted by BFP. Nevertheless, Rinaldi and Conde[34] demonstrated the existence of inequality in the pattern of food consumption by Brazilian children of lower socio-economic status before 2 years of age, with higher consumption of sugary drinks and lower consumption of fresh foods when compared with wealthier children.

Among the child feeding practice indicators evaluated in our study, the consumption of a higher number of food groups, meat, dairy and bottle feeding was associated with protection against IDA, with a 3, 9, 14 and 12 % prevalence reduction, respectively. No significant associations were found between IDA and the other WHO indicators evaluated.

The high number of food groups consumed in our study (4·72 ± 1·66) that led to IDA protection reflects a greater food diversity and diet quality. Studies indicate that, in general, children who consume an average of four food groups in the previous day tended to consume at least one animal food and one fruit or vegetable, as well as a staple food, with a diversified dietary intake in terms of macro- and micronutrients[22,35]. This is consistent with study done by Belachew and Tewabe[36] which found that children who take <4 food groups daily were 1·71 times more likely to have anaemia. However, it is important to highlight that studies conducted with children assisted by BFP not only showed the impact of the programme on increasing diet diversity but also unhealthy food choices with a higher intake of ultra-processed foods[37,38]. This indicates that

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Table 1 Socio-economic, demographic, environmental and health characteristics of children aged 6–24 months, assisted by the Bolsa Família Program and their families in the State of Alagoas, Brazil, 2018

	Total (*n* 1604)		Anaemia		Non-anaemia		χ^2 test
	*n**	%*	*n**	%*	*n**	%*	*P*-value
Household characteristics							
Municipalities of Alagoas							
Batalha	198	12·3	118	12·7	80	12·0	0·081
Murici	300	18·7	185	20·0	115	17·2	
Pão de Açúcar	190	11·8	116	12·5	74	11·1	
Pilar	310	19·3	165	17·8	144	21·5	
São Luís do Quitunde	320	20·0	193	20·8	122	18·2	
Teotônio Vilela	286	17·8	150	16·2	134	20·0	
Household per capita income†,‡							
USD ≤ 21·90	1490	92·9	860	92·8	623	93·1	0·785
USD 21·91–43·81	88	5·5	53	5·7	34	5·1	
USD 43·82–122·94§	26	1·6	14	1·5	12	1·8	
Number of residents per household‡							
≤4	1042	78·3	601	78·0	437	79·0	0·685
>4	289	21·7	170	22·0	116	21·0	
Housing location‡							
Urban	1364	85·0	768	82·8	588	87·9	0·006
Rural	240	15·0	159	17·2	81	12·1	
Drinking water							
Adequate	1224	76·3	682	26·4	536	19·9	0·002
Inadequate	380	23·7	245	73·6	133	80·1	
Sanitation‡							
Adequate	665	41·5	370	39·9	292	43·6	0·035
Inadequate	639	39·8	365	39·4	272	40·7	
Unknown	300	18·7	192	20·7	105	15·7	
Household food security							
Food security	537	33·5	255	27·5	280	41·9	<0·001
Food insecurity	1067	66·5	672	72·5	389	58·1	
Caregiver characteristics							
Age (years)							
<19	346	21·6	215	23·3	128	19·1	0·013
19–35	1083	67·6	625	67·6	454	67·9	
>35	172	10·7	84	9·1	87	13·0	
Education (years)							
No education	94	6·0	56	6·2	38	5·9	0·285
<9	553	35·5	331	36·7	216	33·3	
9–12	861	55·3	491	54·5	369	56·9	
>12	48	3·1	23	2·6	25	3·9	
Child characteristics							
Gender							
Female	806	50·2	458	49·4	345	51·6	0·417
Male	798	49·8	469	50·6	324	48·4	
Age (months)							
6–11	520	32·4	352	38·0	167	25·0	<0·001
12–17	554	34·5	321	34·6	229	34·2	
18–24	530	33·0	254	27·4	273	40·8	
Fe deficiency anaemia							
Yes	927	58·1					
No	669	41·9					
Length-for-age							
Stunting	155	9·7	100	10·8	54	8·2	0·085
Normal	1440	90·3	825	89·2	608	91·8	
Type of delivery							
Vaginal	999	62·6	589	63·8	406	61·0	0·284
Caesarean	598	37·4	334	36·2	260	39·0	
Diarrhoea episodes in the last 15 d							
Yes	404	25·2	239	74·2	163	75·6	0·559
No	1199	74·8	688	25·8	505	24·4	
Day care enrolment							
Yes	97	6·0	63	6·8	34	5·1	0·168
No	1507	94·0	864	93·2	635	94·9	

*Values are presented as total number (*n*) and frequency (%) for categorical variables.
†Family per capita income values do not include the amount received by the Bolsa Família Program.
‡Secondary data obtained through the CECAD bank (Consultation, Selection and Information Extraction database), provided by the State government.
§Amount referring to half the minimum wage in reais in the year of 2018 (minimum wage in 2018 = R$ 954·00); in December 2018, $1·00 USD was approximately R$ 3·88 reais.

https://doi.org/10.1017/S1368980020002542 Published online by Cambridge University Press

Table 2 Characteristics of dietary practices according to WHO indicators of children aged 6–24 months assisted by the Bolsa Família Program in the State of Alagoas, Brazil, 2018

	Total (*n* 1604)		Anaemia		Non-anaemia		χ^2 test
Complementary feeding indicators	*n**	%*	*n**	%*	*n**	%*	*P*-value
Children ever breastfed	1489	92·8	859	92·7	623	93·1	0·768
Early initiation of breast-feeding	1303	81·2	744	80·3	555	83·0	0·192
Continued breast-feeding at 1 year†	223	60·3	140	62·2	81	57·0	0·327
Continued breast-feeding at 2 years‡	161	47·6	74	46·0	86	48·9	0·662
Introduction of solid, semisolid or soft foods§	210	81·1	141	82·5	68	78·2	0·406
Food groups consumed in the previous day							
Grains, roots or tubers	1322	82·4	757	81·7	557	83·3	0·425
Legumes and nuts	1293	80·6	734	79·2	553	82·7	0·084
Dairy	1176	73·3	648	69·9	523	78·2	<0·001
Meat	1158	72·2	634	68·4	519	77·6	<0·001
Eggs	352	21·9	194	20·9	155	23·3	0·297
Vitamin-A-rich fruits and vegetables	1055	65·8	586	63·2	466	69·7	0·007
Other fruits and vegetables	1217	75·9	687	74·1	526	78·6	0·038
Number of food groups consumed in the previous day	4·72¶	1·66¶	4·57¶	1·71¶	4·93¶	1·56¶	<0·001‖
Minimum dietary diversity	1301	81·1	727	78·4	568	84·9	0·001
Minimum meal frequency	1161	72·6	667	72·1	489	73·3	0·609
Minimum acceptable diet	915	57·0	513	55·3	398	59·5	0·101
Milk feeding frequency for non-breastfed children	576	87·7	314	87·0	259	88·4	0·634
Consumption of Fe-rich or Fe-fortified foods	1411	88·0	801	86·4	603	90·1	0·024
Bottle feeding	1039	64·8	352	38·0	211	31·5	0·008
Participation in the supplementation programmes							
PNSF	109	6·8	55	5·9	54	8·1	0·107
PNSA	473	29·5	252	27·2	219	32·7	0·017

PNSF, National Program for Iron Supplementation; PNSA, National Program for Vitamin A Supplementation.
*Values are presented as total number (*n*) and frequency (%) for categorical variables.
†Sample of children aged 12–15 months (*n* 367).
‡Sample of children aged 20–24 months (*n* 337).
§Sample of children aged 6–8 months (*n* 258).
¶Continuous variable presented as mean and SD.
‖An independent *t* test analysis was performed to compare group means.

solely income increases are not sufficient to promote healthier diet patterns. Food choice is not only based on economic but also social and cultural. In addition to income transfer, it is necessary to strength public policies to combat FI, as well as actions of food and nutrition education to guarantee the consumption to healthy foods[16,37].

Although meat is one of the main sources of Fe, the direct protective association between meat consumption and IDA is still controversial in the literature[39–43]. Cox *et al.*[43] also observed that meat consumption reduced the risk of Fe deficiency, concluding that, if combined with other healthy eating practices, it could prevent this deficiency in early childhood. This reinforce the need of a complementary feeding based on a diversified dietary intake for IDA protection with the introduction of a greater variety of Fe-containing foods, as well as the intake of vitamin-C-rich foods, known to improve Fe absorption and bioavailability[1,43–45].

In disagreement with the literature, our findings indicated a significant association between dairy consumption and bottle feeding with a reduced prevalence of IDA. Ziegler[46] asserted that cow's milk consumption by children is closely associated with an increased risk of Fe deficiency due to the low Fe content in cow's milk and the high content of its absorption inhibitors (Ca and casein), and its tendency to induce occult intestinal blood loss. Furthermore, Parkin *et al.*[47] observed that children with severe IDA tended to consume large amounts of cow's milk daily with bottle feeding. Other studies have reported an association between bottle use and increased risk of IDA[47–49]. According to Li *et al.*[50], bottle feeding possibly leads to excess milk consumption due to a lack of self-regulation of this intake, consequently causing Fe deficiency. However, a more recent study conducted by Huang *et al.*[51] found that intake of milk powder or infant formula was associated with a reduction in anaemia. These new findings may be justified by the fortification of some cow's milk with Fe and other micronutrients. However, we cannot confirm this in our study because we did not ask about what kind of milk or infant formula the children were consuming.

Thereby, cow's milk consumption should be part of a diversified and balanced diet, with all food groups. According to Bortolini *et al.*[52], 40·1 % of children under 6 months had already consumed milk other than breast milk, with cow's milk regularly consumed by 62·4 %. The new Dietary Guidelines for the Brazilian children under 2 years old[53] point out that on average, among three Brazilian children under 6 months of age, two have already received another type of milk, mainly cow's milk, which is usually fed with added cereal flour fortified with Fe, other micronutrients and sugar, a mix that is commonly

https://doi.org/10.1017/S1368980020002542 Published online by Cambridge University Press

https://doi.org/10.1017/S1368980020002542 Published online by Cambridge University Press

Table 3 Association by crude and adjusted hierarchical Poisson regression between iron deficiency anemia (IDA) and socio-economic, demographic, environmental, health and complementary feeding characteristics of children aged 6–24 months, assisted by the Bolsa Família Program and their families in the State of Alagoas, Brazil, 2018

	Crude			Adjusted		
	PR	95 % CI	*P*-value	PR	95 % CI	*P*-value
Level 1						
Caregiver age (years)			0·019			0·019
<19	1·27	1·07, 1·51	0·006	1·27	1·07, 1·51	0·006
19–35	1·18	1·04, 1·38	0·045	1·18	1·04, 1·38	0·045
>35	1			1		
Caregiver education			0·331			
No education	1·24	0·88, 1·74	0·208			
<9 years	1·26	0·93, 1·71	0·131			
9–12 years	1·92	0·88, 1·61	0·253			
>12 years	1					
Household per capita income*			0·784			
USD ≤ 21·90	1·07	0·75, 1·54	0·685			
USD 21·91–43·81	1·31	0·76, 1·67	0·539			
USD 43·82–122·94†	1					
Level 2						
Housing location*						
Urbana	1			1		
Rural	1·17	1·06, 1·29	0·002	1·16	1·05, 1·29	0·003
Drinking water						
Adequate	1					
Inadequate	1·16	1·06, 1·26	0·001	1·16	1·06, 1·27	0·001
Sanitation*						
Adequate	1					
Inadequate	1·02	0·93, 1·13	0·609			
Unknown	1·15	1·04, 1·29	0·008			
Type of delivery						
Vaginal	1					
Caesarean	0·95	0·87, 1·04	0·251			
Number of residents per household*						
≤4	1					
>4	1·03	0·92, 1·14	0·636			
Level 3						
Household food security						
Food security	1			1		
Food insecurity	1·33	1·20, 1·46	<0·001	1·32	1·19, 1·46	<0·001
Level 4						
Child age (months)			<0·001			<0·001
6–11	1·41	1·26, 1·56	<0·001	1·43	1·28, 1·59	<0·001
12–17	1·21	1·08, 1·35	0·001	1·22	1·09, 1·37	0·001
18–24	1			1		
Child gender						
Female	0·96	0·88, 1·05	0·394			
Male	1					
Participation in PNSF						
Yes	1			1		
No	1·16	0·96, 1·41	0·121	1·14	0·94, 1·38	0·167
Participation in PNSA						
Yes	1			1		
No	1·12	1·02, 1·23	0·020	1·01	0·92, 1·12	0·750
Day care enrolment						
Yes	1			1		
No	0·88	0·76, 1·03	0·125	0·83	0·71, 0·97	0·022
Diarrhoea episodes in the last 15 d						
Yes	1·03	0·94, 1·13				
No	1		0·527			
Length-for-age						
Stunting	1·12	0·99, 1·27	0·058	1·13	0·99, 1·27	0·055
Normal	1			1		
Level 5						
Children ever breastfed	0·97	0·83, 1·14	0·720	0·96	0·82, 1·12	0·608
Early initiation of breast-feeding	0·93	0·84, 1·03	0·158	0·91	0·83, 1·01	0·084
Continued breast-feeding at 1 year‡	1·08	0·91, 1·29	0·331	1·07	0·90, 1·27	0·431
Continued breast-feeding at 2 years§	0·94	0·75, 1·18	0·595	0·94	0·76, 1·17	0·602
Introduction of solid, semisolid or soft foods‖	1·10	0·86, 1·40	0·432	1·10	0·88, 1·40	0·389
Food groups consumed in the previous day						
Grains, roots or tubers	0·95	0·86, 1·06	0·399	1·00	0·90, 1·11	0·986
Legumes and nuts	0·91	0·82, 1·01	0·071	0·95	0·86, 1·05	0·331
Dairy	0·84	0·77, 0·92	<0·001	0·86	0·79, 0·94	0·001
Meat	0·83	0·76, 0·90	<0·001	0·91	0·83, 0·99	0·030
Eggs	0·94	0·85, 1·05	0·296	0·98	0·88, 1·09	0·716

Table 3 *Continued*

	Crude			Adjusted			Crude			Adjusted		
	PR	95 % CI	*P*-value	PR	95 % CI	*P*-value	PR	95 % CI	*P*-value	PR	95 % CI	*P*-value
Level 5												
Vitamin-A-rich fruits and vegetables	0·89	0·81, 0·96	0·006	0·93	0·85, 1·01	0·081						
Other fruits and vegetables	0·90	0·82, 0·99	0·031	0·97	0·88, 1·06	0·483						
Number of food groups consumed in the previous day	0·95	0·93, 0·97	<0·001	0·97	0·95, 0·99	0·009						
Minimum dietary diversity	0·84	0·77, 0·93	<0·001	0·92	0·84, 1·01	0·086						
Minimum meal frequency	0·97	0·89, 1·07	0·592	1·01	0·92, 1·10	0·877						
Minimum acceptable diet	0·93	0·86, 1·01	0·096	0·96	0·88, 1·04	0·296						
Milk feeding frequency for nonbreastfed children	0·94	0·77, 1·15	0·574	0·85	0·69, 1·04	0·109						
Consumption of Fe-rich or Fe-fortified foods	0·87	0·77, 0·97	0·014	0·94	0·84, 1·05	0·293						
Bottle feeding	0·89	0·82, 0·97	0·007	0·88	0·82, 0·96	0·004						

PR, prevalence ratio; PNSF, National Program for Iron Supplementation; PNSA, National Program for Vitamin A Supplementation.
*Secondary data obtained through the CECAD bank (Consultation, Selection and Information Extraction database), provided by the State government; Family per capita income values do not include the amount received by the Bolsa Família Program.
†Amount referring to half the minimum wage in reais in the year of 2018 (minimum wage in 2018 = R$ 954·00); in December 2018, $1·00 USD was approximately R$ 3·88 reais.
‡Sample of children aged 12–15 months (*n* 367).
§Sample of children aged 20–24 months (*n* 337).
‖Sample of children aged 6–8 months (*n* 258).

consumed by children under 2 years old via bottle feeding. This may also be one of the reasons for the IDA protection found in this study, although we cannot confirm this because we did not ask about the composition of bottle feeding mix the children were consuming.

The most vulnerable phase for the establishment of IDA in children is between 6 and 24 months[1]. It is during this period that Fe and vitamin A supplementation programmes are recommended[25,26]. Synergistic supplementation of Fe and vitamin A is based on evidence that these two together are more effective in combating IDA[54,55]. In Brazil, both supplementation programmes are widely implemented; however, our study showed low adherence in the State of Alagoas, with 29·5 % in PNSA and only 6·8 % in PNSF. The lower PNSF adherence compared with PNSA could be explained by the decentralised competency in the management of the PNSF. According to programme rules, the municipalities, states and districts are responsible for the acquisition of ferrous sulphate through the resources of the PNSF, which may have removed the preventive characteristic of the programme and equated it to any another medicine distributed by the Primary Care network in a therapeutic way. The management of PNSA is centralised, that is, the Ministry of Health of Brazil is responsible for the purchase and distribution of supplements throughout the country[25,26]. It is noteworthy that in our study, no significant associations were found between adherence to PNSF and PNSA with IDA.

This study has some limitations. First, the diagnosis of IDA was restricted to capillary Hb dosage by HemoCue®, with no other measures to aid in classifying anaemia type. However, Hb measurement using HemoCue® is one of the two WHO recommended methods for the diagnosis of IDA in population-based studies[56]. Second, we used a non-probabilistic sampling approach, which may cause selection bias, including only those who have more access to health services. As reported in the online supplementary material (Supplemental Table S1), in three out of the six municipalities, there were differences between housing locations of the children participating and not participating in the study. However, we reinforce that all eligible children were invited to participate in the study. Third, no data on acceptance or length of ferrous sulphate supplementation by PNSF were available in the Child Health Handbook and so could not be collected to explain the lack of association between programme adherence and IDA. Fourth, we did not ask about what type of milk or infant formula the children were using, which makes it difficult to explain the association between dairy consumption and bottle feeding with a reduced prevalence of IDA. Finally, the questionnaire method used to assess infant feeding practices has potential memory response bias and may represent an atypical feeding day not representing long-term eating patterns. However, we followed the recommended research methodology with the use of the questionnaire for the evaluation of the WHO Indicators for assessing

infant and young child feeding practices. This method is widely used and considered appropriate in food consumption research when the objective is to describe infant feeding practices in populations[22]. Despite the limitations observed, this study provides important information regarding the prevalence of anaemia and its relationship with the early childhood food landscape of children in extreme social vulnerability assisted by BFP. Given the socio-economic similarities of the population studied with those of other parts of the country and the world, the results of this research may be extrapolated to other regions.

In conclusion, IDA is still a serious public health problem in children under 2 years of age assisted by BFP in Alagoas. Our results highlight the importance of a complementary diet based on the diversified dietary intake. Therefore, we recommend intensifying public policies aimed at healthy complementary feeding together with social strategies to combat poverty and FI, to ensure physical and economic access to sufficient and quality food. In addition, given the high prevalence of IDA found, it is essential to strengthen national programmes to address nutritional deficiencies in conjunction with the ongoing and continuous implementation of food and nutrition education focusing on healthy eating to achieve food autonomy, and thus, make it possible to break the intergenerational cycle of poverty and malnutrition in the country.

Acknowledgements

Acknowledgements: The research in the municipalities had the consent and partnership of the Municipal and State Health Departments. *Financial support:* This work is part of a larger project entitled: Evaluation of the management and operationalization of the National Program for Iron and Vitamin A Supplementation and their relationship with the nutritional status of children aged 6 to 24 months in municipalities of Alagoas state, carried out with funds from Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq (process number 408445/2017-3). The funder had no role in the design, analysis or writing of this article. *Conflict of interest:* None. *Authorship:* M.M.M. participated in designing the study, acquisition of data, data entry, analysis and interpretation of the data, and drafting the article. G.d.M.M., M.D.G.M.F., T.M.d.M.T.F. and N.B.B. took part in the acquisition of data, data entry, analysis and interpretation, and writing. A.P.G.C. took part in the project's conception, obtained the respective financial support, coordinated all implementation steps and realised the final review of the article. All authors approved the final version to be submitted. *Ethics of human subject participation:* This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving study participants were approved by the Ethics Committee in Research of Alagoas Federal University (process number 80416617.0.0000.5013). The mothers or legal guardian of each participating child aged 6–24 months gave written informed consent.

Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980020002542

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https://doi.org/10.1017/S1368980020002542 Published online by Cambridge University Press