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Validation of a food security experience scale among indigenous populations in Brazil

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Abstract

Background Assessing food and nutrition security among indigenous populations in Brazil is challenging due to their significant cultural and linguistic diversity. This study aimed to validate a national food insecurity measurement scale for indigenous peoples in Brazil (EBIA-I).

Methods A total of 495 indigenous households, from 15 rural communities and one urban area, were included in the analyses. Internal psychometric validity scale was tested with the Rasch Model, and external validity was examined with bivariate analyses.

Results An 8-item scale was internally valid (Infit values ranged between 0.7 and 1.3), 6 of the items referred to households with children under 16 years of age, 5 to households only with residents aged 16 years or more, with 3 being common to both. The external validity of the EBIA-I was high, as shown by the significantly lower prevalence of moderate or severe food insecurity, in households where some members regularly received income vs. those not receiving any income, 17.5% vs. 30.6%, respectively. Likewise, interviewees who self-reported good/very good health vs. poor/very poor health status were less likely to experience moderate or severe food insecurity (19.1% vs. 34.8%).

Conclusions EBIA-I is a valid scale with strong potential to inform decisions by policymakers and to support indigenous organizations monitoring, addressing, and advocating for policies to prevent or mitigate food and nutrition insecurity in their communities.

Keywords Food security, Scale, Measurement, Indigenous peoples, Validation, Brazil

Introduction

Assessing food insecurity (FI) and hunger among indigenous populations in Brazil using standardized approaches is methodologically and conceptually challenging, but crucial for equitable policies. To account for the diverse cultural diversity of these populations, including language, it is essential to ensure that proposed Food Security and Food Insecurity (FS/FI) measurement tools are co-designed and tested to ensure that they are adequate for the social and cultural reality of indigenous peoples.

The need for developing a valid FS/FI measurement instrument appropriate to the socio-cultural diversity of indigenous peoples in Brazil is supported by the

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experience of more than 20 years adapting, validating, and implementing the household food insecurity scale (EBIA) for the general Brazilian population [29]. The first national household FI diagnosis, with direct EBIA measurement, occurred in the 2004 National Household Sample Survey. This was performed because EBIA had been validated for Brazilian urban and rural contexts [19]. Since then, EBIA has been used as a direct FI indicator for diagnosing and monitoring food insecurity and hunger in the country, through five representative national surveys, conducted between 2009 and 2022 [18, 20, 21, 34, 35]. Even though these surveys have assessed the respondents' self-reported race, including whether they identify themselves as indigenous, it was not possible to validate an indigenous EBIA, due to sample size limitations, and the fact that traditional indigenous communities have usually not been included in these surveys.

Indigenous peoples in Brazil have been consistently socially marginalized. Since the colonial period, from the sixteenth to the nineteenth century, they were systematically expelled from their territories, and subjected to major injustices, including widespread ethnic cleansing or genocide [33]. Today, violence against indigenous peoples continues with the harming of their leaders, as well as illegal exploitation of their territories, with exploitative extraction of their natural resources and expropriation of their lands [8, 9, 15, 25]. Nowadays, this exploitative neo-colonial system enables large transnational agribusiness and mining enterprises to continue their often-illegal intrusion into indigenous territories [8–10].

FS has been officially and legally defined in Brazil since 2006 as "the right of everyone to regular and permanent access to quality food in sufficient quantity, without compromising access to other essential needs, based on health-promoting food practices that respect cultural diversity, being socially, economically, and environmentally sustainable" [3, 27]. This multidimensional concept of food and nutritional security (FNS) is still limited as has not specifically considered the diverse life experiences and the cultural and territorial diversity of indigenous communities in Brazil. The concept of food security among Indigenous people, implies protecting their territory, which is the foundation of their identity, in addition to their cosmological sense of food production and feeding practices [36].

Given the holistic interpretation of FS among indigenous peoples, capturing and measuring their food experiences becomes a complex task, due to the wide ethnic diversity, the dynamism of their food systems, their trade and monetization processes, the degradation of their territory due to the intrusion of external groups, and

the food production seasonality [1]. However, similarities in the perception of hunger and lack of food, when diagnosed among indigenous peoples, make the task of developing and testing the validity of a scale that directly measures food insecurity crucially important.

Preliminary studies

The first study examining the psychometric validity of an indigenous FI scale in Brazil was conducted between 2007 and 2012 among the Guarani people living in four communities in the coast of the state of São Paulo [36]. This study used a mixed methods approach, starting with qualitative methods including field observation, in-depth interviews with community leaders and other key informants, and three focus groups with adult women, adult men, and young male and female participants.

The qualitative approach was essential to capture the Guarani people's knowledge, perceptions and experiences with fundamental concepts of FS and FI and hunger, including healthy eating, sufficient food and the conditions that lead to food scarcity or abundance, as well as strategies for coping with different FI aspects or dimensions.

An 11-item scale resulting from this qualitative and highly participatory and inclusive phase was then tested in population surveys, also in Guarani Mbya and Nandeva communities in the coast of São Paulo [36]. The analyses led to a 7-item scale with strong internal and external validity.

In 2013, a study carried out in Guarani Nandeva and Kaiojá communities located in the state of Mato Grosso do Sul, used the EBIA validated among Guarani peoples in the state of São Paulo, demonstrating its adequacy also among these communities [15]. Other studies had been previously conducted in indigenous communities in Brazil, but only with language adaptations of the national EBIA [14, 40], which raised concern about the suitability of the scale for the contexts of indigenous peoples.

In sum, the evidence suggested that there was a strong need to study the possibility of developing a valid common FI scale to be applied across indigenous peoples in Brazil [36].

The results of the present study will be essential to provide national research institutes, academic researchers, policymakers, and civil society movements and organizations of indigenous peoples, with an instrument for diagnosing and monitoring FI and hunger among indigenous peoples in Brazil. We expect that identifying a common scale can help to improve FS governance among indigenous communities, as has been observed for the general Brazilian population [29].

Methods

Ethical considerations

The ethical procedures of this study followed the precepts of the Declaration of Helsinki, in addition to the mandatory requirements of the Brazilian legislation related to ethics in research with indigenous peoples in the national territory. It is important to note that Brazilian standards expand the Helsinki requirements. The investigation followed all ethical principles required by Brazilian Resolution number 466, of December 12, 2012, of the National Research Ethics Commission (CONEP), for research with human beings, and Resolution number 304, from 2000, for research with indigenous peoples in Brazil. Thus, the study was approved by CONEP (approval number 40372614.2000.5404) and by the National Indigenous Peoples Foundation (FUNAI) (approval number 08620.0678142014–42) in 2015.

As required by the research ethics committee, an Informed Consent Form was used to obtain the agreement of indigenous community leaders and of all individuals before they were interviewed. Informed consents were also obtained from study participants through signature or fingerprints. After reading the consent text, written in Portuguese, the interviewer collected participants' signatures or fingerprints. In situations where participants had an insufficient understanding of the form content, an interpreter read the consent form in the interviewee's language. This situation was rare, since in almost all households, there was an adult fluent in Portuguese and eligible for the interview.

In addition to the CONEP requirements, to obtain agreement in community inclusions and local support to the research procedures, in-person meetings were held with indigenous leaders at the headquarters of the Federation of Indigenous Organizations of Rio Negro (FOIRN) and the Indigenous Association of Middle Rio Negro (ACIMRN). Additionally, contacts were made with health professionals from the Indigenous Health District of Rio Negro (DSEI-RN), and the Regional Coordination of FUNAI. These contacts facilitated the presentation and discussion of the research questionnaire and the selection of indigenous communities to be included in the study. These consultations led to the decision to include households in the city of Santa Isabel, given that 96% of people residing in the city were indigenous population according to the 2010 IBGE Census [16].

Study design and sample

The study used a mixed methods approach, combining qualitative and quantitative methods. The qualitative phase included in-depth interviews with community leaders, using a standardized form with open ended questions. The results presented in this article are only related

to the quantitative phase of the study, involving a population-based study to generate the data needed for the psychometric validation of an indigenous Brazilian scale (EBIA-I) that could be applied across indigenous groups in Brazil. In the state of Amazon in northern Brazil, households in the urban area of the city of Santa Isabel do Rio Negro were included. Only in this city, households were randomly selected, based on a census list provided by the city health office. In rural areas, in the 10 communities of Middle Rio Negro, and 4 communities of Upper Rio Negro, all households were included, due to the small number of inhabitants within each community. These 14 communities were selected based on an official list of communities in the indigenous Rio Negro Health District (DSEI-RN). Nevertheless, considering cost constraints, the selected communities needed to have more than 10 households, and they needed to be no more than 8 h by motorboat away from the city of Santa Isabel. This selection criterion was discussed and approved in a meeting with indigenous organizations. Furthermore, one more community from the south of the country (state of Paraná), Mangueirinha Indigenous Land (IL) of the Kaingang people, was included to achieve greater regional diversity. Therefore, the convenience sample included 15 communities with 16 different ethnicities and its diverse languages.

Household was defined as the sampling unit, given that FI prevalence is usually estimated for households [26, 27, 30]. As previously explained, due to limited research resources and logistical field complexity, especially in reaching distant communities that takes hours to reach by motorboat, in the banks of Rio Negro, it was not possible to use a representative sampling model for indigenous peoples in the Northern and Southern regions of the country. This is justified because the objective was to test the internal and external validity of a scale and not the estimation of the FS/FI prevalence of indigenous peoples living in these regions.

The sample size was planned to reach the total of 160 households in each of the 3 groups of communities under study. This sample size was considered sufficient for the validation procedures, based on previous EBIA validation studies in Brazil, both nationally [31, 38] and in a local indigenous Guarani territory [36]. Thus, the estimated total sample size was 480 households. Furthermore, as the Mangueirinha IL households were very much spread out within the territory, it was decided, for logistical reasons, to include all the 259 households, as it was done in the Rio Negro rural communities. As a result, a total of 579 households were included, 160 in the Upper/Middle Rio Negro communities, 259 in Mangueirinha IL, and 160 in urban Santa Isabel do Rio Negro. The Santa Isabel sample was randomly selected from a list of indigenous

households provided by the Municipal Family Health Service.

A total of 84 households across communities had missing data, primarily in Manguinhos IL, where 61 had incomplete scale item responses, and 23 households were abandoned or without residents, but in spite of these missing data, the total sample size of 480 households was reached. There were three refusals to participate, two in Santa Isabel and one in the Middle Rio Negro group. Therefore, the final analytical sample was composed of 495 households, 178 households in Manguinhos IL, 159 in Upper/Middle Rio Negro communities, and 158 in urban Santa Isabel do Rio Negro.

Instruments, indicators and data collection

The research questionnaire included indicators related to FS and FI determinants, as well as others capturing the individual and collective consequences of these conditions. Specifically, health, socioeconomic, demographic, and contextual indicators were included, such as self-reported health status, if the household chief spoke Portuguese, if someone was hospitalized during the previous year, had resident with alcohol abuse; sex, age, religion, schooling, of respondent and household chief; household resident with regular job payment, household members with participation in the “Bolsa Família” cash transfer

program; type of water source, school meal access; if family have farm or if they lost harvest recently and lack of food during the past year. These households and individual indicators were used to describe the characteristics of the included communities and for testing the external validity of EBIA-I.

The initial 11-item scale used in this study originated from the study in Guarani communities of the state of São Paulo [36]. This decision was based on the objective of testing the potential to expand such scale to other ethnic, social and cultural contexts. A second key decision made was not to start with the final 7-item EBIA Guarani scale [36], because it was only suitable for households with children under 16 years of age, given that the Guarani sample contained few households with only adult residents, which prevented examining the scale’s validity for these households.

These original 11-item scales (Fig. 1), theoretically represent different food insecurity severity levels. Four items probed for the household’s collective access to food, three items focus on the food situation of the interviewee specifically, and the remaining four items on the food access of children and young people in the household. Regarding the different FI dimensions, five items addressed the food quality for both adults and children/young people in the household, five items addressed food quantity, and

Items in English	Items in Portuguese
1. In the past month, were you worried about obtaining food for your household?	1. No mês passado, o Sr(a) sentiu preocupação em conseguir comida para sua casa?
2. In the past month, did everyone in your household always eat food from your culture?	2. No mês passado, vocês desta casa, comeram sempre comida da sua cultura?
3. In the past month, did everyone in your household always eat food they like?	3. No mês passado, vocês nesta casa, comeram sempre comida boa (do gosto de vocês)?
4. In the past month, did everyone in your household always eat healthy food (food that is good for health)?	4. No mês passado, vocês nesta casa, comeram sempre comida saudável (que faz bem pra saúde)?
5. In the past month, was there food in your household every day?	5. No mês passado, na sua casa, teve comida todos os dias?
6. In the past month, did you spend an entire day without eating anything because there was no food in the household?	6. No mês passado, você ficou um dia todo sem comer nada, porque não tinha comida na casa?
7. In the past month, did you eat less to leave food for the children and young people in the household?	7. No mês passado, teve dia que você comeu menos para deixar comida para as crianças e jovens da casa?
8. In the past month, did the children and young people in the household always (every day) eat good food?	8. No mês passado, as crianças e jovens da casa comeram sempre (todos os dias) comida boa?
9. In the past month, did the children and young people in the household always (every day) eat food that helps them grow healthily?	9. No mês passado as crianças e jovens da casa comeram sempre (todos os dias) comida que faz crescer com saúde?
10. In the past month, were there days when children and young people in the household ate less food than necessary because there was little food?	10. No mês passado, teve dia em que as crianças e jovens da casa comeram menos quantidade de comida do que é necessário, porque tinha pouca comida?
11. In the past month, were there days when children and young people in the household spent the entire day without eating and went to bed hungry because there was no food?	11. No mês passado, teve dia em que as crianças e jovens da casa passaram o dia todo sem comer e foram dormir querendo comer, porque não tinha comida?

Fig. 1 11-item EBIA Indigenous test

one item focused on the stress or anxiety about the risk of experiencing food shortages in the near future.

The response options for all items were “Yes” or “No” or “Do not know/No response”. Among Guaraní peoples, there was no consensus on which item best described food quality. Therefore, the scale was presented to test three items related to food quality: “cultural food,” “preferred food,” and “healthy food,” with “healthy” being replaced by “food that promotes healthy growth” for young people and children. Additionally, the Guaraní peoples suggested avoiding items with negative connotations, such as “...last month, there were days with no food in the household,” and replacing it with “...last month, there was food in the household every day” which has a positive connotation. Thus, in this sense, this Guaraní scale differs from other FS scales in Brazil and around the world [12, 37].

Data were collected through face-to-face interviews with a household member aged more than 16 years, mainly women, who were considered the person with the better understanding of the family food dynamics. The great majority of interviews were carried out in Portuguese and, when needed, in the local language, with the support of an interpreter. The vast majority of interviews (> 90%) were conducted in 2015 and the remaining ones in early 2016. Interviewers were mainly indigenous students with completed high school or more, and a nutritionist with previous extensive health research experience in the Amazon. The interviewer training focused on the correct application of the questionnaire, strong adherence to the ethical procedures, and strong sensitivity towards indigenous peoples.

Internal validity analysis

EBIA-I was psychometrically tested for internal validity using the Rasch Model, with the WINSTEPS software version 3.72, a single-parameter logistic model [2, 39]. This statistical technique has been extensively used in studies aiming to test the psychometric validity of scales used for measuring household FI. This model is based on a theoretical model that assumes that the lack of access to food is a phenomenon with varying severity levels, in which the more positive responses to EBIA-I items related to poor access to food, the stronger the FI severity [26, 39]. Thus, the Rasch model assumes that respondents in a situation of FS or mild FI are less likely to respond positively to items indicating greater food deprivation, compared to respondents experiencing moderate or severe FI. The model also provides item fit statistics (FITs), to test the assumption that the scale is unidimensional and measures only one construct, namely, the FI of families [2]. The analytical procedures involved the progressive and iterative exclusion of items according to

their position in the optimal FIT range from 0.7 to 1.3 by the study group.

The internal validity of the scale was initially assessed separately by study communities and by households with and without residents under 16 years of age. Analyses of households with only residents aged 16 years or older were conducted by aggregating households across communities, including households from the city of Santa Isabel. This aggregated analysis for households with residents aged 16 years or older was necessary due to their small number in the samples, which reflects the reality that indigenous populations in Brazil have strong preponderance of young people, resulting in few households with only adult residents.

External validity analysis

The external or predictive scale validity was determined by categorizing the FI household status, incorporating all the study groups combined in the analyses. Then, scores were calculated for each household by summing the EBIA-I items affirmed and classifying the households into mutually exclusive FS/FI categories. The item severity levels were described for each of the three communities (Fig. 2), and the cut-off points proposed were used only to allow the classification of their FS/FI status (Table 3). To perform the scale external validity tests, it was used cut-off points established for the combined group. These cut-off points were based on how the items grouped with each other, following the progressive order of severity, observed in the Rasch analyses (Fig. 3), thus, no other analytical process was used to establish the cut-off point, which is different from FAO's recommendations [13]. In these analytical procedures, all households with missing responses, i.e., items marked as ‘Do not know or no response’ (NS/NR) on the EBIA-I, were excluded. After classifying the household as food secure or by FI levels, these categories were cross tabulated with health, socioeconomic, demographic, and contextual indicators. Pearson's Chi-square test with significance level of 5% was used to test the significance of associations. For these bivariate analyses, it was necessary to combine moderate and severe FI categories into one, due to sample size limitations.

Results

In indigenous communities, both riverine and urban, interviewees and household heads identified themselves as belonging to the following ethnic groups: Tuyuka, Baré, Tukano, Baniwa, Wanana, Tariano, Barasana, Kubeo, Arapaso, Desana, Karapanã, Kuripaco, Piratapua, Miriti-tapua, Bakasana, Dãw, Hupda, and Nadeb. The majority (76%) of the sample consisted of Baré,

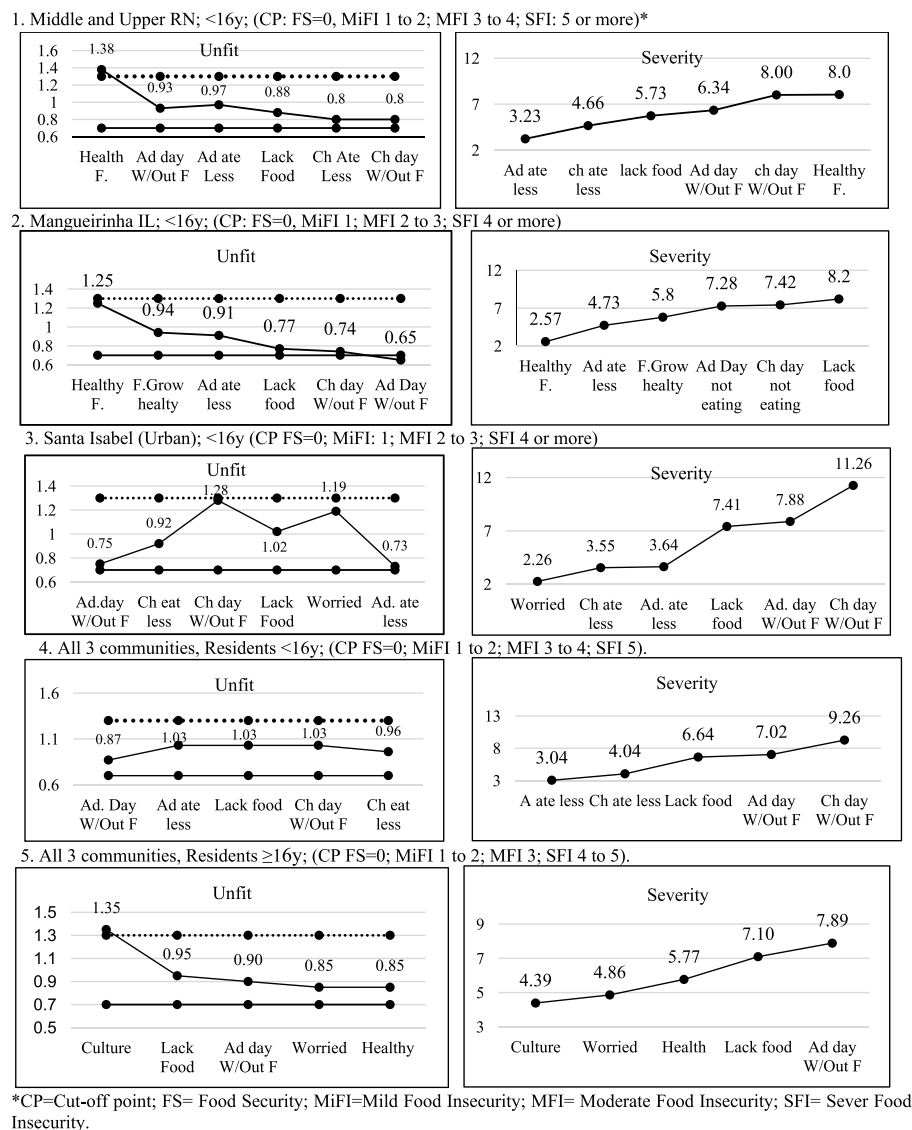


Fig. 2 EBIA-I item unfit values and FI severity levels in households with and without residents under 16 years of age. Brazil, 2015–2016

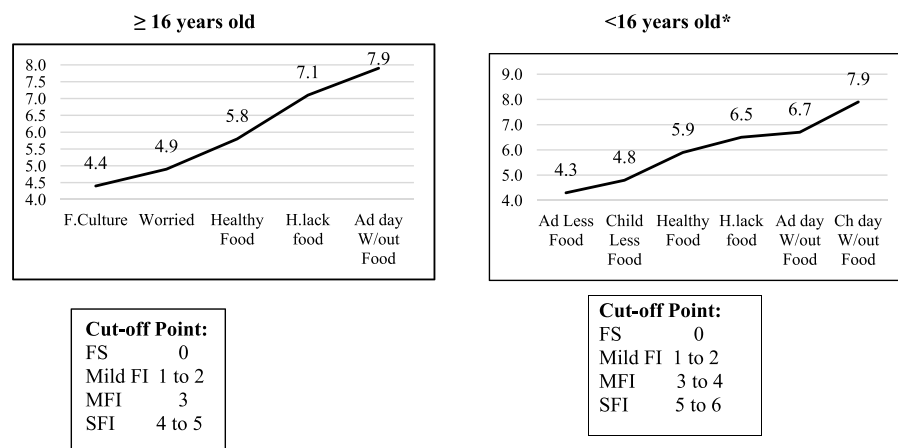
Baniwa, Desana, Piratapuaia, Tukano, and Tuyuka peoples. In the Manguairinha Indigenous Land (IL), households from three settlements were included: Campina (Headquarters), Paiol Queimado, and Água Santa, whose population included in the study was exclusively from the Kaingang people.

In addition to the ethnic diversity, the findings of this research highlighted the diverse socioeconomic and demographic profiles of indigenous communities in the Amazon and Southern Brazil. The descriptive indicators demonstrated the strong diversity among the three groups: residents of the city of Santa Isabel, indigenous riverine communities of the Middle/Upper Rio Negro, and the Kaingang people of Manguairinha IL in the South

of the country (Tables 1 and 2). Kaingang interviewees and household heads were younger than those in Santa Isabel. Among Kaingang peoples, there was higher proportion of single people as heads of households, while in the middle and upper Rio Negro, the vast majority were married.

In all locations, respondents were mostly women (80.0%); the vast majority spoke Portuguese (98% or more) in addition to their indigenous languages; the majority reported having very good or good health; and the vast majority were Catholic (Table 1).

Almost all households in Santa Isabel and in Manguairinha IL had piped water, while almost none of the households in Rio Negro communities had access to this



*Including “Health food”.

Fig. 3 EBIA-I item severity levels and cut-off points by households with or without residents under 16 years of age – Brazil 2015–2016

resource (Table 2). Another significant difference among groups was the ethnic homogeneity observed in Manguoeirinha IL, with only Kaingang people, in contrast with the ethnic diversity of Amazon groups, where 18 out of the 22 existing ethnic groups were identified. About 80% or more received cash transfers through the “Bolsa Família” Program (Table 2). Likewise, there was no significant difference among groups regarding threats or violence, which prevalence ranged from 3.0% to 4.0% in the six months preceding the interviews (data not included in the table).

Internal validity analysis of EBIA-I

The internal or psychometric validity analysis of the proposed EBIA-I, as detailed in the methods section, consisted of iterative analyses using the Rasch model. The analytic process began with testing the fit to the scale of the 11 initially proposed items [36] and repeating the analysis, removing items with inadequate fit values below 0.7 or above 1.3 in each step [2, 26, 39]. In the initial stages of the analyses in each of the three study groups, two items were removed: “... residents consumed their preferred foods” (see item 3 in the list of questions presented in the methods section) and “...children under 16 years consumed good food” (item 8), as they did not meet the model fit criteria.

As shown in the Fig. 2, all items related to the quantitative FI dimension, as “Lack of food”, “Adult ate less”, “Child ate less”, and “child day w/out food”, had an adequate fit (Infit between 0.7 and 1.3) in households with residents under 16 years of age in the three study groups. In households with residents under 16 years, an item related to dietary quality (“lack of access to healthy food”) had a marginally adequate fit in the Rio Negro and

adequate fit in Manguoeirinha IL communities, but not in the urban households in the city of Santa Isabel.

EBIA-I items addressing the consumption of culturally relevant food and concerns about future food scarcity had varying fit values across study groups. The item “worried” showed adequate internal validity only in the urban indigenous community of Santa Isabel, while the item “cultural food” had adequate fit only in the riverine communities of Upper and Middle Rio Negro. Item “Adult day W/Out food” had a marginally adequate fit (infit = 0.65) in Manguoeirinha IL but was retained as it had adequate fit in the other two groups. We decided to retain the item “healthy food” focusing on food quality in households with residents under 16 years of age, as it had adequate fit in two of the three groups, Rio Negro and Manguoeirinha IL. This decision was justified by the fact that the proposed scale is expected to be used more in communities like these two study groups, and less in urban communities like Santa Isabel.

As mentioned before, due to sample size limitations for households with only residents aged 16 years or older, it was necessary to analyze all the three study community groups combined. Five items had adequate psychometric behavior, and only one item, “Food they like”, was excluded due to inadequate fit. Therefore, the scale with adequate internal validity for households with only adults (people ≥ 16 years) included the five items “Concern”, “Cultural food”, “Healthy food”, “Lack of food”, and “Adults went throughout the day without eating” (Fig. 2).

As part of the psychometric analysis, the severity measures of each EBIA-I item was also assessed. The items with the lowest severity measures, in households with children under 16 years of age, were: “Concern”, “Healthy food”, and “Adults consumed less food”, in the cities of Santa Isabel,

Table 1 Social, demographic and health status of individuals interviewed and household heads from the city of Santa Isabel do Rio Negro, Upper and Middle Rio Negro, and Mangueirinha Indigenous Land—Brazil, 2015–2016

Variables	Santa Isabel		Upper/Middle Rio Negro		Mangueirinha IL		p-value
	n	%	n	%	n	%	
Interviewed person:							
Sex							0.632
Male	35	22.2	31	19.7	32	18.0	
Female	123	77.8	126	80.3	142	82.0	
Total	158	100.0	157	100.0	174	100.0	
Age (Years)							0.000
Less than 30 years	24	15.3	27	25.0	65	36.5	
30 to 50 years	79	50.3	55	50.9	65	36.5	
50 years and more	54	34.4	26	24.1	48	27.0	
Total	157	100.0	108	100.0	178	100.0	
Portuguese Speaker							0.117
Yes	158	100.0	154	98.7	176	100.0	
No	0	0.0	02	0.3	0.0	0.0	
Total	158	100.0	156	100.0	176	100.0	
Self-reported health status							0.513
Very good/Good	90	57.0	101	63.9	115	65.0	
Regular	57	36.1	49	31.0	56	31.1	
Poor/very poor	26	5.3	11	7.0	07	4.0	
Total	173	100.0	158	100.0	177	100.0	
Household Head:							
Sex							0.000
Male	101	87.1	127	95.5	80	68.4	
Female	15	12.9	06	4.5	37	31.6	
Total	159	100.0	133	100.0	117	100.0	
Age (years)							0.000
Less than 30 years	11	9.7	14	15.6	36	31.0	
30 to 50 years	53	46.9	41	45.6	50	43.1	
50 years and more	49	43.4	35	38.9	30	25.9	
Total	113	100.0	90	100.0	116	100.0	
Religion							0.219
Catholic	95	82.6	99	77.3	78	72.9	
Protestant	20	17.4	29	22.7	29	27.1	
Total	115	100.0	128	100.0	107	100.0	
Schooling (years)							0.027
High (8 years or more)	60	53.1	43	33.9	43	38.1	
Average (from 4 to 7 years)	28	24.8	40	31.5	39	34.5	
Low (< 4 years)	25	22.1	44	34.6	31	27.4	
Total	113	100.0	127	100.0	113	100.0	

Mangueirinha IL, and Upper and Middle Rio Negro, respectively. The item with the highest severity was "Child spent the entire day without eating" in all three study groups. In households without children under 16 years of age, in the pooled sample, the items of lower severity were "Concern" and "Healthy food", while the highest severity item was "Adults spent the entire day without eating".

Figure 3 presents the severity score for each scale item, considering households with and without children under 16 years of age, and in both cases with pooled analysis of all the three study groups combined. Severity cut-off points were then established for households with and without children under 16 years of age based on how the items coalesced around

Table 2 Absolute and relative frequencies of household indicators in the city of Santa Isabel, communities of Upper/Middle Rio Negro, and Mangueirinha Indigenous Land- Brazil, 2015–2017

Variables	Santa Isabel		Upper/Middle Rio Negro		Mangueirinha IL		p-value
	n	%	n	%	n	%	
Resident with job with regular pay (last 6 months)							0.000
Yes	105	78.9	27	20.0	103	69.1	
No	28	21.1	108	80.0	46	30.9	
Total	133	100.0	135	100.0	149	100.0	
Cash transfer program ("Bolsa Família")							0.076
Yes	131	89.7	127	83.6	77	79.4	
No	15	10.3	25	16.4	20	20.6	
Total	146	100.0	152	100.0	97	100.0	
Resident abusing alcohol consumption							0.050
No	125	79.1	140	88.1	149	87.1	
Yes	33	20.9	19	11.9	22	12.9	
Total	158	100.0	159	100.0	171	100.0	
Type of water access							0.000
Piped water	153	98.7	2	1.3	171	97.2	
No piped water	02	1.3	147	98.7	05	2.8	
Total	155	100.0	149	100.0	176	100.0	
Resident that had been hospitalized (last year)							0.363
No	136	87.2	138	89.0	150	92.0	
Yes	20	12.8	17	11.0	13	8.0	
Total	156	100.0	155	100.0	163	100.0	
Family Farm							0.000
Yes	106	67.9	152	97.4	53	30.8	
No	50	32.1	04	2.6	119	69.2	
Total	156	100.0	156	100.0	172	100.0	
Crop loss							0.000
No	76	71.7	130	86.1	29	56.9	
Yes	30	28.3	21	13.9	22	43.1	
Total	106	100.0	151	100.0	51	100.0	
Period of the year with lack of food							0.000
Yes	82	79.6	134	89.9	04	8.9	
No	41	20.4	15	10.1	41	91.1	
Total	123	100.0	149	100.0	45	100.0	
School meal access							0.000
During School period	105	88.2	8	6.1	147	100.0	
Lacked several times	14	11.8	124	93.9	0	0.0	
Total	119	100.0	132	100.0	147	100.0	
Resident < 16 years of age							0.000
Yes	123	78.3	140	88.1	104	59.1	
No	34	21.7	19	11.9	72	40.9	
Total	157	100.0	100	100.0	100	100.0	

different severity scores. For classifying households as FS or across FI severity categories, an EBIA-I score was firstly computed for each household by adding the number of positive items, and then the established cut-off points specific to households with and

without children under 16 years of age were applied. Fifty households with missing EBIA-I item data or those that selected the option "Do not Know/No Response" for at least one item were excluded from the Rasch analyses.

Based on the psychometric analyses, an EBIA-I scale was identified with 6 items for households with residents under the age of 16 years and 5 items for households only with residents aged 16 years and older, with three items being common to both types of households (see questions 4, 5, and 6 in Fig. 4). Therefore, the final proposed scale (EBIA-I) consists of a total of 8 items, with some of them specific and others common to each type of household (Fig. 4).

Table 3 presents the prevalence of FS and FI using the proposed 8-item EBIA-I. Households in Mangueirinha IL and in the city of Santa Isabel were less likely to experience FI. In contrast, the study group represented by the indigenous riverside communities of Upper and Middle Rio Negro had the highest prevalence of moderate/severe food insecurity, which was almost twice as high as the prevalence in Mangueirinha IL and Santa Isabel, 32.4% vs. about 17%, respectively.

External validity analysis (EBIA-I)

The definition of cut-off points allowed for classifying households as having FS or any of the three FI severity levels for each community group and all combined. For the external validity analysis of EBIA-I (Table 3), to maximize statistical power, the pooled sample was used and categories of moderate food insecurity and severe food insecurity were combined into a single one. The indicators that were expected to be associated with FI were selected for assessing the external or predictive EBIA-I validity. Table 3 shows the associations between these indicators and FS and the two FI levels: Mild (MiFI) and Moderate (MFI) or Severe (SFI) combined.

Having someone in the family receiving income from work vs. not having such income was inversely associated with MFI/SFI, 17.5% vs. 30.6%, respectively. The current health status of the respondent was a predictor of MFI/SFI prevalence following a dose/response pattern. The prevalence of moderate or severe FI was 23.9% among those self-reporting 'Very Good/Good health', compared with 26.4% and 40.0% among those reporting 'Regular' or 'Very Poor/Poor Health' (Table 3). Engagement of households with farming was significantly associated with higher prevalence of MFI/SFI compared with those not engaged with farming, 24.7% vs 16.0%, respectively. On the other hand, families that reported having experienced lack of food at some point in the previous year were significantly more likely to have an increased prevalence of MFI/SFI. In contrast, crop loss was not associated with MFI/SFI, although FS was higher among farmers that did not experience food production losses (Table 3).

Lack of access to school meals during the entire school period was associated with higher prevalence of MFI/SFI compared with households where children had permanent access to such programs (32.8% vs 17.0%, respectively) and this association was statistically significant (Table 3). Households with a member who consumed alcohol in excess presented higher prevalence of MFI/SFI compared with households without this condition, 38.2% vs. 23.4%, respectively. Absence of piped water in the household was associated with higher prevalence of experiencing MFI/SFI. Lower schooling of the household head tended to be associated with low food access, but this relationship was not statistically significant. On the other hand, a statistically significant association was observed between MFI/SFI and the fact that a

Nº.	Items in English	Items in Portuguese	Answers (Codes)
1	In the past month, were you worried about obtaining food for your household?	No mês passado, o Sr(a) sentiu preocupação em conseguir comida para sua casa?	Yes (1) No (0) NR (99)
2	In the past month, did everyone in your household always eat food from your culture?	No mês passado, vocês desta casa, comeram sempre comida da sua cultura?	Yes (0) No (1) NR (99)
3	In the past month, did everyone in your household always eat healthy food (food that is good for health)?	No mês passado, vocês nesta casa, comeram sempre comida saudável (que faz bem pra saúde)?	Yes (0) No (1) NR (99)
4	In the past month, was there food in your household every day?	No mês passado, na sua casa, teve comida todos os dias?	Yes (0) No (1) NR (99)
5	In the past month, did you spend an entire day without eating anything because there was no food in the household?	No mês passado, você ficou um dia todo sem comer nada, porque não tinha comida na casa?	Yes (1) No (0) NR (99)
6	In the past month, did you eat less to leave food for the children and young people in the household?	No mês passado, teve dia que você comeu menos para deixar comida para as crianças e jovens da casa?	Yes (1) No (0) NR (99)
7	In the past month, were there days when the children and young people in the household ate less food than necessary because there was little food?	No mês passado, teve dia em que as crianças e jovens da casa comeram menos quantidade de comida do que é necessário, porque tinha pouca comida?	Yes (1) No (0) NR (99)
8	In the past month, were there days when the children and young people in the household spent the entire day without eating and went to bed hungry because there was no food?	No mês passado, teve dia em que as crianças e jovens da casa passaram o dia todo sem comer e foram dormir querendo comer, porque não tinha comida?	Yes (1) No (0) NR (99)

*Items/questions 1, 2, 3, 4, and 5 are applicable for households without children under 16 years of age (only adults). Items/questions 3, 4, 5, 6, 7, 8 are applicable to households with children under 16 years of age. Items 3, 4 and 5 are common to both types of households (with or without children under 16 years of age).

Fig. 4 The validated Indigenous Household Food Security/Insecurity Scale—EBIA-I*. Brazil 2015–2016

Table 3 Prevalence distribution of food security (FS) and mild food insecurity (MiFI), moderate or severe food insecurity (MFI/SFI) levels by indigenous communities, socioeconomic, demographic, and health indicators. Brazil, 2015–2016

Variables	FS		MiFI		MFI/SFI		Total		p-valor
	n	%	n	%	n	%	n	%	
Study Groups									0.003
All Groups Combined	204	45.8	145	32.6	117	25.1	466	100.0	
Mangueirinha IL	75	44.9	64	38.3	28	16.8	167	100.0	
Upper/Middle Rio Negro	60	44.1	32	23.3	44	32.4	136	100.0	
City of Santa Isabel	69	48.6	49	34.5	24	16.9	142	100.0	
Household Head Schooling (years)									0.565
High (8 years or more)	72	50.3	40	28.0	31	21.7	143	100.0	
Medium (4 to 7 years)	45	45.9	32	32.7	21	21.4	98	100.0	
Low (< 4 years)	37	39.4	33	35.1	24	25.5	94	100.0	
Resident with regular job pay									0.007
Yes	103	46.2	81	36.3	39	17.5	223	100.0	
No	72	42.4	46	27.1	52	30.6	170	100.0	
Household Farm									0.020
Yes	129	46.9	78	28.4	68	24.7	275	100.0	
No	71	43.8	65	40.1	26	16.0	162	100.0	
Crop loss									0.001
Yes	20	29.9	31	46.3	16	23.9	67	100.0	
No	112	52.11	52	24.2	51	23.7	215	100.0	
Period with lack of food									0.049
Yes	82	42.9	56	29.3	53	27.7	191	100.0	
No	41	57.7	16	22.5	14	19.7	71	100.0	
Resident abusing alcohol consumption									0.013
Yes	20	29.4	22	32.4	26	38.2	68	100.0	
No	181	45.9	121	30.7	92	23.4	394	100.0	
Perceived Health status (Interviewed Person)									0.021
Very Good/Good	141	50.7	82	29.5	55	19.8	278	100.0	
Regular	51	35.9	58	40.9	33	23.2	142	100.0	
Poor/Very Poor	10	43.5	5	21.7	10	34.8	25	100.0	
Access to School meals									0.002
During entire year	113	46.9	87	36.1	41	17.0	241	100	
Lacked several times	51	42.9	29	24.4	39	32.8	119	100	
Someone Experiencing Threats									0.001
Yes	1	5.9	6	35.3	10	58.8	17	100.0	
No	197	45.3	132	30.3	106	24.4	435	100.0	
Receiving Cash Transfer ("Bolsa Família")									0.868
Yes	134	44.4	98	32.5	70	23.2	302	100.0	
No	23	43.4	19	35.8	11	20.8	53	100.0	

resident had been victim of some type of threat in the last 6 months, with prevalence of 58.8% in these households and 24.4% in those where this event was not reported. Receiving or not benefits from the cash transfer program ("Bolsa Família" Program), was not associated with FI in the pooled sample, perhaps due to its very high coverage in all groups (> 80%).

Discussion

The strong ecological, ethno-cultural and social structure diversity among the three indigenous communities study groups (Santa Isabel, communities of Upper/Middle Rio Negro, and Mangueirinha IL), combined with their highly diverse ethnic and social characteristics, allowed this study to investigate if it was possible to propose a

single valid scale for measuring household FI across the strongly diverse indigenous communities in Brazil. In fact, indigenous communities that participated in the study presented quite contrasting contexts. Indeed, communities located in the urban area or in riverside villages in the north and, indigenous land in the south, reflected the rich social and ethno-cultural diversity of indigenous peoples in Brazil, observed also in other studies [17, 22].

Nineteen different ethnic groups were included in the study, 18 of which were located on the banks of the Rio Negro, in riverside communities and, in the urban area of the city of Santa Isabel, where more than 90% of its inhabitants were indigenous [17]. In addition to these ethnic differences, there were other social and demographic contrasts. For instance, Kaingang household reference persons from the south were younger than those from the north, where it was also observed the lowest proportion of women as reference persons. The lowest frequency of residents with regular job payment were found in riverine communities of Rio Negro and, household reference persons from Santa Isabel urban area had the highest educational levels.

A key strength of our study is that the development of a single experience-based FI scale was informed by a theoretical model that encompasses FI dimensions considered to be universal and transcultural. These include: a) concern or uncertainty about being able to obtain food soon; b) consumption of low-quality diets, and c) lack of access to enough food, besides a dimension of socially/culturally unacceptable food consumption [5], as illustrated in Table 4. In this framework the initial changes in dietary quality among people in the household to them not having access to enough quantity of food, first among adults and eventually among children, as a result of sequential coping strategies for managing the family's experience of food insecurity [27], Pérez-Escamilla, Segall-Corrêa, 2007).

The FI dimensions considered universal were initially explored among indigenous peoples in Brazil, through an in-depth mixed methods study conducted with the Guaraní people in São Paulo, resulting in the valid Guaraní EBIA [36]. Importantly, the psychometric properties of EBIA-I resulting from the current study also confirmed the theoretical assumption of the FI framework discussed above, in all three groups and types of households, i.e., with and without children under 16 years of age. However, in households with residents under 16 years of age, the item "healthy food" did not have adequate fit in the pooled sample although it did have adequate fit among Kaingang peoples of Mangueirinha IL and a marginally adequate fit in communities of Rio Negro. For this reason and because EBIA-I will be primarily used in indigenous communities, and not in urban areas, this item was kept in the EBIA-I. The item on uncertainty or concern about lack of food in the future showed adequate internal validity in urban households with residents under 16 years of age and in households without residents in this age group in the pooled sample.

It is important to note that in households with only adult residents, people reported concerns about lack of access to traditional or culturally specific food. However, this item has not been included in any of the psychometric scales measuring FI but needs to be included in future research as it is likely to be linked to the feeling of loss of access to culturally accepted ancestral foods with profound spiritual meaning, especially among older people.

In summary, consistent with the 14-item EBIA that was validated and applied to the general population of Brazil since 2004 in national surveys [29, 31, 37, 38], EBIA-I met the theoretical framework assumptions, and the final items included the expected FI dimensions or domains. This study adds to prior knowledge on the robust

Table 4 Theoretical framework of universal food security and insecurity dimensions—Brazil, 2015–2016^a

Domain/Dimension	Items ^c
1. Uncertainty of obtaining food	...feel worried about not being able to obtain food
2. Insufficient food quality	... always consumed healthy food
3. Insufficient food quantity	had food every day in the household
	...adult consumed less to leave food for children
	...adult spend the entire day without eating
	Child consumed less food than necessary
	...Child spend the entire day without eating
4. Social unacceptability ^b	... not consumed food from their culture

^a Adapted by Coates, [5]

^b This dimension could be related to the way of obtaining food [5] or, as it is the case in this study, because the food they have is not what they desire or prefer

^c Recall items refer to the past month

behavior of experience-based FI scales domains across different social and cultural contexts [5, 27] (Table 4).

The EBIA-I psychometric validation confirmed that the severity progression of the scale's items for most part followed theoretical expectations [30]. As expected, the items of greater severity in these households were related to adults and children spending a whole day without eating. Furthermore, in households with only adults, the severity distribution of the items follows the previously mentioned theoretical progressivity model. However, for households with children, in the pooled analyses, there were slight deviations from the theoretical model expectations for less severe items. In households with children, the item "Healthy food" had severity score that fell between the items "Adults ate less and, Children ate less" and the item "Food was lacking in the house", when the theoretical expectation was for 'Healthy food' to have been the least severe of these three items. Overall, the items' severity progressive is in full agreement with validation studies of the National EBIA conducted in 2003 with the general population [26].

The external validity assessment showed that the absence of household members receiving employment-related income on a regular basis was strongly associated with a high prevalence of MFI/SFI. Other two conditions, likely related to poor access to food, as families had lost their crops and families lacked food at some point during the last year also were significantly associated with FI in its two more severe levels (MFI/SFI). This indicates that food production seasonality is a topic that needs to be further explored in detail in indigenous communities in Brazil [23, 24, 41]. Families having farms also deserve further studied, since in this study, this variable was unexpected positively associated with MFI/SFI.

It is important to note that the lack or irregularity of food supply access during the school period was associated with high prevalence of MFI/SFI, which is consistent with the study conducted within Guarani Nandeva and Guarani Kaiowá peoples in the state of Mato Grosso do Sul (MS) using EBIA-I [25]. Both studies also found similar results related to the negative association between low or lack of income lack with FI.

An innovative finding of this study was the association between family members experiencing threats in the last 6 months, and the higher prevalence of MFI/SFI, 2.4 times more, when compared with households free of threats. It is possible that the lack of community safety may prevent families from moving around to access food or to plant, take care of and harvest their crops. Threats to people living in indigenous communities are common in Brazil, as annually documented in the reports on "*Violence Against Indigenous Peoples*" published by the Indigenous Missionary Council (CIMI) (8, 9), in the Report of

the National Truth Commission [6, 7]. All these adversities certainly will become more and more frequent in the context of climate changes, when displacements of people are forced, suggesting the need for research especially in the field of food security and extreme climate events [32].

In the present study, it was found that receiving cash transfers through the "Bolsa Família" Program did not prevent FI, which is consistent with studies among indigenous peoples and in the general population [15, 35]. Based on these findings, we hypothesized that the condition of food insecurity among those eligible to be included in the cash transfer program may be so severe, that even major programs such as "Bolsa Família" cannot prevent food insecurity in the most socio-economically vulnerable households.

This study met its first objective, as it was able to psychometrically validate an 8-item EBIA-I scale that can be used to assess FI in households with (6 items) or without children (5 items) among the diverse indigenous communities in Brazil. Secondly, the scale's external validity findings were strong as FS and the two aggregate most severe levels of FI (MFI/SFI) were associated in the expected direction with the majority of geographical/territorial, social, and demographic indicators.

Although EBIA-I has adequate validity for use in indigenous community studies, given its high internal and external validity, it is still necessary to carry out further validity tests in households without children and adolescents, due to the limited number of households with only residents older than 16 years of age. Furthermore, the meaning of "healthy diet" and "cultural diet" needs to be better understood across different indigenous contexts. Likewise, it is necessary to confirm or modify the wording of some items of the EBIA-I that followed the Guarani people recommendation regarding the positive framing of the scales' items, for example, stating "in your house, there was food every day" instead of "in your house, there were days with lack of food" [36]. This concern did not appear to be as relevant in other ethnic groups, as it was among Guarani Nandeva and Guarani Kaiowá peoples [25]. In addition, the term "always ate" may not necessarily indicate higher FI but rather more purchasing power or connectivity to the market economy, given that indigenous peoples may have access to 'food outside their culture'. Similarly, respondents may not "always eat healthy food" but rather this may also indicate more purchasing power. The methodological choice of phrasing items in the positive rather than the negative as in other FI experience-based scales needs to be followed up with more studies as this is a unique way of rephrasing the questions that differs from other FI scales.

Other potential limitations about the EBIA-I is that it may not be appropriate to apply that scale in communities where food consumption is based on a collective or communal systems, which go beyond the family nucleus. In addition, it may not be appropriate to use EBIA-I in situations of environmental calamities or other humanitarian emergencies, where family structures are highly disrupted, and all people are being exposed to the same food restriction. Under those circumstances, it is recommended to develop and test community and environmental indicators to indirectly identify the level of FS/FI.

It is important to note, as it has been previously suggested, that the application of EBIA-I should always be accompanied by other indicators that can help to identify the determinants and consequences of the access to food, and potential solutions to mitigate or eliminate FI and hunger among indigenous peoples. Additionally, strong efforts should always be made to include indigenous academics, researchers, and community collaborators in all stages of any study involving indigenous peoples [36].

Conclusion

The current study developed the EBIA-I, which is a valid and reliable instrument to assess FS/FI in Brazilian indigenous households with or without child residents. The EBIA-I can and should be included in national or local research, as well as in the Brazilian Food Security Monitoring Systems (SISVAN), which aims to organize, monitor and evaluate the food security and nutritional policies and to inform the population about their effectiveness, specially toward eliminating hunger [28, 29].

The EBIA-I should also be included, in official national surveys carried out by the Brazilian Institute of Statistics (IBGE), giving visibility to the indigenous food deprivation and contributing to improve their food security status.

The availability of a scientifically valid instrument that can directly diagnose and monitor food insecurity and hunger can help strengthen the governance of indigenous food security and nutrition policies in Brazil [4, 28, 29]. Similarly, understanding the FS status and FI severity levels among indigenous peoples, using the EBIA-I with complementary indicators, will allow for designing, monitoring, and improving public policies, contributing to better meeting the needs of all indigenous communities.

This research study completes the validation cycle with the EBIA-I, which over two decades ago started with the study that validated EBIA for the direct measurement of FI in the general Brazilian population [26, 31, 38]. The validated EBIA-I can now be applied to indigenous communities across Brazil responding to the demands of

their leaders, expressed at the II National Conference on Food and Nutrition [11]. Timely and reliable FI information is essential for promoting the well-being and dignity of indigenous peoples in Brazil, as well as their right to healthy and culturally adequate food as expressed in the Brazilian constitution.

Acknowledgements

Our sincere and heartfelt thanks to all who contributed to the realization of this investigation, especially to several indigenous leaders, associations, and the anonymous indigenous individuals who welcomed us and were willing to share their stories and respond to our questionnaires. We would also like to thank those who funded the research, The National Council for Scientific and Technological Development (CNPq), through the cooperation project of the Ministry of Social Development and Fight Against Hunger (MDS), and the representation of Food Agriculture Organization (FAO) in Brazil—MDS/SESAN-CONVÊNIO SESAN FAO-Brazil.

Authors' contributions

The authors (AMSC, VGL, MMAA, LE, BRF, DRG, LML, JSAL and RPE) participated in the planning of the research project, preparation of questionnaires, field research planning, training of interviewers and data collection supervision. Data analysis was performed by AMSC, VGL and RPE. The first draft of the manuscript was written by AMSC, VGL and RPE. AMSC, VGL, MMAA, LE, BRF, DRG, LML, JSAL and RPE commented on previous versions of the manuscript and approved its final version.

Funding

The National Council for Scientific and Technological Development (CNPq), through the cooperation project of the Ministry of Social Development and Fight Against Hunger (MDS), and the representation of Food Agriculture Organization (FAO) in Brazil—MDS/SESAN-CONVÊNIO SESAN FAO-Brazil.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The ethical procedures of this study follow the precepts of the Declaration of Helsinki, in addition to the mandatory requirements of Brazilian legislation on ethics in research with indigenous peoples in the national territory. It is important to note that Brazilian standards expand the Helsinki requirements. The investigation followed all ethical precepts required by Brazilian Resolution number 466, of December 12, 2012, of the National Research Ethics Commission – CONEP, for research with human beings, and Resolution number 304, from 2000, for research with indigenous peoples in Brazil. Thus, the study was approved by CONEP (approval number 40372614.2000.5404) and by the National Indigenous Peoples Foundation (FUNAI) (approval number 08620.0678142014–42) in 2015.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 28 October 2024 Accepted: 13 May 2025

Published online: 15 June 2025

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