Determinants Influencing the Consumption of Iron-Rich Foods among Senegalese Young Children: A Path Analysis

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Abstract: *Background:* Anaemia is a public health concern among Senegalese children aged 6-59 months old. One of the potential causes of this situation is the low consumption of iron-rich foods (IRF). Understanding factors that influence the provision of IRF among young children could help prevent and control anemia. Using the extended version of the theory of planned behavior (eTPB), this nationwide study examines psychosocial and environmental determinants of the consumption of IRF in children aged 6-23 months.

Methods and Materials: To this end, an existing questionnaire used for the same purpose was reviewed and re-validated. Using data collected among 418 children's caregivers on each construct of the eTPB, pathways by which individual and environmental constructs may influence the daily IRF consumption were identified. Data on IRF consumption were collected using a food frequency questionnaire.

Results: Overall, 42% of children consumed IRF, while 95% of caregivers intended to provide them with IRF daily. There was no association between the intention and the actual behavior. The daily IRF consumption was instead predicted by the child's age and environmental factors. In turn, the subjective norm and the perceived behavioral control predicted the intention.

Conclusion: By using a valid and reliable tool to collect data on individual and environmental factors affecting the consumption of IRF among Senegalese young children on a national scale, our research highlights potential barriers to their provision. These barriers should be considered in the design and implementation of effective interventions to improve their nutrition.

Keywords: food intake, determinants, young child, environment, Africa

1. INTRODUCTION

Adequate nutrition is paramount for optimal growth and development of young children. Yet, globally, about 22% of children under five are stunted, 7% wasted, and 40% anemic [1,2]. West Africa is one of the hardest-hit regions, but worldwide, the region ranks at the top regarding anemia prevalence. In Senegal, although stunting and wasting have decreased in the past decade [3,4], anemia among children 6-59 months old has barely been reduced (from 76% to 68% between 2010 and 2019) and remains a public health concern [5]. Iron deficiency due to inadequate dietary intake is one of the causes of this poor nutrition situation [6-8].

Breast milk alone is no longer sufficient to meet young children's macro- and micronutrient requirements from six months onwards, and complementary foods must be introduced. These foods should be provided promptly and responsibly, but also of good quality, safe, and in sufficient quantity and frequency. In particular, children aged between 6 and 23 months should consume animal-source foods daily, such as meat, fish, or eggs [9]. Despite these guidelines, in Senegal, 10% of children 6-23 months of age benefit from the minimum acceptable diet, and only 4 out of 10 consume either meat, fish, or poultry daily, while 3% receive eggs [4]. Considering these findings, more efforts need to be undertaken to improve the consumption of iron-rich foods to prevent and control anemia among young children and ensure their optimal growth and development [9,10].

Hence, the feeding behaviors of young children's caregivers are influenced by a wide range of factors. Thus, to be effective, nutrition interventions aimed at modifying them should be rooted in an understanding of factors that may limit caregivers from providing nutritious foods to their children 6-23 months of age, as they are often the main caretakers of young children. From that perspective, behavioral theories could be of great aid as they may guide the investigation of factors that could influence the behavior and subsequently

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lead to the development of valuable interventions to address the problem.

The theory of planned behavior has been used to investigate factors influencing maternal feeding decisions, such as the introduction of complementary foods [11-13], the provision of a healthy diet [14-16], or specific nutritious foods [15,17] to young children. Findings have revealed that the mother's attitude, including beliefs and subjective norms, predicted the intention to introduce solid foods at six months and that the intention was a predictor of the behavior [11,12], while the perceived behavioral control and the intention were associated with healthy feeding [14,15]. Interestingly, in some settings, the intention did not emerge as a predictor of the behavior under study, either the consumption of fruits and vegetables [15] or iron-rich foods [17]. Environmental factors have also been reported as barriers to providing healthy foods [17-20] and socio-demographic characteristics [21,22].

Using an extended version of the theory of planned behavior, which integrates individual and environmental-related factors, this nationwide research aims to identify the pathways by which psychosocial (attitude, subjective norm, and perceived behavioral control) and environmental-related factors may influence the consumption of iron-rich foods (IRF) among children aged 6-23 months old in Senegal. For this study, a questionnaire was validated and used to examine the relationships between psychosocial factors and the consumption of IRF among a small sample of young children in one region of the country [17]. The questionnaire was reviewed and re-validated before identifying the pathways.

2. METHODS

2.1. Design and Sampling

This research uses a cross-sectional design. In each region of Senegal, a list of all census units was gathered, and, in each region, 100 census units were randomly selected proportionally to the population size. Each unit listed households with children aged 6-23 months old, and eleven households were selected randomly. The sample size was determined using the expected proportion of children who had eaten any IRF the day or night before the study. The following formula [23] was used: $n = t^2 \times p (1-p) / m^2$ where t (confidence interval at 95% = standard value of 1.96), p (expected proportion of children having consumed IRF) of 27 % [24], m (relative precision) of 0.05. A design effect of 1.5 was used. The total final was 454 children.

2.2. Theoretical Framework

The extended TPB (eTPB) [25,26] guided this research (Figure **1**). According to this framework, an individual's intention is the main predictor of a behavior. In turn, the intention is determined by the attitude,

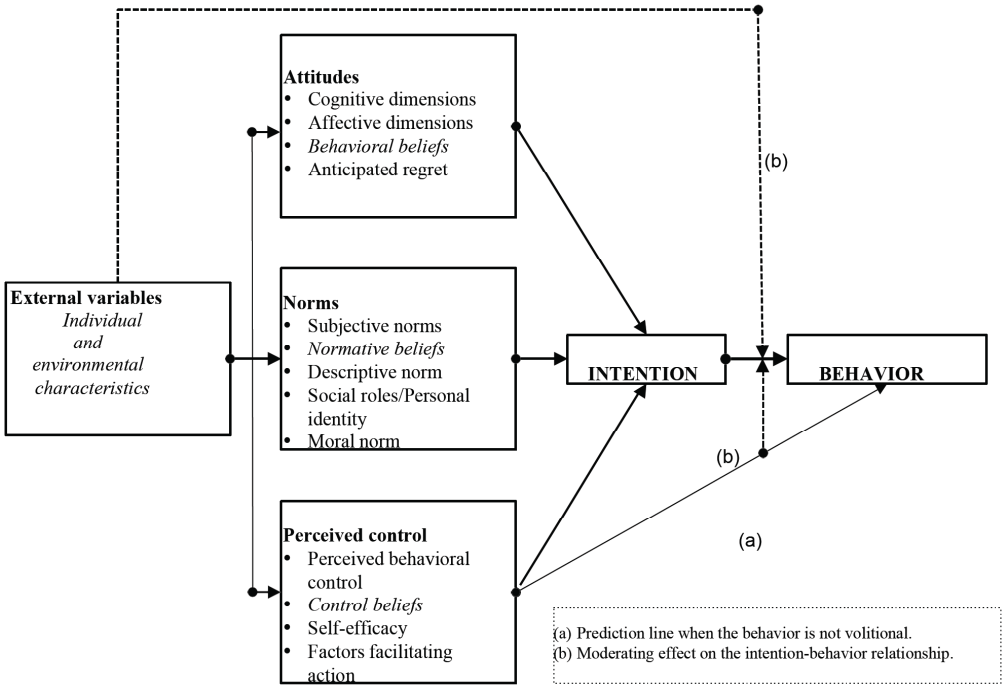

Figure 1: Extended theory of planned behavior (eTPB).

which comprises two sub-constructs, namely, the individual's beliefs about the behavior and the evaluation the person makes about the consequences of adopting it or not [25]. Similarly, the subjective norm is determined by two sub-constructs, which are the importance given by an individual to the opinion of people or groups of people around him/her (normative beliefs) and his/her motivation to comply [25]. Perceived behavioral control (PBC) is the degree of control the individual belief (control beliefs) can exercise over a certain behavior compounded by his/her perception of the degree of ease or difficulty with the behavior being adopted [27]. If the behavior is not under the volitional control of the person, PBC can directly predict it [25,26]. Environmental factors (*e.g.*, health facilities, families, workplaces, socio-demographic characteristics, food markets) are external and include social and physical characteristics that can influence the three constructs (through moderation) as well as the operationalization of the intention to a concrete behavior [28].

2.3. Preparatory Work

2.3.1. Revision of the Questionnaire on the Measurement of eTPB constructs

Before initiating the data collection on each construct of the eTPB, a validated questionnaire was used to gather data on each psychosocial construct of the framework (attitude, norms, and PBC) influencing the consumption of IRF among children aged 6-23 months old (n = 120) in the region of Matam, Senegal [17] was reviewed. To ensure that the tool contains all relevant salient beliefs associated with each construct of the framework in our context, focus-group discussions (FGDs) were held with caregivers of children 6-23 months old in five different regions of Senegal (Tambacounda, St-Louis, Matam, Kolda and Dakar). Each discussion was tape-recorded, and the content was translated into French by each team of enumerators. The different steps of the process leading to the final questionnaire are described in Appendix **A**.

2.3.2. Recruitment and Training of Surveyors

Local surveyors were recruited using the following criteria: having completed a university degree, being fluent in relevant languages (Wolof, Pular), and having experience in nutrition or health surveys. All were trained on survey tools and methodology. The theoretical training was completed by in-class and field practical exercises in Grand Dakar.

2.4. Data Collection

The data collection ranged from mid-July to mid-September 2023. Data on the consumption of IRF among children aged 6-23 months were collected through a face-to-face interview with their caregiver using the food frequency questionnaire included in the women's questionnaire of the Senegal Demographic and Health Survey (DHS) package [24]. The same questionnaire was used to gather data on the child and the caregiver's characteristics. The DHS household questionnaire [24] was also adapted to collect data on household size, age, gender, and level of education of the head, housing conditions, ownership of assets, and access to improved water and sanitation. Data on household food security were collected using the food insecurity experience survey module [29]. Face-to-face interviews were performed with the child caregiver and the head of the household, respectively, to gather the information above. The information gathered is presented in Table **1**.

After the questionnaire's validity and fidelity were assessed, the revised version was used to collect data on each construct of the eTPB through a face-to-face interview with each caregiver of children 6-23 months old.

2.5. Data Analysis

2.5.1. Behavior of Interest

The performance of the behavior of interest (consumption of IRF) was determined by assessing if the child had consumed at least one IRF (eggs, meat such as beef, pork, lamb, chicken, liver, heart, other organs, fish and shellfish) in the past day and night [30]. A score of "1" was assigned if at least one of the foods mentioned above was consumed, and if none was eaten, a score of zero was given.

2.5.2. Validation of the Revised Questionnaire on the Assessment of eTPB constructs

To ensure the validity of the revised questionnaire (Supplementary Material 1), principal component analyses (PCA) followed by exploratory factor analyses (EFA) and confirmatory factor analyses (CFA) were performed with Mplus 8 [31] using data from two different sub-samples (Samples #1 and #2) of all participating caregivers of children aged 6-23 months old located in the 14 regions of Senegal. Items (3) on direct measurements of each of the three psychosocial constructs were not considered in these analyses, as they asked the caregiver to rate a behavior in a more

general way, namely in agreement/not in agreement with the fact that there are no disadvantages of consuming IRF.

Before conducting PCA, EFA, and CFA, for each item of the tool, a numeric value was assigned to each response on the Likert scale, ranging from a score of -2 (*e.g.*, strongly disagree/unlikely/disapprove) to a score of +2 (*e.g.*, strongly agree/likely/approve). Frequency distributions were conducted to check for data completeness.

Data collected on each construct of the eTPB from Sample #1 were used in PCA to reduce the number of items. After that, with data collected on Sample #1, an EFA was conducted using the principal axis extraction method with varimax rotation with all remaining items. All factors with eigenvalues above 1 were retained. To confirm the scale's structure, a CFA was performed on data gathered on Sample #2 using the revised version of the questionnaire that emerged from the EFA. Five indicators and criteria were utilized to conclude the "goodness of fit" of the final factorial models that were tested, namely: a) Chi-square statistic with a p-value greater than 0.05, b) Comparative fit index (CFI) with a value above 0.95, c) Tucker-Lewis index (TLI) with a value above 0.95, d) Root Mean Square Error of Approximation (RMSEA) and its 90% confidence interval below 0.08 and e) Standardised Root Mean Square Residual (SRMR) of 0.08 or below [32]. The questionnaire's final models' construct fidelity was evaluated using Hancock and Mueller's H reliability coefficient. An H value above 0.80 was considered satisfactory [33]. As this step was not the main focus of this article, these results are not presented. For an in-depth example of the procedure, please refer to Ninamou et al.'s paper [35].

2.5.3. Assessment of Determinants of IRF Consumption among Young Children

Path analyses were conducted with MPlus 8 [31] to investigate pathways through which psychosocial and environmental factors could influence the consumption of IRF among children 6-23 months old. Supplementary Material 2 shows hypothesized pathways through which every construct could influence the behavior under study. Each proposed of the two pathways was tested using direct (Supplementary materials 2a & 2b) and alternate models (Supplementary materials 2c and 2d), with indirect measurements that were established through PCA, EFA, and CFA when the questionnaire was validated. To conclude the final model, all postulated pathways had to be statistically significant ($p < 0.05$), and standardized regression coefficients were estimated for all remaining pathways to the size of each statistically significant path's association.

2.5.4. Socio-Demographic Characteristics

Data on children, caregivers, and household characteristics were entered into SPSS [35]. To define a socioeconomic score for each household, a factor analysis using principal axis factoring was performed. Items for which distribution frequency showed that at least 85% of households were having (or not) the item/housing conditions were removed. In total, 17 items were included in the final score, which explains 22.13% of the factor's total variance and composition of the score. The Kaiser-Meyer-Olkin test was 0.816, which is very good [36].

Regarding household food security status, a score of "1" was given if the response was a yes to each of the 8 items on the scale, while a score of zero was assigned if the answer was a no. The raw score (0 to 8) was used for the analyses. A household was categorized as food secure if the total score was zero and as food insecure if the score ranged from 1 to 8 [29].

Chi-square and Fisher's exact tests were conducted to assess differences in proportions of pregnant women who had consumed IRF between categories of caregivers and household characteristics. Socio-demographic characteristics were considered in path analysis if significant differences ($p < 0.05$) were found between categories.

3. RESULTS

3.1. Population's Characteristics

In total, 454 children between 6 and 23 months old were identified among the 100 census units. Of that number, 15 were removed because they were later discovered to be out of the age-targeted range, and 21 had incomplete datasets, bringing down the final sample size to 418. Socio-demographic characteristics of young children and their caregivers are presented in Table **1**.

3.2. IRF Intake

Within the participants, 41.9% of children aged 6-23 months old had consumed IRF the past day and night (result not shown). The proportion of young children who had consumed IRF was higher among those aged

between 12-23 months. Those who were not breastfed at the time of the survey, sick with ARI, dewormed, and had received a vitamin A capsule in the past six months also consumed more IRF. The proportion of children consuming IRF was higher for children living in households with improved access to water and health facilities. Differences in proportions of children who had consumed IRF the past day and night were also observed between the caregiver's current physiological status and her ethnic group, as well as between household socioeconomic quintiles (Table **1**).

3.3. Validity and Reliability of the Questionnaire to Assess Determinants of the Daily Consumption of IRF

Results of the process for developing the questionnaire and assessing its validity and reliability are also briefly described in Appendix **A**. In total, five (5) focus group discussions (FGDs) were held with 54 caregivers of children 6-23 months old. Following this process, a total of 11 items were added to the questionnaire, including direct measurements of each psychosocial construct of the eTPB that had initially been absent. As such, five (5) items on the environment as well as four (4), one (1) and one (1) on the attitude, the subjective norm, and the PBC constructs, respectively, were added. Also, two items were removed from the subjective norm section of the initial questionnaire as caregivers did not mention these beliefs during FGDs, even when these items were prompted. In total, the revised questionnaire included 47 items (Supplementary Material 1): 16 to measure the attitude construct, 15, the subjective norm, 10, the PBC, 5, the environment, and one item to measure the intention. For subsequent PCA, EFA, and CFA, only items related to the indirect measurements of each construct were used (a total of 43 items).

The description of the two sub-groups 1 (n = 200) and 2 (n = 218) of our total sample used for validation purposes is presented in Appendix **B**. With the exception of the percentage of caregivers who were reading/or not newspapers once a week, no differences in proportions between the two samples were observed with regards to the child's mean age as well as to caregiver religion, ethnic group, level of education, literacy and exposure to mass media such as TV and radio.

From the total of 43 initial items, the five (5) followings were removed after PCA: 2.11, 3.5, 4.6, 6.2, and 8.2. Results from the EFA are shown in Supplementary Material 3. Overall, ten (10) factors explained 70.9% of the variance of the model and all had eigenvalues above 1. One item (8.5) of the environment construct was not loading on any factor and was removed in subsequent CFA.

For CFA, the first model tested a 9-factor structure inspired by the EFA. Model 0 was run, and with the exception of the SRMR and the chi-square test p values, fit indices respected the selected criteria for the RMSEA, CFI, and TLI indices. In the subsequently tested models, three correlations between items were either added or removed because they were insignificant. No item was added or removed from a factor, thus remaining in the EFA structure. In the final model, all criteria were met besides that of the chi-square test: a) RMSEA value = 0.05 (confidence interval: 0.05-0.06), b) CFI and TLI = 0.95, c) SRMR = 0.07 and, d) chi-square = 967.8 ($p < 0.001$, degree of freedom = 589). Hancock and Muller's reliability coefficients for the final model were all above 0.80 for each construct and their related factors with the exception of factor 9: a) attitude: 0.92, 0.80, and 0.92 for factors 1, 2, and 3 respectively, b) subjective norm: 0.96, 0.88 and 0.93 for factors 4, 5 and 6 respectively, c) PBC: 0.89 and 0.93 for factors 7 and 8 respectively, and, d) 0.77 for the environment construct (or factor 9).

3.4. Description of Responses to Items of the Questionnaire

About 95% of caregivers intended to give IRF to their children at least once a day (Appendix **C**). More than 90% of child caregivers agree that providing IRF to their child each day will allow them to be in good health and to grow well, as well as give them more blood and a lot of vitamins. About 25% perceived that their consumption may lead to language difficulty for the young child. Moreover, around 10% believed that their child will vomit if they eat IRF daily, will get intestinal worms, and that bones present in some IRF will block their throat. About ¾ of caregivers reported no disadvantages in providing IRF to their child at least once daily.

More than 80% of child caregivers believed that their spouse, the midwife, and health agents would approve/strongly approve if they provided IRF to their child at least once daily (Appendix **C**). In addition, between 50 and 75% of them perceived that their mother-in-law, mother, and grandmother would approve if they adopted the behavior toward their child. About 70% to 80% of women were also motivated to

Table 1: Socio-Demographic Characteristics of Children Aged 6-23 Months Old and of their Caregivers (n = 418)

Characteristics	%	Children who had consumed IRF (%)	p-value
Child			
Age (months)			.000
6-11	46.5	20.6	
12-23	53.6	60.3	
Actually breastfed (*vs.* not)*	85.9 (14.1)	37.0 (71.2)	.000
Was sick with fever < 2 weeks (*vs.* not)*	65.8 (34.2)	39.3 (46.9)	.144
Was sick with diarrhea < 2 weeks (*vs.* not)*	55.3 (44.7)	39.8 (44.4)	.370
Was sick with ARI (*vs.* not)*	44.7 (55.3)	35.8 (46.6)	.028
Was dewormed in < 6 months			.000
Yes	36.8	56.5	
No	59.1	33.2	
Do not know	4.1	35.2	
Has received vitamin A capsule < 6 months			.021
Yes	79.2	44.7	
No	19.6	32.9	
Do not know	1.2	0.0	
Has received iron supplement < 6 months			.968
Yes	33.7	41.1	
No	62.0	42.1	
Do not know	4.3	44.4	
Has received multivitamins/minerals in powders			.819
Yes	45.4	43.2	
No	51.4	40.5	
Do not know	3.1	46.2	
Has received postnatal care			.289
Yes	89.2	42.6	
No	7.4	29.0	
Do not know	3.3	50.0	
Mother practice of early initiation of breastfeeding (*vs.* not)*	44.0 (56.0)	41.8 (41.9)	.999
Birth weight in kg			.601
< 2.5	13.6	47.4	
≥ 2.5	63.6	41.7	
Not weighed/do not know	22.7	38.9	
Had received postnatal care before leaving the health facility			.289
Yes	89.2	42.5	
No	7.4	29.0	
Do not know	3.3	50.0	
Caregiver			
Religion			.999
Muslim	95.7	41.8	
Christian	4.3	44.4	
Animist	0.0	0.0	
No religion/Other	0.0	0.0	
Ethnic group			.001
Wolof	33.0	47.1	
Peul	30.6	34.3	
Serere	18.9	44.3	
Mandingue	6.7	39.3	
Diola	4.3	50.0	
Soninke	2.2	44.4	
Others/non Senegalese	4.3	38.9	

(Table 1). Continued.

Characteristics	%	Children who had consumed IRF (%)	p-value
Caregiver			
Age (years)			.319
< 20	5.3	22.7	
20-29	49.0	42.0	
30-39	36.4	43.4	
40-49	5.7	50.0	
≥ 50	0.2	100.0	
Marital status			.689
Currently married/with a partner	93.5	42.2	
Not married	6.5	37.0	
Level of education			.372
No formal education	49.8	38.0	
Some primary	23.0	42.7	
Primary completed	12.0	44.0	
Some secondary	9.3	51.3	
Secondary completed	4.3	44.4	
More than secondary	1.7	71.4	
Literacy			.082
Able to read a full/part sentence aloud	44.7	46.5	
Not able	55.3	38.1	
Health status perception			.561
Very good	22.7	43.2	
Good	38.3	43.1	
Average	30.9	39.5	
Bad	7.7	37.5	
Very bad	0.5	100.0	
Physiological status currently			.001
Non-pregnant/non-breastfeeding	19.1	56.3	
Pregnant	2.9	66.7	
Breastfeeding	77.5	37.0	
Had antenatal care during child pregnancy (*vs*. not)*	97.6 (2.4)	41.7 (50.0)	.748
Had received advice on nutrition during child pregnancy (*vs*. not)*	58.3 (41.7)	45.0 (37.3)	.151
Had received advice on breastfeeding during child pregnancy (*vs*. not)*	52.0 (48.0)	42.0 (47.5)	.961
Has received postnatal care before leaving health facility (*vs*. not)*	88.3 (11.7)	43.6 (28.6)	.046
Exposure to mass media			
Reads newspapers (*vs*. not reads)*	12.7 (87.3)	47.2 (41.1)	.457
Watches TV (*vs*. not watches)*	75.8 (24.2)	44.8 (32.7)	.037
Listens to radio (*vs*. not listens)*	35.9 (64.1)	41.3 (42.2)	.918
Mother/caregiver earned income < 7 days (*vs* not)*	31.8 (68.2)	48.9 (38.6)	.055
Household			
Socioeconomic quintiles**			.036
Lowest	18.2	40.8	
Second	21.1	51.1	
Middle	20.8	47.1	
Fourth	19.9	41.0	
Highest	20.1	28.6	

(Table 1). Continued.

Characteristics	%	Children who had consumed IRF (%)	p-value
Household			
HH size**			.911
3-4	9.3	50.0	
5-6	16.9	42.0	
7-8	15.2	45.2	
9-10	13.2	37.0	
11-12	11.0	40.0	
13-14	9.5	38.5	
≥ 15	24.5	43.1	
Age of head of HH**			.852
20-29	3.4	50.0	
30-39	19.3	45.6	
40-49	24.9	37.3	
50-59	20.3	42.2	
60-69	15.6	45.3	
≥ 70	16.4	41.8	
Male as the sex of head of HH (*vs*. female)*	83.4 (16.6)	41.1 (48.5	.249
Food security status			.749
Food secure	31.3	40.5	
Food insecure	68.7	42.5	
Access to improved water (*vs* no access)*	87.1 (12.9)	44.2 (25.9)	.012
Access to improved sanitation (*vs* no access)*	84.0 (16.0)	42.7 (37.3)	.422
Region			.393
Dakar	23.4	48.0	
Ziguinchor	4.8	55.0	
Diourbel	12.7	47.2	
Saint-Louis	9.3	43.6	
Tambacounda	4.5	31.6	
Kaolack	6.2	50.0	
Thiès	11.5	25.0	
Louga	6.0	40.0	
Fatick	7.9	42.4	
Kolda	4.1	23.5	
Matam	1.4	50.0	
Kaffrine	3.6	33.3	
Kédougou	1.2	40.0	
Sédhiou	3.3	42.9	
Residence**			.086
Rural	54.5	38.1	
Urban	45.5	47.3	
Access to a health facility ≤ 30 minutes of distance (*vs* no access)*	72.5 (27.5)	45.2 (33.0)	.027

*For these characteristics, comparisons using the Chi-square or Fisher test were performed between proportions listed outside and within the bracket.
** n = 409.

comply with the opinion of their spouse, the health agent, and the midwife, while around 55% agreed to comply with the point of view of the other family members. Overall, 85% believed nobody would disagree if they adopted the behavior.

Close to 95% of caregivers reported that they could provide IRF to their children at least once daily (Appendix **C**). However, regarding control beliefs, about 85% perceived that the lack of financial resources and the high price of IRF hinder them from giving these foods to their children. For about 75% of caregivers, the absence of IRF at the market and in their household was also perceived as a barrier to providing IRF to their child. Regarding the environment (Appendix **C**), the expensiveness of IRF available in their village was reported as a barrier to their provision to young children by about 85% of caregivers. However, around 70% agreed that IRFs are generally available in their village, while for about half of them,

the cost of transportation to get an IRF in another location was a constraint.

3.5. Final Path Models

In the first hypothesized pathway (Supplementary material 2a), using direct measurements of each construct, as per the theoretical framework, in model 1, we stipulated that the intention predicts the behavior, but in turn, the intention was predicted by the three constructs (attitude, subjective norm, perceived behavioral control) which were under the influence of the environment. Correlations were also presumed between each pair of constructs. Although the results of the path analysis provided acceptable fit indices, none of the constructs was associated with the behavior of interest. Demographic variables for which significant differences ($p < 0.01$) in proportions of children who had consumed IRF the day and night before the survey were then added to the second postulated model. The initial model did not provide acceptable indices (Table **2**). Subsequently, nonsignificant relationships were removed, and two correlations (behavior and child age & behavior and environment) were added as they were significant. Following these modifications, results showed significant associations between the behavior and the environment ($\beta = 0.24$, $p < 0.001$) as well as with the

Table 2: Fit Indices for the Initial and Final Models among Caregivers of Children Aged 6-23 Months Old (n = 418): Direct and Indirect Measurements of Constructs

Indices*	Direct measurements		Indirect measurements	
	Initial model	Final model	Initial model	Final model
χ^2	85.1	14.1	397.13	54.46
df	12	17	37	29
p	< .001	< .658	< .001	< .001
RMSEA	0.12	0.00	0.16	0.05
90% C.I.	0.10-0.15	0.00-0.04	0.14-0.17	0.03-0.06
p	< .001	.993	< .001	.619
CFI	0.88	1.00	0.60	0.97
TLI	0.64	1.00	0.01	0.95
SRMR	0.10	0.06	0.10	0.04

*χ^2: chi-squared test value; df: degree of freedom, RMSEA: root mean square error of approximation; CI: confidence interval; CFI: comparative fit index; TLI: Tucker-Lewis index; SRMR: standardized root mean square residual.

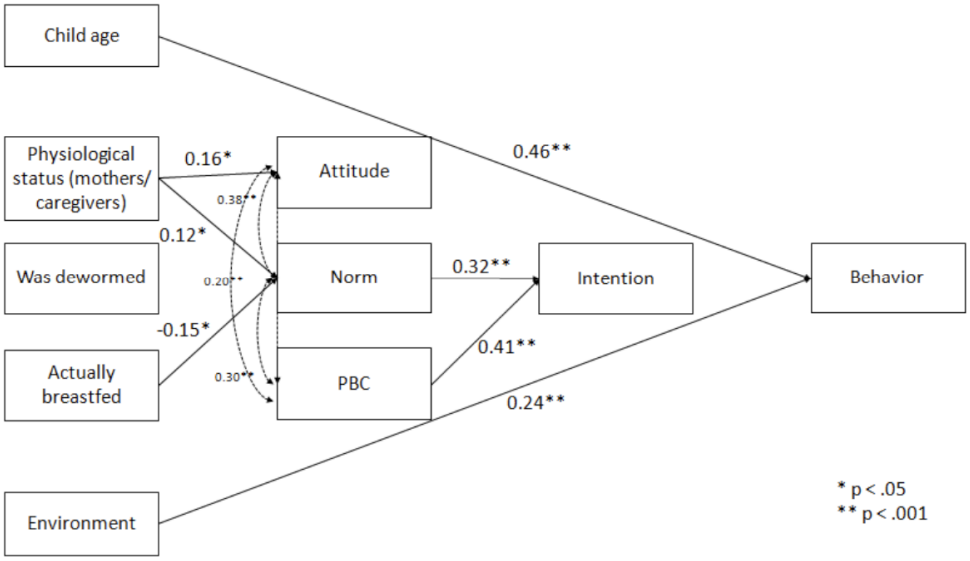

Figure 2: Final model of the hypothesized pathways between psychosocial (attitude, subjective norm, perceived behavioral control/PBC), environment, the intention and the behavior with standardized estimates for the structural equation model among caregivers of children 6-23 months old (n = 418): Direct measurements of constructs (solid lines represent postulated predictions between constructs while dotted lines represent potential correlations).

child's age (β = 0.46, p < 0.001) (Figure **2**). Yet, there was no relationship between the behavior and the intention. In turn, the intention was predicted by the subjective norm (β = 0.32, p < 0.001) and the PBC (β = 0.41, p < 0.001). The physiological status of the caregiver was positively associated with the attitude (β = 0.16, p < 0.05) and the subjective norm (β = 0.12, p < 0.05) while having a child breastfed was negatively associated with the norm (β = -0.15, p < 0.05). Criteria for all indices indicating a good fit of the model were respected (Table **2**).

With regard to the second hypothesized pathway (Supplementary material 2b), even though all criteria for model fit were met besides the chi-square p-value (results not shown), after testing this model, the correlation between the intention and the environment was not significant, rendering this correlation model invalid.

Results of the same process mentioned above, using indirect measurements (Supplementary material 2c and 2d) for each construct, are also presented in Table **2**. In the initial hypothesized model, criteria for all indices were met, but there were no relationships between the intention or the PBC and the behavior. Adding socio-demographic variables did not improve the model fit criteria (Table **2**, Final model). The second hypothesized pathway (Supplementary material 2d) was tested, and most criteria of indices used to assess the model fit were not met (results not shown). Moreover, results show no association between the environment and the intention, making this model invalid.

4. DISCUSSION

Given the scarcity of research investigating caregivers' decisions related to the provision of IRF to their children and the persistence of high levels of anemia among this group in low-and middle-income countries, the objective of this study was to identify pathways by which psychosocial and environmental-related factors may influence the consumption of IRF among Senegalese children aged 6-23 months old. Beforehand, an existing and validated questionnaire used for the same purpose was reviewed and re-validated [17]. The validation process of the revised questionnaire suggests a reliable tool composed of 41 items, which respects every criterion for all indicators of goodness of fit. Our findings show that 42% of children consumed IRF the day or night preceding the survey, while 95% of caregivers had the intention to provide them with IRF daily. There was no association between the intention and the actual behavior. Daily IRF consumption was rather predicted by the child's age and environmental factors. In turn, the subjective norm and the perceived behavioral control were predictors of the intention.

It is worth mentioning that our revised questionnaire is shorter than its original version, which had 53 items and had been initially developed solely through PCA and EFA, as well as using a small sample of children of the Matam region [17]. In addition, our questionnaire contains specific items to assess the environment construct, which were absent in the Akpaki *et al*. tool [17]. In our case, it is interesting to note that the CFA structure with acceptable fit indices was identical to the one that emerged naturally from the EFA with a different sample, adding further credibility to the questionnaire's structure.

As reported among children aged 6-23 months living in the Matam area [17], caregiver's intention to provide IRF daily to their young children was high. As also observed by Akpaki *et al*. [17] and Kalam *et al*. [37], a majority of caregivers were aware of several benefits associated with the provision of IRF to their children (*e.g.*, keeping them healthy and contributing to their development and growth). However, about a quarter of them perceived negative impacts (*e.g.*, eggs will lead to speech difficulty and provide intestinal worms to children), though they appear to be less frequent in our population than in the Matam group of children [17].

Although in a different setting, Spinks and Hamilton [16] found the spouse/partner has a major role in influencing mothers' nutritional decisions for their 2-3-year-old child in Australia. In Kenya, Lagerkvist *et al*. [38] also reported that caregivers were motivated to comply with the opinions of their spouses and mothers-in-law/child grandmothers regarding integrating biofortified sweet potato in a young child's diet. The key role of grandmothers in young child nutrition has been documented [39]. With regards to fathers/partners, although they are mostly seen as providers to the households and may not be directly involved in young child nutrition, in our setting, they were perceived as people who will approve the provision of IRF to their young child and with for whom opinions, mothers will comply with.

Perceptions about the lack of financial resources, the high price of IRF, and the limited availability at

home, which emerged as significant obstacles to providing IRF to young children, have been reported in other settings [20,37]. So far, these perceptions are the reality. In six African countries, Ryckman *et al*. [18] assessed the affordability of nutritious foods for young children. They concluded that besides a few foods (dried fish, liver, eggs), sources of iron were unaffordable. They also highlighted that food price was a key driver of food choices. In the Dakar area (Senegal), Marras *et al*. [40] have shown that meat and fish were more expensive than chicken eggs. Therefore, it is plausible that the cost of IRF is an environmental-related barrier that hinders their daily consumption by young children. Availability at the village level is also perceived as another potential constraint.

Results from path analyses, either while using direct or indirect measurements, showed no relationship between the intention or the PBC and the behavior. In other words, even though the caregiver intended to provide IRF to their child, it was not translated into concrete behavior. This finding is rather unexpected given that, as stipulated by the TPB, either the intention alone or combined (or not) with PBC predicts a behavior [25]. Yet, the absence of relationships between the intention and the behavior, as well as between PBC and the behavior, has been reported by Akpaki *et al*. [17] among caregivers of young children. As pointed out by Akpaki *et al*. [17], the absence of a relationship between the intention and the behavior might be attributed to a social desirability bias in the caregiver's response who may have wanted to please the enumerator even though she was told that there was no good or bad response before the administration of the questionnaire. Another reason for this unanticipated finding could be a measurement issue about the intention. As such, the formulation of the item may not have been well understood by the mother: In fact, she may have thought that she was asked about her intention of giving IRF to her child at any point of time between the age of 6 and 23 months and not necessarily at the time of the survey when her child was 6 months old for instance. Moreover, previous studies have shown that past behavior and habit strength are two predictors of healthy feeding behavior [15]. In the context of our study, these two variables should have been considered even though the original TPB has been used to assess factors that may influence maternal decisions about healthy eating behaviors of their young children [12,14,16].

As demonstrated by our final path analysis as well as by Akpaki *et al*. [17], results showed that the child's age came out as a predictor of the consumption of daily consumption of IRF among children 6-23 months in addition to environment-related factors. Child age seems to influence the mother's decision to provide IRF to their young children. In our case, only 20% of children 6-8 months had received IRF the day or night preceding the survey, while that percentage was 60% for those aged 12-23 months. Results from a multi-level analysis of DHS conducted in sub-Saharan Africa showed a higher consumption of IRF among children 12-23 months old compared to those aged 6-11 months [41]. Similarly, the FAO [19] reported an increase in heme iron-rich foods with age among Malawian children 6-23 months old. As a new finding, children were more likely to consume IRF if the environment was favorable in particular, if affordable IRF were available in the village, and if the transportation cost to get them to another location was expensive. High food prices and limited availability have also been highlighted in African countries as challenges to optimal young child nutrition, including providing iron-rich foods [18,20].

In addition to the above, path analyses showed that PBC predicted the intention to provide IRF. Hence, caregivers perceived that if they could overcome barriers such as having financial resources and improving the availability of IRF at household and village levels, their intention to provide them to their children would increase. Similarly, a positive subjective norm was also associated with a higher intention to provide IRF. In turn, the subjective norm was predicted by the physiological status of the mother and the breastfeeding status of the child.

Our findings highlight the importance of environmental factors, particularly access, concerning the caregivers` performance in providing IRF daily. Although nutrition education of caregivers certainly remains a valuable intervention to improve and maintain current knowledge regarding the benefits and positive consequences of providing IRF to their young children, it might be more appropriate to focus on children of younger age to increase its effectiveness. Thus, it could help to alleviate and prevent iron deficiency in early childhood. Fathers could also be more involved in supporting child nutrition as it may help increase the frequency of consumption of animal-sourced foods among children 6-23 months old [42].

Our study has important strengths that deserve to be highlighted. It proposes a valid, reliable, and simple tool that could be used to assess psychosocial and

environmental potential determinants of IRF consumption among Senegalese children aged 6-23 months old. Also, this research is innovative given that for the first time, in a low-and middle-income country, a nationwide study has been conducted to assess factors that may influence IRF consumption in young children. However, some weaknesses need to be acknowledged. Given its cross-sectional design, the results may not reflect the situation of an entire year. The measurement of the intention could also be refined by integrating the specific age of each child. To do so, this data could be pre-recorded on the cover page of the questionnaire before its administration so the enumerator could access it easily and refer to it when asking every question. Lastly, although the measurement of IRF consumption did not capture the amount of IRF consumed by children, our assessment is in line with what is usually performed in Senegal and several other African countries regarding the evaluation of IRF consumption among children 6-23 months of age. Despite these limitations, our study sheds further light on predictors of IRF consumption among young children.

5. CONCLUSIONS

Findings from the assessment of psychosocial and environmental determinants of the consumption of IRF among Senegalese children aged 6-23 months old using a valid, reliable, and simple tool reveal that a favorable environment and being older were associated with higher daily consumption of IRF among them. Yet, research is warranted in other contexts, and the intention measurements deserve to be reviewed with more socioclinical data.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the Comité national de la recherché en santé du Sénégal (#000034/MSAS/CNERS/SP). Verbal informed consent was obtained from all participants before the data collection. Participation was voluntary, and participants could withdraw from the study at any time without negative consequences or prejudice and without justifying their decision.

CONFLICT OF INTEREST

None.

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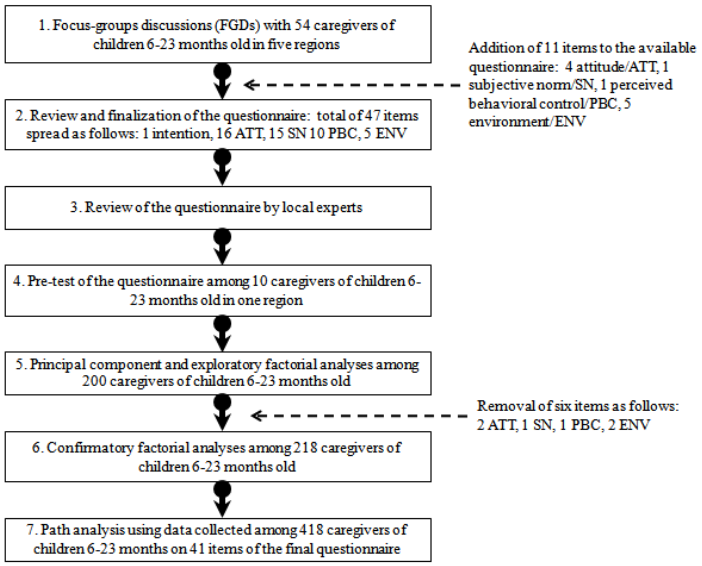
SUPPLEMENTARY MATERIALS

The supplementary materials can be downloaded from the journal website along with the article.

APPENDIX A



Flow diagram showing the different steps for the development and validation of the questionnaire.

APPENDIX B

Sociodemographic Characteristics of Samples of Young Children Aged 6-23 Months and of Their Mothers/Caregivers Were Used for the Questionnaire Validation Process

Characteristics	Sub-sample #1 (n = 200)		Sub-sample #1 (n = 218)		p-value
	%	Mean ± SD*	%	Mean ± SD	
Child mean age (months)		13.0 ± 5.4		13.1 ± 5.0	.955
% of children whose caregiver is the mother	99.0		98.6		.999
Religion of the caregiver					.852
Muslim	95.5		95.9		
Christian	4.5		4.0		
Animist/No religion/other	0.0		0.0		
Ethnic group of caregivers					.464
Wolof	29.5		36.2		
Peul	34.5		27.1		
Serere	18.5		19.3		
Mandingue	6.0		7.3		
Soninke	1.5		2.8		
Diola	5.5		3.2		
Others/non Senegalese	4.5		4.1		
Level of education of the caregiver					.980
No formal education	48.0		51.4		
Some primary	23.5		22.5		
Primary completed	13.0		11.0		
Some secondary	9.5		9.2		
Secondary completed	4.5		4.1		
More than secondary	1.5		1.8		
Literacy of the caregiver					.487
Able to read a full/part sentence aloud	46.5		43.1		
Not able	53.5		56.9		
Caregiver`s exposure to media. once /less than once a week					
Reads newspapers	12.5		12.8		
Watches TV	81.5		70.6		.916
Listens to radio	38.0		33.9		.010
					.388

*SD = standard deviation.

APPENDIX C

Frequency Distributions (%) of Responses for Each Construct and Item of the Questionnaire for Mothers/Caregivers of Children 6-23 Months Old (n = 418)

Constructs and description of items	Scores and answers` options				
	-2	-1	0	1	2
	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Intention	1.4	2.9	1.2	42.8	51.7
Attitude					
Behavioral beliefs					
If I give IRF to my child aged 6-23 months at least once a day...					

2.1 My child will be in good health	0.7	1.4	2.4	39.5	56.0
2.2 My child will grow well	0.7	2.2	1.9	43.5	51.7
2.3 My child will have a lot of blood	0.5	2.4	5.0	43.5	48.6
2.4 My child will be intelligent	1.0	2.6	5.7	41.9	39.0
2.5 My child will have a lot of vitamins in his body	1.0	2.6	5.7	51.7	39.0
2.6 My child will vomit	30.1	41.4	19.1	7.2	2.2
2.7 Bones will block his throat	32.1	44.5	11.5	8.1	3.8
2.8 My child will get intestinal worms	29.2	42.3	17.0	8.1	3.3
2.9 My child will have difficulty to speak	30.6	34.9	11.0	15.1	8.4
2.10 There is no disadvantage in giving IRF to my child aged 6-23 months old at least once a day*	6.2	10.3	9.1	46.7	27.8
Evaluation of consequences	Not very important	Not important	Neither /not important/ important	Important	Very important
3.1 For me, having my child healthy is.	4.3	0.0	0.0	8.4	87.3
3.2 For me, having my child growing well is	2.9	0.2	0.0	12.0	84.9
3.3 For me, having my child with a lot of blood in his body is…	2.2	0.7	2.2	19.1	75.8
3.4 For me. having an intelligent child is	1.4	1.2	1.7	13.9	81.8
Subjective norm					
Normative beliefs	Strongly disapprove	Disapprove	+/- Approve	Approve	Strongly approve
Do you think that the following persons will agree or disagree if you give IRF to your child aged 6-23 months at least once a day?					
4.1 The health agent will...	0.5	1.0	10.8	17.2	70.6
4.2 Your spouse will...	0.7	1.4	17.0	17.0	63.9
4.3 Your mother-in-law will...	1.4	0.7	34.2	17.9	45.7
4.4 Your mother will...	1.0	1.2	23.9	21.3	52.6
4.5 The midwife will...	0.5	0.2	11.2	15.1	73.0
4.7 Grandmother will...	0.5	0.7	47.6	15.6	35.6
Motivation to comply	Very unlikely	Unlikely	+ / -	Likely	Very likely
5.1 The health agent	5.5	7.4	9.3	36.6	41.1
5.2 The spouse	4.5	6.9	16.7	31.8	40.0
5.3 The mother-in-law	3.1	10.8	33.5	28.7	23.9
5.4 The mother	3.3	8.6	25.1	34.7	28.2
5.5 The “Badiene Gokh”	4.5	7.2	30.9	28.5	28.9
5.6 The midwife	4.3	6.0	9.1	34.0	46.7
5.7 My grandmother	4.1	8.4	47.6	22.5	17.5
	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
5.8 If I give IRF to my child aged 6-23 months at least once a day, nobody will disagree*	3.3	4.8	7.7	44.7	39.5
Perceived Behavioral Control	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Control beliefs					
6.1 If I have IRF, I am able to give them to my child 6-23 months old at least once a day*	1.4	3.3	1.4	38.5	55.3
6.3 The lack of financial resources could hinder me from giving IRF to my child 6-23 months old at least once a day	3.1	6.7	3.6	41.9	44.7

6.4 The absence of IRF at the market could hinder me from giving them to my child 6-23 months old at least once a day	6.5	16.5	3.8	41.9	31.3
6.5 The absence of IRF in my household could hinder me from giving them to my child 6-23 months old, at least once a day	4.3	13.6	4.8	42.6	34.7
6.6 The high price of IRF could hinder me from giving them to my child 6-23 months old at least once a day	2.6	9.6	1.7	42.3	43.8
Perceived power of the control	Very low	Low	+ / -	High	Very high
7.1 The lack of financial means is an obstacle that hinders me from giving IRF to my child 6-23 months old, at least once a day	4.3	11.0	5.3	32.5	46.9
7.2 The absence of IRF in the market is an obstacle that…	6.9	18.9	7.7	32.8	33.7
7.3 The high cost of IRF is an obstacle that…	3.3	6.9	5.3	37.1	47.4
7.4 The absence of IRF in my household is an obstacle that …	4.3	13.9	6.2	38.8	36.8
Environment	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
8.1 IRF are generally available in my village	12.7	16.5	4.3	40.2	26.3
8.3 IRF available in my village are expensive	1.2	8.1	6.2	47.1	37.3
8.4 Transportation to get IRF in another location is expensive	9.3	28.0	9.6	33.0	20.1

*This item is either a direct measurement of the construct of attitude (item 2.10) or subjective norm (5.8) or perceived behavioral control (6.1).

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