

Complementary feeding practices: determinants of dietary diversity and meal frequency among children aged 6–23 months in Southern Benin

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Abstract Poor complementary feeding practices have detrimental effects on child growth, development and survival. This cross-sectional study in rural areas of southern Benin examined some determinants of complementary feeding practices using socioeconomic and dietary data collected among 1225 primary caregivers. Determinants of complementary feeding practices in the study areas are multidimensional and include many interacting factors such as socio-economic aspects, farming practices, household demographics, cultural practices and geography. Child age, diversity of food groups produced, income allocated to feeding, commune of residence, ethnicity, caregivers' occupation, marital status and household size were identified as the main factors affecting complementary feeding practices. Food group diversification in farm-systems and overall social behavior and support as well as women's empowerment are necessary to improve children's diets. Reducing women's workload through improved working conditions appears crucial to decrease time burdens and allow more time for child care. Multisectoral interventions should be embraced to improve complementary feeding practices in Benin.

Keywords Complementary feeding practices · Dietary diversity · Meal frequency · Diversity of food group produced · Gender · Benin

1 Introduction

Complementary feeding refers to children aged 6–23 months, a challenging period until the child is able to eat like the rest of the family. It is the process of introducing complementary foods, which are any non-breastmilk foods or nutritive liquids that are given to young children from 6 months to above (WHO, 2008). It is a transition from exclusive breastfeeding to family foods and a very vulnerable period in which malnutrition starts in many infants, contributing significantly to the high prevalence of malnutrition in children under five years of age world-wide. Achieving appropriate complementary feeding of young children is a crucial milestone in efforts to enhance survival and promote healthier growth and development of children (Menon, 2012). Inappropriate complementary feeding practices during the first two years of childhood drastically increase morbidity, mortality and risks of chronic diseases. Poor complementary feeding practices have detrimental effects on overall growth and development of children (Black et al., 2013; Khanal, Sauer, & Zhao, 2013). Worldwide, about one-third of the mortality of children under five years is caused by malnutrition related to inadequate complementary feeding (WHO, 2003).

Complementary feeding practices are still poor in most developing countries and are even worsening in some of them (Lutter et al., 2011). For instance, national assessments available in West African countries reported that the prevalence of a minimum acceptable diet ranged from 11.0% in Nigeria (2003) to 29.9% in Ghana (2007) (Issaka, Agho, Burns, Andrew, & Dibley, 2014; Ogbo, Page, Idoko, Fernanda, & Agho, 2015).

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In Benin, 15% of children met the minimum acceptable diet (WHO, 2010). This persistent prevalence of inadequate complementary feeding requires more intensive and efficient efforts from different organizations to improve the situation (Lutter et al., 2011), requiring a better understanding of the drivers of inappropriate complementary feeding as well as better identification of vulnerable groups (Lutter et al., 2011; Issaka et al., 2015c). Until now, very few studies have investigated these drivers in order to understand the complex processes underlying inappropriate feeding practices at individual, household and community levels (Menon, 2012; Chapagain, 2013; Issaka et al., 2015b; Ogbo et al., 2015). Moreover, major explanatory factors highlighted by these studies include mainly socioeconomic factors such as cultural beliefs and habits, household poverty, maternal literacy and ignorance of appropriate practices (Menon, 2012; Chapagain, 2013; Issaka et al., 2014; Ogbo et al., 2015). Maternal education level, for example, could influence complementary feeding practices with potentially beneficial effects on child nutritional status. Indeed, Agueh, Makoutode, Diallo, Soton, and Ouendo (1999) found that mothers' instruction level had a tendency to be positively and significantly associated with child wasting (weight for height) z-scores.

Recent studies in Benin showed the important role of crop diversity in dietary habits of rural people and the complex relationships between socioeconomic characteristics of households and their access and use of these resources (Segnon & Achigan-Dako, 2014; Bellon, Ntandou-Bouzitou, & Caracciolo, 2016). However, the influence of such socioeconomic factors on complementary feeding practices have rarely been investigated in Benin.

Therefore, the present study aims to assess the adequacy of complementary feeding practices of infants aged 6–23 months in rural areas in Southern Benin and identify key factors that influence them and key socio-economic characteristics of vulnerable groups where practices are inadequate. We hypothesize that the adequacy of complementary feeding practices is determined by the combined effects of socioeconomic and cultural factors, household and caregiver characteristics, in association with factors related to agricultural and food diversity, availability and accessibility.

2 Methods

2.1 Study design

A cross-sectional survey was performed in two communes of Mono Department, Southern Benin. Data were collected over a three month period, from October to December 2013, a transition period between the short rainy season and the long dry season. This period corresponded to moderate food availability. Harvesting is the main agricultural activity undertaken.

2.2 Research setting

The study was carried out in two rural communes *Bopa* (latitude: 6.702; longitude: 1.949) and *Houeyogbe* (latitude: 6.532; longitude: 1.870), in Mono Department, Southern Benin. Mono department was chosen because of the high level of malnutrition, which contrasts with the high agricultural biodiversity in this area. *Bopa* and *Houeyogbe* were selected due to their high food insecurity index (40.5% and 34.1%, respectively). The study sites are located in slightly contrasting environmental conditions and socioeconomic contexts. *Bopa* is landlocked and less densely populated (264 inhabitants/km²) than *Houeyogbe* (315 inhabitants /km²) (Sarll, 2010; Benin Consulting, 2011; INSAE-Benin, 2013).

The soil in *Bopa* is dominated by vertisol while land in *Houeyogbe* is dominated by ferrallitic and patches of hydromorphic soils. Vertisols are more fertile than ferrallitic soils. The natural vegetation is more degraded by anthropogenic pressure in *Houeyogbe* than *Bopa*. Thus, *Bopa* has a more diversified natural vegetation including tree species such as baobab (*Adansonia digitata*) and kapok tree (*Ceiba pentandra*). There are reforested perimeters consisting mainly of teak (*Tectona grandis*), acacia (*Acacia auriculiformis*), iroko (*Milicia excelsa*), samba (*Triplochytton scleroxylon*), *Elaeis* sp. and fruit trees. The herbaceous vegetation consists of grasses, marshy grasslands and a mangrove along the “*Aheme*” lake.

Bopa is also more farming-oriented (82% of households) compared to *Houeyogbe* (47% of households). The main crops produced in the study area include: maize (*Zea mays*), cassava (*Manihot esculenta*), sweetpotato (*Ipomoea batatas*) - cereals, roots and tubers group-, cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogaea*), palm oil (*Elaeis guineensis*)- legume and nuts group-, Jew's mallow (*Corchorus olitorius*), amaranth (*Amaranthus cruentus*), tomato (*Solanum lycopersicon*), okra (*Abelmoschus esculentus*), pawpaw (*Carica papaya*), banana (*Musa spp.*) -fruits and vegetables. The main animal species reared are chicken (*Gallus gallus domesticus*), duck (*Cairina moschata*), goat (*Capra aegagrus*) and fish (*Tilapia guineensis*) -flesh foods group. Gardening is more widely practiced in *Bopa* than *Houeyogbe*. In *Bopa* with the proximity of the “*Aheme*” lake, many households also engage in fishing activities. Women are involved in all agricultural activities, especially in crop production, livestock keeping and home gardens. Harvesting and post-harvest activities - drying, storage, preservation, processing and marketing of agricultural products are time consuming and are predominately implemented by women. Regarding living standards, the poverty threshold is lower in *Bopa* [291 XOF (= 0.50 USD) per capita (XOF: means the code of FCFA which is the currency used in the UEMOA area including Benin.)], with a poverty rate of 33%) compared to *Houeyogbe* (328 XOF (= 0.56 USD) per capita with a poverty rate of 43%) (Schreiner, 2012).

2.3 Respondents and sampling

The study focused on children aged 6 to 23 months and their mothers or primary caregivers.

The sample size was calculated using a classic formula for sample size calculation:

$$N = [Z^2 * p(1-p) / m^2] * DE * 1/(1-\lambda) \text{ (Magnani, 1997),}$$

where N refers to the required sample size in each commune: *Bopa* and *Houeyogbe*; Z is the z-value corresponding to the level of confidence of 95%, thus equals 1.96; p is the estimated prevalence of childhood stunting in *Mono* province in 2006 at 44.7% (INSAE-Benin, 2006); m is the margin of error at 5% (standard value of 0.05); DE is the design effect fixed at 2.8 (1.4×2) - due to cluster sampling with *Bopa* and *Houeyogbe* representing two different clusters; λ is the refusal rate (household non-response) fixed at 10%.

An initial sample size of 1182 children was obtained and further extended to 1190.

A multistage sampling method was used in selecting participant villages and subjects. Briefly, the estimated sample size (1190) was allocated to the two communes proportionally to the population size of children from 0 to 2 years old, 47% for *Bopa* ($n = 560$) and 53% for *Houeyogbe* ($n = 630$). A total of 17 villages (8 and 9 in *Bopa* and *Houeyogbe*, respectively) were randomly selected from a list of villages in each commune with infant populations equal or above 80 subjects. In each selected village, all households with at least one child between 6 and 23 months old were systematically selected to be enrolled in the study upon satisfaction of the following inclusion criteria: children must be 6 to 23 months old, complementarily fed, not suffer severe illness or malnutrition; caregivers and their children must have lived in the village for the past 2 years and were not planning to leave in the next year. Twenty one children did not meet inclusion criteria. Finally, 1263 households were selected of which 1225 households completed all questionnaires. Within each household, the household head and the mother or child caregiver were interviewed. Where more than one child aged between 6 and 23 months old was found in the same household, the interviews focused on the youngest child.

2.4 Data collection and processing

Data were collected in local languages by well trained and experienced interviewers with bachelor's degrees as minimum grade. Structured questionnaires were used to collect demographic and socioeconomic household characteristics, including food security status measured by the Household Food Insecurity Access Scale, (Coates, Swindale, & Bilinsky, 2007). Agricultural production and availability of the previous

year as well as utilization of local biodiversity were also integrated into the questionnaire.

Additionally, gender aspects, households' sanitation, child feeding and care practice data were collected. Two non-consecutive 24-h recalls were used to assess child dietary intakes. Primary caregivers recalled the meals, drinks and snacks the child had consumed the previous day in a 5 step-method described in Gibson and Ferguson (2008). Intake data were entered and processed with Lucille software developed by Gent University, Belgium. The other data were entered and processed with Microsoft Access. All filled questionnaires were cross-checked by field supervisors as well as the principal investigator (first author). The data were entered twice by two different individuals who were blind to the other's entries. Subsequently, databases were screened for discrepancies and cleaned.

2.5 Explanatory variables

Five groups of potential explanatory variables were identified from the literature (Fein, Labiner-Wolfe, Scanlon, & Grummer-Strwan, 2008; Upul, Sanjeeva, Hiranya, Indika, & Michael, 2012; Khanal et al., 2013; Melkam, Molla, Zelalem, & Azeb, 2013; Brown et al., 2014; Issaka et al., 2015a, b).

The first group of potential variables is related to socioeconomic characteristics of households. It included 8 variables namely: (1) the commune of residence (*Bopa* or *Houeyogbe*), (2) the sex of the household head (male or female), (3) primary and other income sources of the household, (4) the sociolinguistic group of household head (native *Saxwe* or others), (5) the marital status of the mother (alone - single, divorced, widowed, married but living alone - or not alone - married and living with husband), (6) the household size, (7) the number of children under 5 years (categorized on an ordinal scale, normal is ≤ 2 and high is > 2) and (8) the household wealth index. The last is a composite variable of a household's cumulative living standards. It was developed using a series of nineteen assets, proxy variables used in the DHS survey and wealth index construction for rural areas in Benin (Rutstein & Kiersten, 2004; Vyas & Kumaranayake, 2006): housing characteristics (house construction materials, energy source for lighting and meal cooking); durable asset ownership (means of transportation, media and communication assets); and access to utilities and infrastructure (health center access, transportation means used to access markets or health centers, the availability and quality of household sanitary facilities and practices such as water sources, state of toilets, waste management and overall hygiene habits). Each household was assigned a score for each asset variable using principal components analysis. The scores were then summed for each household to derive the corresponding wealth index. Further, based on the quintiles of the wealth index, households were classified into five socioeconomic status categories, from the

poorest to the richest category (Filmer & Pritchett, 2001; Vyas & Kumaranayake, 2006).

The second group of variables refers to the households' food insecurity, food availability and accessibility. It includes: (1) the share of the household income allocated to food (categorized on an ordinal scale; $\leq 50\%$ is normal, 50–75% is moderately high, $> 75\%$ is high); if a high percentage is allocated to food, people are really poor (INSAE-Benin, 2014); (2) the food availability (related to the duration of food shortage experienced by the household (Bilinsky & Swindale, 2010) and coded on an ordinal scale as follow: very low- 5 to 11 months of shortage, low - 3 to 4 months of shortage, medium - 2 months of shortage and high – 0 to 1 month of shortage and (3) the household food insecurity which is an ordinal scale variable determined with the Household Food Insecurity Access Scale (HFIAS) (Coates et al., 2007; Bilinsky & Swindale, 2010). Households were categorized into four levels of household food insecurity (access): food secure, mildly, moderately and severely food insecure.

The third group of explanatory variables is related to production diversity and assets that might affect this diversity. It includes: (1) production diversity defined as the number of different food groups produced over the past year in analogy with the WHO classification for infant and young child dietary diversity (WHO, 2008; Berti, 2015); (minimum = 0 and maximum = 7 food groups); (2) the ownership of a home garden, which indicates the availability of vegetables at the household level.

The fourth group of potential explanatory variables refers to social support. It includes only one binary variable which refers to any support received by the household in terms of training, awareness, counseling, financial or material support related to child care practices. This is a categorical variable: yes if the household received any type of support or no, if none of the above cited types of support were received.

The fifth group of variables includes child, maternal and caregiver characteristics that might influence the feeding practices: (1) age of the child which may affect the choice of adequate complementary foods, (2) age of the mother as proxy of maturity which may reflect her experience, (3) education level of the mother which may affect her knowledge (coded as no schooling or any form of formal schooling), (4) mother's occupation which may reflect her availability to take care of the child (coded as no occupation and worker); and (5) the maternal sociolinguistic group ("Saxwe" or others) which may reflect beliefs and dietary habits.

2.6 Outcome variables

Among the set of infant and young child feeding (IYCF) practices indicators defined by WHO (2008), two have been explored in this work as outcome variables: (1) minimum dietary

diversity (MDD) and (2) the minimum meal frequency (MMF). Child breastfeeding status was taken into account.

- The MDD is defined as the proportion of children aged 6–23 months who consumed foods from at least four food groups out of the seven referenced food groups within a 24-h time period. The seven food groups are: (1) grains, roots and tubers, (2) legumes and nuts, (3) dairy products, (4) flesh foods (meat, fish, poultry and liver/organ meats), (5) eggs, (6) vitamin A-rich fruits and vegetables and (7) other fruits and vegetables (WHO, 2008).
- The MMF is the proportion of breastfed and non-breastfed children aged 6–23 months who received solid, semi-solid or soft foods (but also including milk feeds for non-breastfed children), the minimum number of times or more. The minimum number of times was set to two and three meals for breastfed infants aged 6–8 months and 9–23 months, respectively; and four meals for non-breastfed children aged 6–23 months (WHO, 2008).
- The Minimum acceptable diet (MAD) is defined as the proportion of children 6–23 months of age who had both minimum meal frequency and dietary diversity (in both breastfed and non-breastfed children) during the previous day (WHO, 2008; UNICEF, 2011).

The age bracket (6–23 months) was further disaggregated into the following age groups: 6–11 months, 12–17 months and 18–23 months (WHO, 2008).

WHO infant and young child feeding (IYCF) indicators focusing primarily on breastfeeding were outside the scope of this study on complementary feeding practices. Also, the paper did not focus on the minimum acceptable diet (MAD), as this is a composite indicator of MDD and MMF, which reflects both quality and quantity of diet. Indicators on 'consumption of iron-rich or iron-fortified foods' will be discussed in a subsequent paper dealing with quantitative dietary intake data and nutrient adequacy of diets.

2.7 Statistical analysis

Descriptive statistics and Wilcoxon rank test and Chi-square test were used to describe and compare the two study areas. Simple logistic regressions were computed using MDD and MMF as dependent variables to preselect candidate explanatory variables. Multiple logistic mixed regressions were further used to test significance of the effects of the preselected explanatory variables. Fixed terms included the preselected variables and all two-order interactions. Villages were included as a clustering variable. The final model was constructed using a backward elimination approach, where non-significant terms were excluded, based on the likelihood ratio test at a significance level of 0.05. Plots of predicted probabilities of

meeting MDD or MMF were then used to examine significant relationships among variables.

Statistical analyses were performed in “R” software (Team, 2015). For screening of variables with simple logistic regression, we used the function ‘glm’ of the package ‘stats’. Logistic mixed regression models were performed with the function ‘glmer’ of the package ‘lme4’ (Crawley, 2013).

3 Results

3.1 Characteristics of the sample

The socio-economic and demographic profiles of children, primary caregivers and households are presented in Table 1. Among the 1225 children enrolled in the study, over one-third was between 6 and 11 months old. The majority of primary caregivers (98%) were the mothers. They were generally young (average 28 ± 3.7 years) with more than half of them under thirty. Most of the mothers did not attend formal school and were illiterate, with the highest proportion observed in *Bopa* commune. Most mothers (97%) pursued income generating activities such as agriculture, post-harvest handling, food processing and small trade. The majority of households (94%) were male-headed. Mean household size was significantly higher in *Bopa* (5.5 ± 2.0) than *Houeyogbe* (5.1 ± 1.8). The dominant ethnic group is “*Saxwe*” (77% of interviewees). Only 10% of households reached a production diversity of 4 or more food groups, with a higher proportion observed in *Bopa*. Mean diversity of food groups produced (DFGP) score was also significantly higher in *Bopa* (2.3 ± 1.2) than *Houeyogbe* commune (1.3 ± 1.1 ; Table 1). More than 80% of households were food insecure with a significantly higher rate in *Houeyogbe* commune. On the contrary, the proportion of the poorest households was significantly higher in *Bopa* than *Houeyogbe* (40% vs 36%; $p < 0.001$).

3.2 Types of foods given to child by age

Table 2 presents the proportion of surveyed children consuming the different food groups and the derived dietary diversity scores (DDS). Cereals, roots and tubers were the most widespread food groups used to feed children. Half of the children were fed with vitamin A rich foods but only 2% of the children consumed eggs. Except for eggs and dairy products, the group of children aged between 18 and 23 months had the highest consumption rates for all food groups.

3.3 Complementary feeding indicators

Figure 1 shows the proportion of children meeting the selected WHO complementary feeding indicators in each commune. The prevalence of minimum dietary diversity (MDD) among

the children aged 6–11 months in *Bopa* and *Houeyogbe* were 49% and 39%, respectively. The corresponding rates among children aged 12–17 months were 74% vs 62% and were 71% vs 75% for 18–23 months children. The rates of MDD among children of *Houeyogbe* increased significantly with the age of children. However, the prevalence of minimum meal frequency (MMF) within age group in *Houeyogbe* were significantly different.

3.4 Factors associated with complementary feeding practices

Four main factors were found significantly associated with minimum dietary diversity, either positively or negatively: (1) child’s age, (2) production diversity, (3) combined effect of share of income allocated to feeding and commune of residence and (4) the combined effect of ethnicity and commune (Table 3). While the probability of meeting minimum dietary diversity increased with child’s age and with increased diversity of food groups produced (DFGP) (number of food groups grown) ($p < 0.05$), it decreased substantially when income allocated to food purchase increased in *Houeyogbe* commune ($p < 0.05$). However, there was no substantial effect of income allocated to food on the probability of minimum dietary diversity in *Bopa* ($p < 0.05$). The chance of meeting MDD decreased substantially for “*Saxwe*” people residing in *Houeyogbe* while it increased among minority groups ($p < 0.05$).

The probability of meeting minimum meal frequency was significantly affected by three factors namely (1) ethnicity, (2) caregiver’s occupation and (3) the combined effect of marital status and size of household (Table 4). Children from minority ethnic groups (other than the native “*Saxwe*” people) were more likely to meet MMF, while those of large household size and those whose mother/primary caregivers are involved in income-generating activities, were less likely to meet MMF ($p < 0.05$). Increase in household size had a detrimental effect on children’s probability of minimum meal frequency among single mothers ($p < 0.05$).

4 Discussion

To our knowledge, this is one of the first publications in Benin that explores determinants of complementary feeding practices using selected WHO recommendations (WHO, 2008). Factors positively or negatively associated with compliance to recommended complementary feeding practices were children’s age, caregivers’ occupation and marital status, ethnicity of household head, household size, production diversity, share of household income allocated to feeding and commune of residence. Interactions noticed between some of these factors

Table 1 Households and individuals characteristics in the study communes (*Bopa* and *Houeyogbe*), ($n = 1225$)

Characteristics	All		Communes				<i>p</i> -value
			Bopa		Houeyogbe		
	n	%	n	%	n	%	
<i>Characteristics of children</i>							
Age (months)							
6–11	460	37.6	222	39.9	238	35.6	0.188
12–17	402	32.8	183	32.9	219	32.8	
18–23	363	29.6	152	27.3	211	31.6	
Gender							0.440
Male	633	51.7	286	51.3	347	51.9	
Female	592	48.3	271	48.7	321	48.1	
<i>Characteristics of caregivers</i>							
Caregivers							
Primary caregivers	1202	98.1	546	98	656	98.2	0.624
others	23	1.9	11	2	12	1.8	
Caregivers' age (year), (mean \pm SD)	28.35 \pm 3.66		28.82 \pm 6.42		27.97 \pm 6.83		0.027
Age (years)							0.012
< 20 years old	60	4.9	20	3.6	40	6	
20–29 years old	638	52.1	275	49.4	363	54.3	
\geq 30 years old	527	43	262	47	265	39.7	
Education							<0.001
Formal schooling	400	32.7	109	19.6	291	43.6	
No schooling	825	67.3	448	80.4	377	56.4	
Ethnicity							<0.001
Saxwe	939	76.7	479	82.6	479	71.7	
Others	286	23.3	97	17.4	189	28.3	
Marital status							0.304
Alone	230	18.8	112	20.1	118	17.7	
Not Alone	995	81.2	445	79.9	550	82.3	
Caregivers' occupation							0.016
household tasks only	35	2.9	23	4.1	12	1.8	
Household + Income generating activities	1190	97.1	534	95.9	656	98.2	
Type of caregivers' occupation							
Agricultural activities	691	56.4	413	74.1	278	41.6	<0.001
Food process/Post-harvesting	285	23.3	151	27.1	134	20.1	0.004
Small trade	514	42	211	37.9	303	45.4	0.009
Others activities	169	13.8	40	7.2	129	19.3	<0.001
<i>Characteristics of HH</i>							
Sex of HH head							0.005
Male	1152	94	512	91.9	640	95.8	
Female	73	6	45	8.1	28	4.2	
Size of HH Mean \pm SD	5.31 \pm 1.91		5.53 \pm 1.98		5.13 \pm 1.83		< 0.001
DFGP score (Means \pm SD)	1.71 \pm 1.282		2.26 \pm 1.231		1.25 \pm 1.137		< 0.001
Minimum DFGP (%)							< 0.001
Yes	126	10.3	95	17.1	31	4.7	
No	1095	89.7	460	82.9	635	95.3	
Food security (HFIAS)							0.003
Food secure	242	19.8	128	23	114	17.1	
Mildly food insecure	98	8	46	8.3	52	7.8	
Moderately food insecure	289	23.6	107	19.2	182	27.2	
Severely food insecure	596	48.7	276	49.6	320	47.9	

Table 1 (continued)

Characteristics	All		Communes				<i>p</i> -value
			Bopa		Houeyogbe		
	n	%	n	%	n	%	
Share of the HH income allocated to food							0.518
<i>Normal</i> ($\leq 50\%$)	866	70.7	386	69.3	480	71.9	
<i>Moderately high</i> (50–75%)	324	26.4	156	28	168	25.1	
<i>High</i> ($> 70\%$)	35	2.9	15	2.7	20	3	
Socioeconomic status (Wealth index) categories							<0.001
<i>Poorest</i>	248	20.2	224	40.2	24	36.0	
<i>Second</i>	240	19.6	164	29.4	76	11.4	
<i>Middle</i>	244	19.9	82	14.7	162	24.3	
<i>Fourth</i>	243	19.8	52	9.3	191	28.6	
<i>Richest</i>	244	19.9	33	5.9	211	31.6	

DFGP: Diversity of food groups produced; HH: Household; HFIAS: Household Food Insecurity Access Scale

revealed the complexity of determinants of infant and young child (IYC) complementary feeding practices.

Minimum dietary diversity (MDD) reflects the quality of foods given to children (Joseph et al., 2011). Positive association between MDD and age shows the poor quality of diet among the youngest children (6 to 11 months) who received fewer different types of foods than older children (Table 2). This is not surprising, since semi-solid and solid foods are introduced gradually and stomach capacity at 6 months is relatively limited. This also confirms the overall tendency observed in complementary feeding practices in Benin and the West African region and was consistent with recent findings from the study on determinants of complementary feeding practices among children aged 6–23 months in seven francophone West African countries (Issaka et al., 2015b). The same trend has been reported in Ethiopia (Melkam et al., 2013). This finding could, furthermore, be explained by the quality of complementary foods introduced. Cereal porridges were

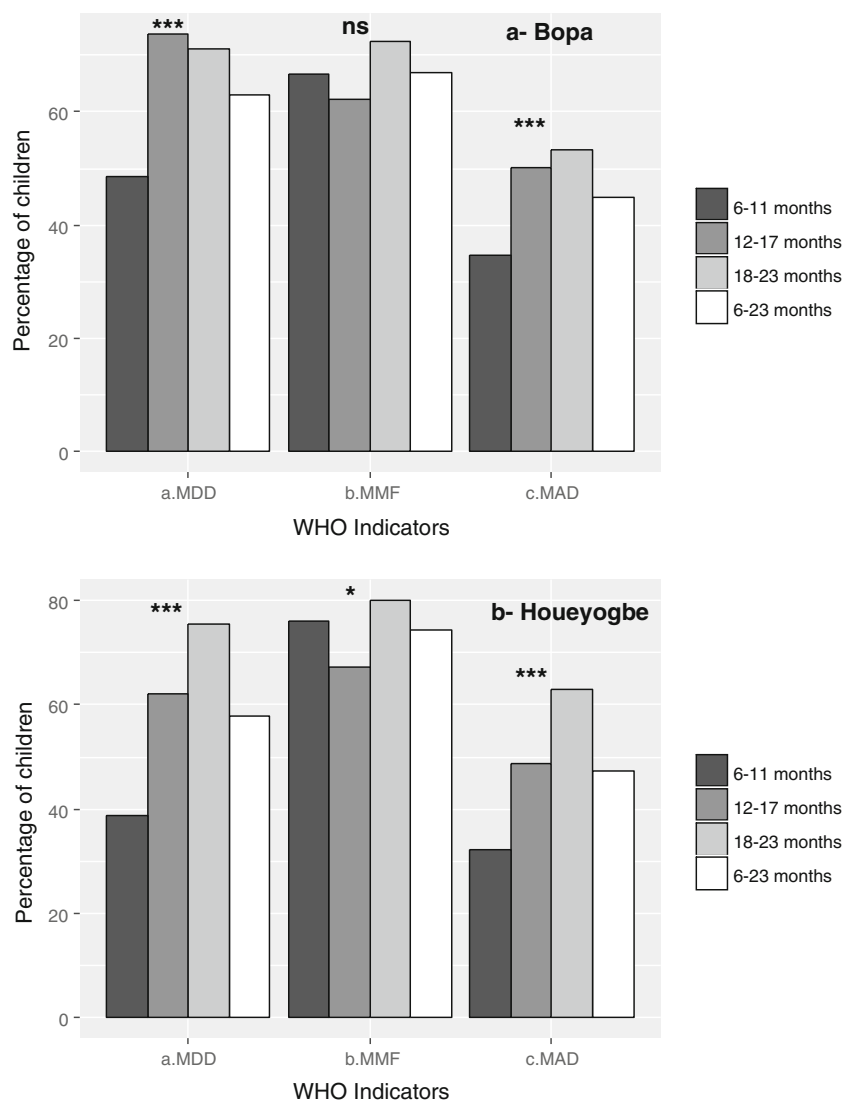
recognized as the most common and first complementary foods given to children followed by family dishes. Victor et al. (2014) showed that the traditional porridges, as complementary foods in West Africa, generally provided low nutritional value due to less food diversity. Hence, it is important to place emphasis on upgrading the quality of porridges, especially for the youngest age bracket (6–11 months) of children by providing appropriate nutrition messages, including hands-on recipes for improved porridges, and promoting food diversification.

Likewise, the association between MDD and age is not linear and may be mediated by other factors as shown by the positive association between MDD and the interaction term DFGP x children's age (Table 3). In other words, the more production diversity at household level increases, the more children meet the requirements for MDD throughout all age groups. Thus, agricultural diversity was strongly associated with improving quality of complementary foods. Following

Table 2 Types of food given to children aged 6–23 months and dietary diversity score by age group, Southern Benin ($n = 1225$)

Food group	Age of children (months)							
	6–11		12–17		18–23		6–23	
	n	%	n	%	n	%	n	%
Cereals, roots and tubers	456	99.1	398	99	361	99.4	1215	99.2
Legumes and nuts	189	41.1	215	53.5	212	58.4	616	50.3
Dairy products	14	3	10	2.5	9	2.5	33	2.7
Flesh foods	273	59.3	330	82.1	326	89.8	929	75.8
Eggs	13	2.8	4	1	9	2.5	26	2.1
Vitamin A-rich fruits and vegetables	176	38.3	224	55.7	228	62.8	628	51.3
Others fruits and legumes	243	52.8	324	80.6	307	84.6	874	71.3
Dietary diversity score (mean \pm SD)	2.97 \pm 1.43		3.74 \pm 1.21		4 \pm 1.07		3.53 \pm 1.34	
Total number of children	460		402		363		1225	

Fig. 1 Prevalence of children meeting minimum dietary diversity, minimum meal frequency and minimum acceptable diet by age group for each commune a- *Bopa* and b- *Houeyogbe*. * $p < 0.05$; *** $p < 0.001$; ns, not significant



the recent PNAS publications (Berti 2015; Sibhatu et al. 2015) and to obtain a nutrition-relevant indicator, diversification was defined as the production of different food groups in farming systems (including home gardens). These findings show the link between agricultural diversification and feeding practices, especially dietary diversity. Strengthening the link between agriculture and dietary diversity can be proposed as one of the solutions to improve infant and young child nutrition. A study conducted in Benin by Segnon and Achigan-Dako (2014) showed that achieving food security can be fostered through production and consumption policies that include the valorization of wild edible plants.

The interaction term ‘share of income allocated to feeding x ‘households’ residence’ was strongly associated with MDD. This means that, in this study, the trend of MDD varied from one commune to another and according to the share of income allocated to feeding. The higher the share of income spent on food, the less probable MDD will be met in *Houeyogbe*. In

contrast, whatever the share of income allocated to food, the probability of meeting MDD remains more or less the same in *Bopa*. This can be explained by the fact that *Bopa* is a purely rural area with high local biodiversity and consumption of own produced foods while the villages in *Houeyogbe* are closer to the main road and more dependent on food purchases. Furthermore, in the same poverty conditions, the “*Saxwe*” living in *Bopa* have fewer difficulties accessing local dietary resources compared to those living in *Houeyogbe*. The cost of food access is higher in *Houeyogbe* than *Bopa*. Achigan-Dako et al. (2011) found that the use of a species as a vegetable depended on socio-cultural attributes in addition to geographical occurrence.

Bopa provided a better diversity of food groups produced on-farm than *Houeyogbe* (Table 1). It is generally known that the higher share of income a household spends on food, the more likely the household is poor (Deaton, 2003). So, poor households bought probably only cereals/tubers and better-off households meat, fruits and vegetables. This result could

Table 3 Factors associated with minimum dietary diversity of 6–23 months children in Southwest of Benin, based on multilevel logistic regression, $n = 1225$

Variables	Logit		Odd-Ratio		<i>p</i> -value
	Estimate	95% IC	Estimate	95% IC	
Intercept	0.31	−0.15; 0.76	1.36	0.86; 2.15	
DFGP	0.16	0.05; 0.27	1.17	1.05; 1.31	
Children age					
<i>Linear</i>	0.97	0.60; 1.33	2.63	1.82; 3.78	
<i>Quadratic</i>	0.08	−0.27; 0.42	1.08	0.76; 1.53	
Share of income allocated to feeding					
<i>Linear</i>	0.22	−0.57; 1.01	1.25	0.57; 2.76	
<i>Quadratic</i>	−0.37	−0.90; 0.17	0.69	0.41; 1.18	
Commune					
Bopa	Ref				
Houeyogbe	−0.67	−1.23; −0.11	0.51	0.29; 0.90	
Ethnicity					
<i>Sahoue</i>	Ref				
<i>Others</i>	−0.46	−0.95; 0.02	0.63	0.39; 1.02	
DFGP × Children age					0.0294
DFGP × (<i>Children age = Linear</i>)	−0.02	−0.19; 0.16	0.98	0.83; 1.17	
DFGP × (<i>Children age = quadratic</i>)	−0.23	−0.40; −0.06	0.79	0.67; 0.94	
Share of income allocated to feeding × Commune					0.0083
(<i>Share of income allocated to feeding = Linear</i>) × (<i>Commune = Houeyogbe</i>)	0.55	−0.50; 1.61	1.74	0.61; 4.98	
(<i>Share of income allocated to feeding = Quadratic</i>) × (<i>Commune = Houeyogbe</i>)	0.39	−0.33; 1.11	1.47	0.72; 3.02	
Commune × Ethnicity					0.0009
(<i>Commune = Houeyogbe</i>) × (<i>Ethnicity = Others</i>)	1.05	0.43; 1.66	2.85	1.54; 5.27	

DFGP: Diversity of food group produced

Ref: Reference category

P-values are those with likelihood-ratio test

No *p*-value was computed for terms that are part of higher-order interaction

explain how the purchasing power or market integration could affect the dietary diversity in *Houeyogbe* but less so in *Bopa*. Hence, the probability of meeting MDD in *Houeyogbe* decreased among children from households with moderate or high shares of income allocated to food. So, in the area under higher urban influence, increasing share of income allocated to feeding constitutes a risk factor negatively influencing dietary diversity. This finding corroborates a recent study where urban location was significantly associated with inadequate dietary diversity among mothers in Benin (Issaka et al., 2015b). While in rural areas households can compensate for potential dietary deficiency by diversifying their own food production, diets of people living in urban areas are likely to be more affected by higher poverty rates.

Supplementation, fortification and dietary diversification are the potential approaches that decision makers should explore for improving nutrition, taking into account context, urgency and resource availability. Besides vitamin A supplementation integrated into the immunization campaigns by the ministry of health and salt iodization under the responsibility

of the Ministry of Agriculture, the Benin Government stresses the importance of food and nutrition security in the national strategy of the agricultural sector (Benin, 2017). Despite several initiatives, movements and commitments at global level, such as the Sustainable Development Goals (SDG), the Scaling Up Nutrition movement (SUN), the Global Alliance for Improved Nutrition (GAIN), Renewed Efforts Against Child Hunger and Nutrition (REACH), the new G8 Food Security and Nutrition Alliance and Zero Hunger Challenge, working on reduction of food insecurity and malnutrition, including micronutrient deficiencies, so far progress is still insufficient, especially in sub-Saharan Africa. Hence the need to consider the socio-economic determinants that explain the lack of progress in each country in order to better contextualize the interventions. Direct addition of micronutrient supplements like sprinkles, baobab and moringa powders (Houndji et al., 2013) to home-prepared complementary foods is gaining ground as a sustainable strategy for improving the micronutrient quality of children's diets (Adu-Afarwah et al., 2007). Our study shows that nutrition-sensitive

Table 4 Factors associated with minimum meal frequency of 6–23 months old children in Southern Benin, based on multilevel logistic regression, $n = 1225$

	Logits		Odd ratio		<i>p</i> -value
	Estimates	95% CI	Estimates	95% CI	
Intercept	2.66	1.31–4.01	14.30	3.69–55.33	<0.0001
Ethnicity					0.0214
<i>Saxwe</i>	Ref				
<i>Others</i>	0.56	0.12–1.00	1.75	1.13–2.72	
Marital status					
<i>Single</i>	Ref				
<i>Married</i>	−1.36	−2.39–0.33	0.26	0.09–0.72	
Caregiver's occupation					0.0326
<i>Householdkeeping</i>	Ref				
<i>Others</i>	−0.97	−1.97–0.03	0.38	0.14–1.03	
HH size	−0.18	−0.34–0.03	0.83	0.71–0.97	<0.0001
Marital status × HH size					0.0055
(<i>Status = Married</i>) × <i>HH size</i>	0.25	0.07–0.42	1.28	1.07–1.53	

HH: Household

Ref: Reference category

P-values are those with likelihood-ratio test

agricultural diversification (including home gardens), appears to be an endogenous solution. Simultaneously, strategies such as Integrated Management of Childhood Illnesses (IMCI - management of immunization, deworming, management of diarrheal and infectious diseases, vitamin A supplementation, iron and folic acid), should be strengthened in the health pyramid. Health and food and nutrition security interventions should also be coupled with WASH (Water Sanitation and Hygiene). Moreover, education and awareness raising of appropriate feeding practices and behavior change communication through counseling and culinary demonstration should be implemented in order to improve child well-being.

Another important factor affecting the probability of reaching MDD was the combined effect of the ethnicity of household heads and the commune of residence. Among “*Saxwe*” households, children living in *Bopa* had higher probability of meeting MDD than those living in *Houeyogbe*. In contrast, among minority ethnic groups, children living in *Houeyogbe* had higher probability of meeting MDD than those living in *Bopa*. As the native ethnic group, “*Saxwe*” are used to consuming a diversity of local food resources that are more readily available in *Bopa* than in *Houeyogbe*, these local food resources are part of their food habits. Avohou et al. (2012) found that ethnicity affected the composition of species managed at the community level. Moreover, children from minority ethnic groups had higher probability of meeting MDD in *Houeyogbe* than in *Bopa* owing to the purchase of foods close to their cultural food habits. This finding could confirm that the interplay of socio-cultural attributes and agro-ecological conditions could explain the diversity of food plants selected and used by communities (Segnon & Achigan-Dako, 2014).

Regarding the minimum meal frequency (MMF), gender aspects and household size were identified as associated factors to complementary feeding practices. Child feeding was influenced by the primary caregivers' occupation. Caregivers' occupations could be one of the main factors affecting complementary feeding practices, especially the frequency of meals needed (MMF) to cover a child's nutrient requirements. This has also been observed by Maisonneuve et al. (2014) who pointed out the dynamic between women's daily activities and household food security with potential impact on child feeding practices.

The interaction term household size x marital status of mothers or primary caregivers had a strong association with adequate MMF. We observed that children were more vulnerable to suboptimal meal frequency when they lived in large female-headed households. On the contrary, household size did not significantly influence probability of meeting MMF in male-headed households. This finding shows the important role of fathers in food security at household level on the one hand and the limited access of women to material and immaterial resources such as land, innovations and knowledge, in the Beninese socio-cultural context on the other hand. As demonstrated in a recent study focused on household food availability in Sub-Saharan Africa, crop production was the major source of energy, contributing 60% of food availability (Frelat et al., 2016). Consequently, it may be difficult for women in rural areas to ensure food security as household head where land is a limiting factor for them. Women's economic empowerment constitutes one of the Sustainable Development Goals (SDGs), the implementation of which would significantly contribute to reducing mothers' vulnerability and thus contribute to better wellbeing of children.

4.1 Limitations of study

The study was carried out in Southern Benin during a period of average food availability. Therefore, the results are not automatically applicable to other seasons or other geographical/agro-ecological areas in the country. We recommend a similar study during the lean period in order to document the determinants of child feeding practices across seasons and to better orient decisions of policy makers related to appropriate strategies for child well-being. Since, the study has been carried out only in Southern Benin, the results should not be generalized for the whole country.

5 Conclusion

The study revealed different factors associated with selected WHO recommended complementary feeding practice indicators. The factors included: child age, household production diversity, share of the household income allocated to food, commune of residence, ethnic group of household head, caregivers' occupation, marital status of caregivers and household size. The results, furthermore, revealed interactions between some of these factors showing the interdependence or complementarity of factors in determining feeding practice behaviors. Providing quantity and quality of diet to meet infants' requirements implies enhancing households' food security related to diversification of the farming system. Socio-cultural characteristics determining food habits influenced the choice of local resources used for food within certain environments. Furthermore, gender aspects and household size influence the achievement of minimum meal frequency. Achieving appropriate complementary feeding practices will require multisectoral interventions encompassing agriculture, nutrition and social affairs. Emphasis on appropriate nutrition messaging linked to the promotion of food group diversification in farming-systems including home gardens or nutrition-sensitive agriculture appear to be important in improving quality of complementary feeding practices. Reducing women's workload through improved working conditions should decrease the burden on their time availability and create more time for child care. Targeting women, mainly single-women, as vulnerable groups, through specific interventions focused on improving access and control over resources could improve complementary feeding practices.

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Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest. The article is original work and has not been submitted for publication elsewhere.

Ethical clearance was obtained from Benin National Ethics Committee for Scientific Research. Political authorities of the two communes were informed and approved the study. Written informed consent of the enrolled children's parents was obtained after they received complete information about the study in the local language. All children that were severely malnourished (wasted) during the survey were referred to the nearest malnutrition management center.

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