

Maternal Knowledge, Attitudes, and Practices of Complementary Feeding and Child Undernutrition in the Vakinankaratra Region of Madagascar: A Mixed-Methods Study

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ABSTRACT

Background: Data are limited on how feeding knowledge and practices relate to child undernutrition in the highlands of Madagascar.

Objectives: This study assessed maternal knowledge and practices of complementary feeding and their associations with anthropometrics of children aged 6–23 mo in the Vakinankaratra region of Madagascar.

Methods: Knowledge was assessed using WHO recommendations on child feeding, and WHO infant and young child feeding (IYCF) indicators were used to evaluate feeding practices. Child growth was measured as length-for-age, weight-for-age, and weight-for-length z-scores using the 2006 WHO growth standards. A z-score less than -2 was classified as child undernutrition. Logistic regression models were used to determine associations between independent variables and outcomes. Focus group discussions among mothers and in-depth interviews with key informants were conducted; barriers and facilitators of optimal feeding practices were identified using a thematic analysis approach.

Results: Maternal knowledge scores regarding child feeding averaged 6.4 of 11. Better knowledge scores were associated with higher odds of appropriate complementary feeding practices before and after covariate adjustments. The proportions of children achieving the minimum dietary diversity (35.8%), minimum acceptable diet (30.2%), and consuming meat, fish, and poultry (14.1%) were low. Only consumption of iron-rich foods was associated with lower odds of underweight (adjusted OR = 0.3; 95% CI: 0.1, 0.7; $P < 0.05$). None of the IYCF indicators were associated significantly with stunting or wasting. Maternal attitudes about complementary foods, as well as mothers' workload and very low income, were identified as barriers to optimal feeding practices. Maternal perceived benefits of giving appropriate complementary foods as well as their positive relationship with the community health workers were the main facilitators of optimal child feeding.

Conclusions: Integrated nutrition-sensitive interventions addressing these barriers while enhancing the facilitators are critical in promoting better feeding practices in the Vakinankaratra region. *Curr Dev Nutr* 2020;4:nzaa162.

Keywords: complementary feeding, child undernutrition, Madagascar, barriers, facilitators

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Abbreviations used: AOR, adjusted odds ratio; CNA, Community Nutrition Agent; FGD, focus group discussion; IDI, in-depth interview; IYCF, infant and young child feeding; LAZ, length-for-age z-score; LMIC, low- and middle-income countries; WAZ, weight-for-age z-score; WLZ, weight-for-length z-score.

Introduction

Feeding infants and young children with diverse, nutrient-dense, safe, and developmentally appropriate complementary foods is essential to promote optimal growth (1–3). Consequently, inadequate dietary intake due to suboptimal feeding practices is a common immediate cause of undernutrition. Inappropriate feeding practices have been associated with impaired growth in low- and middle-income countries (LMIC) (4–7).

The Vakinankaratra region of Madagascar has the highest child stunting (60%) and underweight (42%) rates in the country according to the latest Multiple Indicators Cluster Survey (8). Poor feeding practices could explain, at least partially, such high child undernutrition in this region with high agricultural productivity. Only 31% of the infants and young children were fed the recommended minimum dietary diversity in Vakinankaratra in 2018 (8). Additionally, in the central highlands of Madagascar where the region is located (9), only 11% of those aged 6–23 mo received the minimum acceptable diet. To support efforts

to reduce child undernutrition, improvements in complementary feeding practices clearly are needed in the region. Educational interventions targeting mothers by increasing their knowledge have been shown to be effective to various degrees in improving feeding practices in different settings in LMIC (10).

However, data on maternal knowledge and practices of child feeding and how they relate to child undernutrition in the Vakinankaratra region are scarce. Having context-specific information about child feeding will help to clarify the role of complementary feeding knowledge and practices in child undernutrition in Vakinankaratra and possibly in other agriculturally productive regions with high burdens of malnutrition. Such data also can be used to inform and adjust policies and interventions aiming to improve complementary feeding practices and ultimately child undernutrition in the Madagascar highlands. Therefore, the purpose of this study was to assess the maternal knowledge, attitudes, and practices of complementary feeding and their associations with child undernutrition. The first objective was to determine if maternal knowledge and practices of complementary feeding contribute to the high child undernutrition rate in the Vakinankaratra region. The second was to identify barriers and facilitators to optimal complementary feeding practices.

Methods

Quantitative data collection and analyses

Participants.

This study was conducted in the Antanifotsy and Antsirabe II districts of the Vakinankaratra region. Based on the regional stunting rate of 55% (11) and a margin of error of 0.05, a total of 391 mother-child dyads were enrolled. Participants were selected through multiple stage cluster sampling at the district, commune, and fokontany (smallest administrative unit) levels. Within the 2 districts, 9 communes (out of 32) were selected, and within each commune, 42 fokontany (out of 84) covered by the national community nutrition program were randomly chosen. Mothers having infants aged 6–23 mo and living with their husbands or partners were eligible for the study. The community health workers [community nutrition agents (CNAs)] in each fokontany were asked to establish a list of eligible mothers. Then, an average of 8 mothers per fokontany were randomly selected to participate in the study.

Child and maternal anthropometrics.

Child length was measured to the nearest 0.1 cm using a wooden length board. Measurements were done in duplicate and the average length was recorded. A hanging scale (seca) was used to measure child weight. Using the 2006 WHO growth standards (12), child length and weight were converted to length-for-age (LAZ), weight-for-age (WAZ), and weight-for-length (WLZ) z-scores. Children were classified as stunted if LAZ was less than -2 , underweight if WAZ was less than -2 , and wasted if WLZ was less than -2 . Maternal height was measured against a plastic tape mounted on the wall.

Survey questionnaire.

A pretested questionnaire was used to collect sociodemographic information, maternal knowledge of child feeding, and complementary feeding practices. Questions on maternal knowledge were adapted from

the guidelines for feeding of the breastfed child (13) regarding continued breastfeeding, dietary diversity, and meal frequency. Each mother's knowledge score for the total correct answers was computed and was used in the analyses. Feeding practices were assessed using the WHO infant and young child feeding (IYCF) indicators (14).

Statistical analyses.

Means and frequencies were used to describe the study population. Logistic regression analyses were conducted to determine the association between selected outcome variables (complementary feeding practices and child nutritional status) and maternal knowledge of child feeding and complementary feeding practices. Models predicting the odds of appropriate complementary feeding practices were adjusted for age at first birth, head of household, mothers' frequency of listening to radio, number of living children, and household food insecurity score. The models predicting child nutritional status were adjusted for child age, child sex, birthweight, and years of maternal education for WAZ and WLZ. The LAZ models were additionally adjusted for maternal height. All models were adjusted for cluster design. Analyses were conducted using SAS 9.4 (SAS Institute, Inc.).

Qualitative data collection and analyses

Participants.

A total of 7 focus group discussions (FGDs) with 6 to 8 mothers per group were conducted (total $n = 46$). Participants had to meet the same eligibility criteria as the mothers in the surveys. Also, 8 in-depth interviews (IDIs) were conducted with 6 CNAs, a nurse, and a field monitor (nongovernmental organization worker). Focus groups and semistructured interviews were conducted in the local language, Malagasy, and were audio-recorded. The main author (HR), a native Malagasy, conducted all the interviews. Probing questions were used to achieve saturation during qualitative data collection. Saturation was achieved when no new information was shared during each focus group and each interview. Actually, responses began to become similar during the fourth FGD but 3 more focus groups were conducted to ensure saturation of the responses. Guides for focus group questions and interviews are summarized in **Supplemental Table 1**.

Data analysis.

Recordings were transcribed verbatim and back-translated to English before analyses by the main author. Two teams of 2 coded the transcripts, and the thematic analysis approach (15, 16) was used to identify the barriers and facilitators to appropriate complementary feeding practices. A codebook was first developed with all the coders from the first 2 focus group transcripts. Then, the teams coded the rest of the transcripts separately. All coders assisted with confirming the codes and developing the themes. NVivo v. 12 (QSR International) was used for analysis. Barriers and facilitators were organized under 3 levels of the socioecological model: individual (maternal), interpersonal or household, and community.

Ethics

This study was approved by the Oklahoma State University Institutional Review Board and by the Ethics Committee on Biomedical Research of the Ministry of Public Health of Madagascar. Participants gave written consent before any data collection. Deidentified data from the

TABLE 1 Characteristics of the study population¹

	<i>n</i>	Frequency (%) or mean \pm SD
MATERNAL CHARACTERISTICS		
Maternal age	389	27.4 \pm 6.8 y
Maternal occupation		
Not employed/housewife	31	8.0
Farmer	308	78.8
Office or part-time job	52	13.3
Highest level of education		
None	18	4.6
Primary	204	52.6
Secondary	118	30.4
Higher	48	12.4
Antenatal care attendance		
<4 times	113	28.9
\geq 4 times	278	71.1
Age at first birth		
<19 y		35
\geq 19 y		65
Exposure to radio over past week		
Didn't listen to radio	217	56.1
Once or twice	45	11.6
Almost every day	125	32.3
Source of nutrition information		
Nowhere	66	16.9
Family and relatives	21	5.4
Media	6	1.5
CNA and medical staff	28	7.2
>1 source	270	69.0
HOUSEHOLD CHARACTERISTICS		
Household size	384	4.9 \pm 1.9
Socioeconomic status		
Low	123	33.4
Medium	123	33.1
High	123	33.4
Household food insecurity status (measured with HFIAS)		
Not food insecure	26	6.7
Mildly food insecure	15	3.9
Moderately food insecure	130	33.4
Severely food insecure	218	56
CHILD CHARACTERISTICS		
Child age	391	14.1 \pm 5.2 mo
Age category		
6–8 mo	72	18.4
9–11 mo	76	19.5
12–23 mo	243	62.1
Sex		
Male	197	50.4
Female	194	49.6

¹CNA, community nutrition agent; HFIAS: Household Food Insecurity Access Scale.**TABLE 2** Undernutrition prevalence in the study sample

Indicator	<i>n</i>	Prevalence (%)	Mean z-score \pm SD
Stunting	268/385	69.4	− 2.4 \pm 1.4
Underweight	88/376	23.4	− 1.2 \pm 1.1
Wasting	12/376	3.2	0.1 \pm 1.2

tenatal care sessions for their last pregnancy. Media exposure was relatively low because 56.1% had not listened to the radio in the previous week. Mothers mostly received their nutrition information from the CNAs and other medical staff such as nurses and midwives. Mean child age was 14.1 mo, and children were split almost evenly between males and females. Stunting rates were very high (69.4%) in the study sample (Table 2) and 23.4% of the children were underweight and 3.2% were wasted.

Maternal knowledge of child feeding

Mothers had variable knowledge of the child feeding guidelines (Figure 1). Most of the mothers knew the correct answers to several of the questions except the feeding frequency for children aged 9–23 mo, which only 23.3% of the mothers answered correctly. Also, fewer than half of the mothers reported that children should eat vegetables every day, and only 63.9% agreed that infants aged 0–6 mo should be exclusively breastfed.

Complementary feeding practices

All IYCF indicators were low except for minimum meal frequency at 71.6% (Figure 2). Only 35.8% of the children met the minimum dietary diversity (\geq 4 food groups of 7), and only 30.2% had the minimum acceptable diet. Because of the very high breastfeeding rate in this population (92.3%), the proportion of children meeting the minimum dietary diversity according to the new proposed scoring (\geq 5 of 8 food groups) did not change much (34%) compared with our reported 35.8%. Consumption of iron-rich foods (meat, fish, and poultry) was very low at 14.1%, as was the consumption of eggs (3.3%).

Maternal knowledge and practices of complementary feeding and child nutritional status

Mothers with higher knowledge of child feeding were more likely to feed their infants from \geq 4 food groups [adjusted odds ratio (AOR) = 1.2; 95% CI: 1.1, 1.4] and to reach the minimum meal frequency (AOR = 1.2; 95% CI: 1.0, 1.5) (Table 3). Mothers with increased child feeding knowledge also had higher odds of giving their infants the minimum acceptable diet (AOR = 1.2; 95% CI: 1.1, 1.5) and iron-rich foods (AOR = 1.5; 95% CI: 1.2, 1.8).

Optimal complementary feeding practices were not associated with stunting or wasting after adjustments for child age and sex, birthweight, maternal age, and maternal height (Table 4). Only consumption of iron-rich foods was associated with lower odds of being underweight (AOR = 0.3; 95% CI: 0.1, 0.7). However, higher dietary diversity scores were significantly associated with lower odds of stunting in infants aged 9–11 mo (AOR = 0.6; 95% CI: 0.3, 0.9). Additionally, maternal knowledge of complementary feeding was not associated with child stunting or wasting in the adjusted models. But higher maternal knowledge was

questionnaires were analyzed. Transcripts from FGDs and key informant interviews also were deidentified.

Results

Characteristics of the study population

Most of the mothers (78.8%) were farmers (Table 1) and had at least primary education (95.6%). The majority (71.1%) had attended \geq 4 an-

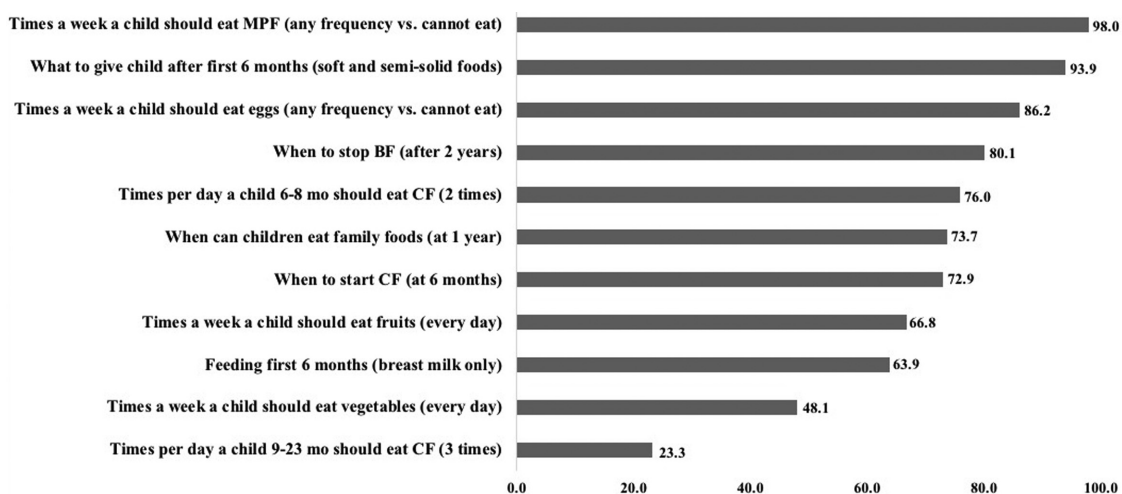


FIGURE 1 Maternal complementary feeding knowledge (percentage of correct responses). BF, breastfeeding; CF, complementary foods; MPF, meat, poultry, and fish.

associated with lower odds of being underweight (AOR = 0.8; 95% CI: 0.6, 0.9) (Table 3).

Qualitative findings

Mothers in the FGDs had similar sociodemographic characteristics (Supplemental Table 2) as the participants in the survey, except for the mean age (23.3 y compared with 27.4 y in the survey). Most of the mothers were also farmers and all had at least primary education. Similar to the survey participants, nearly three-fourths of the mothers had attended ≥ 4 antenatal care sessions but almost half (43.5%) had not listened to radio over the past week. Both barriers and facilitators of optimal complementary feeding were identified at all 3 levels: maternal, household, and community (Figure 3).

Maternal barriers to optimal complementary feeding.

Beliefs regarding breast milk and complementary foods were one of the maternal barriers to appropriate feeding. Many mothers started

introducing foods to their infants before the age of 6 mo because they felt that their breast milk was not enough or the child needed food.

“I gave mine food after 3 months because my milk was not enough” Mother, FGD 4

“When the child is breastfed, he will be irritated because the milk is not enough” Mother, FGD 3

Also, several mothers mentioned avoiding “heavy foods” such as eggs and legumes for their young children, especially those younger than 1 y. They stated that these foods caused vomiting and stomach ache.

“Eggs, cassava, beans...you should wait until one year to give them, but even in small quantities because their stomach can’t tolerate” Mother, FGD 2

“Here, we don’t give children eggs when they are younger than one year because it’s difficult to digest” Mother, FGD 5

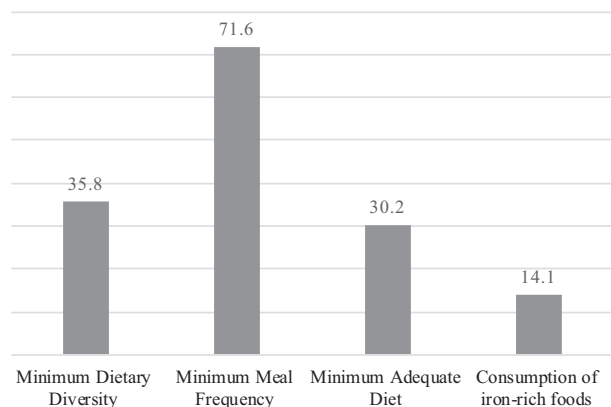


FIGURE 2 Proportions (percentage) of children meeting the WHO Infant and Young Child Feeding indicators in the Vakinankaratra region ($n = 391$).

TABLE 3 Associations of maternal knowledge scores with complementary feeding practices and risks of child undernutrition¹

	COR (95% CI)	AOR (95% CI) ²
CF practices		
Minimum dietary diversity	1.3 (1.3, 1.5)***	1.2 (1.1, 1.4)*
Minimum meal frequency	1.2 (1.0, 1.5)*	1.2 (1.0, 1.5)*
Minimum acceptable diet	1.3 (1.1, 1.6)***	1.2 (1.1, 1.5)**
Consumption of iron-rich foods ³	1.5 (1.2, 1.9)***	1.5 (1.2, 1.8)***
Child undernutrition		
Stunting	1.0 (0.9, 1.2)	1.0 (0.8, 1.2)
Underweight	0.8 (0.7, 0.9)**	0.8 (0.6, 0.9)*
Wasting	0.8 (0.6, 1.1)	0.8 (0.5, 1.1)

¹AOR, adjusted odds ratio; CF, complementary feeding; COR, crude odds ratio. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

²Models are adjusted for clustering and for age at first birth, head of household, radio exposure, number of living children, and food insecurity score.

³Meat, fish, and poultry.

TABLE 4 Associations between complementary feeding practices and the risks of child undernutrition¹

	CF indicators	Minimum dietary diversity	Minimum meal frequency	Minimum acceptable diet	Consumption of iron-rich foods ²
Stunting	COR (95% CI)	0.9 (0.6, 1.4)	1.7 (1.0, 2.7)	1.0 (0.6, 1.7)	0.5 (0.3, 1.0)
	AOR (95% CI) ³	0.9 (0.5, 1.4)	1.3 (0.7, 2.6)	1.0 (0.5, 1.8)	0.7 (0.3, 1.5)
Underweight	COR (95% CI)	0.9 (0.6, 1.3)	1.0 (0.6, 1.7)	1.0 (0.7, 1.5)	0.3 (0.1, 0.7)*
	AOR (95% CI) ⁴	0.8 (0.5, 1.3)	0.6 (0.3, 1.2)	1.0 (0.7, 1.5)	0.3 (0.1, 0.7)*
Wasting	COR (95% CI)	0.9 (0.3, 2.9)	0.5 (0.2, 1.7)	1.1 (0.3, 3.8)	1.2 (0.2, 5.9)
	AOR (95% CI) ⁴	0.9 (0.2, 3.3)	0.4 (0.1, 1.9)	1.1 (0.3, 5.0)	1.6 (0.3, 7.8)

¹AOR, adjusted odds ratio; CF, complementary feeding; COR, crude odds ratio. * $P < 0.01$.

²Meat, fish, and poultry.

³Models are adjusted for clustering and for child age, maternal height, child sex, birthweight for length-for-age z-score.

⁴Models adjusted for clustering and for child age, child sex, and birthweight for weight-for-age z-score and weight-for-length z-score.

Many mothers also perceived their workload as an obstacle limiting their time for caregiving and for complementary feeding activities specifically.

“Sometimes, mothers are so busy they don’t have time to prepare foods for their children” Mother, FGD 1

“We work in the field so there is no time to prepare the food for the child” Mother, FGD 4

This was confirmed by the key informants reporting that mothers were often busy and exhausted from work and had limited time for complementary feeding. When they go for work, many mothers leave their infants with their older children.

“Adding to that when they are tired from work already so they won’t cook separately or prepare something else for the child” CNA, IDI 4

“The main thing is that they go to work, so they don’t have time. They don’t have anyone to take care of that. The older children can just hold the child, nothing else” CNA, IDI 5

Barriers within the household.

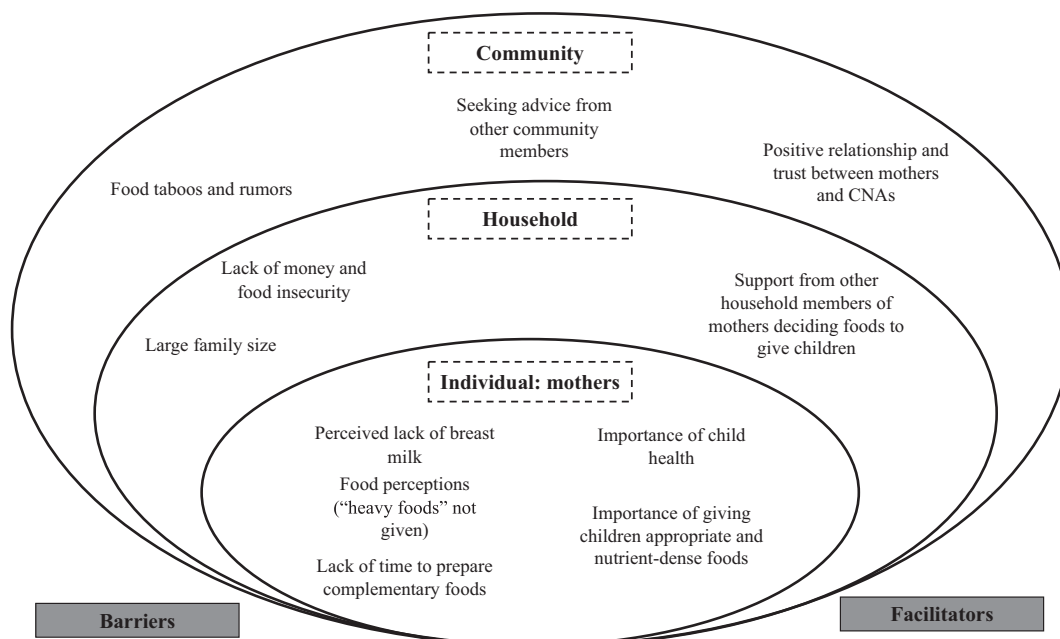
In all of the focus groups, mothers raised the issue of not having enough money for complementary foods.

“We don’t have money to buy complementary foods” Mother, FGD 3

“What we are going to eat today, we are looking for it today” Mother, FGD 4

Having a large family and short birth spacing also contributes to this problem because the parents have to provide for all members of the family, not just for the young children.

“Poverty is the real problem” Mother, FGD 3

**FIGURE 3** Barriers and facilitators of optimal complementary feeding practices in the Vakinankaratra region of Madagascar. CNA, community nutrition agent.

"Also, some families have a lot of children so they can't take care of all of them properly" Mother, FGD 4

These responses were confirmed by the IDIs where most of the key informants stated that poverty and insufficient income were problems for complementary feeding.

"The main problem is the lack of money" CNA, IDI 4

"The main problem is the money to buy the food, because you know the people here do not really have big lands to cultivate, most do the *saraka an-tsaha* [casual labor] for their living. So, they are looking today what they will be eating for today and so on" CNA, IDI 3

Food availability was also cited by many mothers as a difficulty in feeding infants appropriate complementary foods.

"It depends on what is available. Sometimes you can find colorful [foods], sometimes you can't" Mother, FGD 7

"We must live with what is available here in the countryside, you just have to change the way you cook it or how you prepare it" Mother, FGD 5

Some mothers mentioned their difficulty buying inputs for their agricultural crops that could be used for complementary foods.

"We don't have money to buy seeds so that we can plant after" Mother, FGD 2

Lack of resources for agriculture was also mentioned by the key informants. They added that households own small agricultural lands, limiting their agricultural production.

"All of what they are earning goes to buying food, they don't have shovel to work the land, they don't have fertilizer, and they don't have the other tools to do agriculture, seeds, things like that" CNA, IDI 1

"They only have small land to cultivate, some just have 5 × 5 m, and with that they can only grow one crop (...); and if they wanted to cook some vegetable soup, they would have to buy all of the other ingredients" CNA, IDI 4

Consequently, harvest usually does not last until the next season so they have to buy foods.

"They grow some crops but let's say they harvest in April and by August or September, the rice will be finished already. So, from September until April the following year, they will have to live on *saraka an-tsaha* [casual labor]" CNA, IDI 3

Barriers within the community.

Although most key informants reported that there were no cultural taboos regarding foods given to infants, some rumors were still circulating among the community. For example, in a few communities, people traditionally have said that infants and young children should not be given beans, eggs, or milk.

"They [mothers-in-law] would say that the child cannot eat this or that, for example, corn and beans should not be given to children" CNA, IDI 5

"They say that children from 6 months to 2 years shouldn't be given onions. Also, milk, they also say that milk should not be given to children. That's what I heard" CNA, IDI 5

"We always encourage them to give eggs to their children but they will not give the yolk because it's taboo for the children. Taboos still exist here" CNA, IDI 1

Maternal facilitators of optimal complementary feeding.

All of the mothers reported that giving their children adequate complementary foods was important to them. Mothers associated good complementary foods with child growth and health in general. They also mentioned that complementary foods give children energy and help with the child's brain.

"So that the child can grow well" Mother, FGD 1

"[Complementary food is] for physical and mental growth" Mother, FGD 3

"[Complementary foods] give energy and strength" Mother, FGD 4

A few mothers reported that foods are important because breast milk is not sufficient for the child anymore.

"Because breast milk is not enough and [complementary foods] complete it" Mother, FGD 7

"When you work, then the milk is wasting, so it will not be enough for your child's growth" Mother, FGD 4

The key informants confirmed that mothers generally consider their children's health important.

"Yes, I think so, they realize that [children's health is important]" CNA, IDI 1

"... people really love their children. They feel for their children when they don't gain weight, when they are malnourished, it's really sad" CNA, IDI 3

Also, consistent with the survey results, mothers had generally good knowledge regarding complementary feeding. Several mothers mentioned that giving children appropriate foods for their age is important, both in terms of quantity and consistency.

"Because they are still small, they may not digest well what you eat at home so you have to cook for them separate foods, foods that are okay for their age because they are still young" Mother, FGD 1

"For example, corn or rice, so we have to smash them and make them in form of porridge" Mother, FGD 4

"Don't give the child too much food, he won't digest" Mother, FGD 5

Mothers also stated that children should be given nutrient-dense foods including meat, fish, vegetables, dairy, fruits, and rice.

"Food in form of porridge from 6 months until 11 months, because their stomach can't tolerate" Mother, FGD 7

"Foods with a lot of vitamins...potatoes, carrots, fish" Mother, FGD 1

Facilitators at the household level.

Almost all of the key informants mentioned that although generally mothers decide what foods to give to their children, they are supported by their husbands. Fathers or mothers-in-law and other members of the

family, if present, were reported to advise on what to give the child but the decision was made by the mother.

“It’s always the mother” CNA, IDI 3

“They make their own decision but for those who have parents-in-law, they can just advise from outside on what should be given to the child” CNA, IDI 4

“The father can help advising the mother about how to improve the foods” CNA, IDI 2

Facilitators at the community level.

Another potential facilitator was the positive relationship between the mothers and the CNAs. All of the mothers in the focus groups typically would ask the CNAs for advice on child feeding. Their proximity and their knowledge of child health as well as their training were common reasons evoked by the mothers on why they asked the CNAs first.

“She is close to us so we only ask her” Mother, FGD 7

“Because they [CNAs] know a lot about mothers and children” Mother, FGD 4

A few mothers also asked the local medical staff and some received nutrition information from the health booklets provided by the national community nutrition program.

“Because we don’t have the knowledge so we have to ask so that we do not do the wrong thing” Mother, FGD 2

“We look at the booklet so there we can know” Mother, FGD 6

The key informants reported similar responses.

“Yes, most of the times, they will ask us” CNA, IDI 4

“... as I said we are close to them so they talk to us first. They would only talk to the other community members after talking to us, telling them what we told them. So, they would discuss between them” CNA, IDI 3

Lastly, a few mothers in the focus groups sought advice from friends or the elders in the family regarding child feeding.

“Older people should know so we should ask them” Mother, FGD 3

“If you are at home giving food to your child, you’ll have to ask your parents because they are closer” Mother, FGD 2

The key informants confirmed these answers.

“Yes, they do ask them [friends] but they usually come here first” CNA, IDI 1

“They will ask their own parents first” CNA, IDI 2

Discussion

Child undernutrition rates were very high in the Vakinankaratra region, especially for stunting (69.4%), which was even higher than the national average of 42% (8). Stunting rates also were higher than in the other areas within the central region of Madagascar (17, 18). However, our study focused on the 6–23-mo age group, which has been reported to have a rapid decline in LAZ compared with the children aged 24–60 mo (19).

This disturbingly high rate of stunting in children aged <2 y needs immediate attention because it is recognized by the WHO as a serious public health concern (20). Underweight prevalence was still high (23.4%), although lower than the national average of 26%, and remains a concerning problem (20).

The relatively good maternal knowledge of complementary feeding can be attributed to the regular group nutrition education sessions conducted by the CNAs at the community nutrition sites in each fokontany. In fact, 69% of the mothers reported getting nutrition information from the CNAs and other medical staff. However, 36.1% still did not think that infants younger than 6 mo should be exclusively breastfed. Reinforcing the recommendation for exclusive breastfeeding during the first 6 mo among lactating mothers needs to be emphasized in the region. Breast milk is nutritionally adequate and is the safest food source for infants before 6 mo of age (2, 21). Exclusive breastfeeding provides protection against infections, reduces risk of infant mortality, and in the long term, can improve cognition.

Most mothers also knew the importance of diverse meals for infants and young children, but only about half thought that infants and young children should be given vegetables daily. Mothers in the region understood the importance of giving adequate complementary food to growing infants and young children, and qualitative studies from Kenya (22), Ethiopia (23, 24), and Ghana (25) reported similar findings. Also, 33.2% did not know that infants should be given fruits daily. Emphasizing the importance of feeding children fruits and vegetables could be needed to increase mothers’ knowledge.

Complementary feeding practices generally were suboptimal, with minimum meal frequency being the best at 71.6%, which is similar to the findings from the Comprehensive Food Security and Vulnerability Analysis in 2011 (9). In our study, nearly two-thirds of the infants were not fed a diverse or adequate diet. Results from the 2018 Multiple Indicator Cluster Surveys (MICS) (31%) and the 2012 Millennium Development Goals monitoring surveys reported even lower proportions (33.6%) of children aged <2 y achieving the minimum diet diversity in the Vakinankaratra region. Although the proportion meeting the minimum dietary diversity in the current study (35.8%) is higher than the national rate of 25%, there is still a need and potential to increase the diversity of complementary foods in the region given its high agricultural productivity.

Minimum meal frequency was unexpectedly high (71.6%) given that only 23.3% of the mothers knew the correct answer for the appropriate meal frequency for children aged 9–23 mo. At that age, infants and young children were given frequent small snacks throughout the day, which could have overestimated the minimum meal frequency indicator. During data collection, there was no distinction between meals and snacks in tabulating the minimum meal frequency according to the WHO IYCF indicators guidelines (26).

The food group most commonly given to infants and young children was grains, mainly rice. Also, green leafy vegetables, as well as legumes (mainly beans) and nuts were given as complementary foods. A relatively high proportion (51.7%) of infants in the region consumed foods from the meat, poultry, and fish category. However, most infants were given small fish (43.2%) rather than meat or poultry (14.1%) because during the time of data collection (March to April), fish were readily available. These small fish from the rice paddies are sold by many farmers around rice harvesting time at an affordable price. Thus, the propor-

tion of infants who ate meat, fish, and poultry is expected to be lower during other seasons, for example, during the lean season from January to March (27). Yogurt was the most common dairy product given to infants and young children, in contrast to results from the Menabe (central West coast) and the Alaotra Mangoro (central East coast) regions, where only 16.3% and 6.3% respectively of children aged <5 y consumed dairy products (28). Because the dairy industry of Madagascar is concentrated in the Vakinankaratra region, milk and dairy products are more available compared with the other regions. Similar to the Menabe region, the food group with the lowest consumption was eggs, consumed by only 3.3% of the children (28). Although half of the households had poultry, if eggs are produced, they are sold for income rather than consumed. Also, there are still beliefs about egg yolks being a heavy food and not appropriate for young children.

Only consumption of iron-rich foods was associated with lower odds of being underweight. Iron-rich foods such as meat, fish, and poultry are also good sources of protein and zinc, essential for child growth (2). Stunting was not associated with any of the complementary feeding indicators. These results suggest that improvements in complementary feeding alone are not likely to prevent stunting in children aged <2 y in the Vakinankaratra region. Similar results have been reported in other cross-sectional studies where only selected IYCF indicators were associated with better child growth (4–6, 29).

Nevertheless, in infants aged 9–11 mo, eating more diverse foods was associated with lower risk of being stunted. This group could be particularly vulnerable because the drop in LAZ is more dramatic compared with the other age categories (6–8 and 12–23 mo) according to the global child growth trajectory (19, 30). Additionally, compared with children aged 12–23 mo, infants aged 9–11 mo were given fewer diverse foods (mean dietary diversity score 2.98 compared with 3.18) in our sample (Supplemental Table 3). The nutrient gap to be filled by complementary foods in the 9–11-mo age group can be greater than in the younger group (6–8 mo), putting them at a higher risk of deficiency. However, the significant association might be a spurious finding. Nevertheless, there is a need for further study of the nutrient adequacy of complementary foods in different age groups for children aged <2 y in the Vakinankaratra region.

The limited associations found between child anthropometrics and improved IYCF practices do not undermine their crucial roles but rather emphasize the multifactorial aspects of child undernutrition. Besides feeding practices, multiple basic, underlying, and individual factors influence child growth directly or indirectly (31, 32). Because greater knowledge was associated with better practices, continuing the nutrition education sessions at the community sites as part of the National Nutrition Plan is beneficial. Additionally, incorporating key principles of responsive feeding in the current group and individual educational sessions might also be needed (33). Responsive feeding is also an important component of the nurturing framework for better child growth and development (34–36).

Efforts are still needed to improve IYCF practices in the Vakinankaratra region; however, coupling the educational sessions with interventions addressing the identified barriers of complementary feeding practices potentially would yield even greater impacts on child undernutrition. Perceived lack of breast milk and considering certain foods as heavy were identified as maternal barriers for optimal complementary feeding. Lack of breast milk has been reported in various country

settings as a reason to give infants other foods early (37–41). Mothers said that the infants were fussy or still hungry even after being breastfed. Some mothers believed that their milk production decreased because of their workload.

Breast milk generally contains the nutrients needed for infants' growth during the first 6 mo of life. Whereas water-soluble vitamins in breast milk can vary with maternal intake, several other components of breast milk do not change much during the lactation period (2, 42–44). Highlighting the importance of a diverse diet and appropriate fluid intake for the mother during the lactation period could be needed during the nutrition education sessions. Also, increasing support for lactating mothers will be helpful in delaying early introduction of complementary foods because breast milk production is more dependent on breastfeeding frequency, length of each feeding episode, and fluid consumption (45). Support can be material (financial, food, resources), emotional (encouragement and positive reinforcement), or practical (help with household chores). All kinds of support have been shown to improve breastfeeding practices (46), particularly paternal support (47).

Some mothers avoided giving eggs, beans, and sometimes milk as complementary foods because they believed young children could not tolerate these foods. Mothers also perceived that their infants had limited ability to digest foods saying that foods should be appropriate for the infant's age. Not giving children certain foods on the basis of their being "heavy" or "hard" has been also reported in Ethiopia (23), Bangladesh (38), Mexico (48), and Senegal (49). Some of these foods, particularly eggs and beans, are nutrient-dense and should be included in the infant's diet to complement breast milk. In Madagascar, nutrition education sessions would be effective in addressing such maternal barriers because of the mothers' trust in the CNAs. Emphasizing the importance of a diverse diet and providing examples of how to prepare these commonly avoided foods so they are appropriate for young children could encourage the mothers to include them as complementary foods.

Mothers also mentioned as a problem not having enough time and being tired because of agricultural work. Especially during the lean season, most mothers helped their spouses provide for the family by engaging in casual labor. In addition, they still needed to take care of household chores and the children. Encouraging the engagement of fathers in child care activities has the potential to reduce maternal workload by sharing the responsibilities in the household. Greater paternal involvement has been associated with better child feeding practices in various LMIC (50–54).

Similar to other LMIC, food insecurity and lack of income were additional constraints to appropriate complementary feeding (22, 23, 37, 39, 55, 56). This highlights the central role of agriculture in nutrition, because agriculture is a source of both income and food for rural households (57). Due to the seasonality of agricultural production, foods are only available during certain periods of time, mainly during the harvest and postharvest seasons, which considerably constrains food supply. Also, land access is limited; most households in our sample were small-holder farmers owning on average 43.9 m². In addition, farmers very commonly sell all of their fresh produce during harvest season, and then buy food later for consumption. Integrating agriculture and nutrition by addressing food security while emphasizing the importance of diverse, nutrient-dense foods for infant growth and development has potential

benefits. Interventions combining homestead food production and behavior change strategies for complementary feeding practices reported positive results on vegetable production as well as children's nutritional status (58, 59).

In addition, key in improving complementary feeding practices is the support of other family members for the mothers in deciding what foods to give the child. Greater women's autonomy and more agency in decision making over child nutrition have been associated with improved feeding practices and child nutritional status (60–63). The mothers' trust in the CNAs and their overall positive relationship is also an important facilitator for optimal feeding practices. Ensuring that the CNAs, as frontline workers, are well trained in providing the needed services to the population at the community nutrition centers is crucial. Regular training for the CNAs is needed, not only on the technical aspects of child feeding and nutrition, but also on interpersonal communication and counseling.

To a lesser extent, mothers also seek information from their friends and the elders regarding complementary foods. This could be either a barrier or an opportunity for optimal feeding practices, depending on the knowledge and the perceptions of the elders and the community members. Grandmothers' knowledge has been shown to influence maternal feeding practices in various LMIC (64–66). Involving grandmothers when designing interventions can reinforce the messages targeted to the mothers regarding appropriate feeding practices. A peer-to-peer model (67), where a group of mothers share information among themselves in addition to the traditional sessions by health workers, also could increase the effectiveness of interventions. Peer counseling interventions reported promising results in promoting optimal breastfeeding practices (68) and reducing child undernutrition (69, 70).

The identified barriers and facilitators are valuable information to be used to design future interventions in the Vakinankaratra region. Such insights regarding the local context are key factors to consider, especially for behavior change interventions (71).

The cross-sectional design of this study, which does not allow for causal association between child feeding knowledge, practices, and child growth is a limitation. Although such studies will be difficult to conduct because of the multifactorial aspects of undernutrition, longitudinal designs such as cohort and intervention studies are needed. In addition to the suboptimal complementary feeding practices, several underlying factors are likely to contribute to the observed high rates of child stunting and underweight. We only collected data from communities covered by the national community nutrition program, which are assumed to be more vulnerable than communities without community nutrition sites. Also, the timing of our data collection spanned the end of the lean season and the beginning of harvest season, which might influence the quantity and the quality of complementary foods given to infants. Lastly, recall bias and social desirability are inherent limitations for this type of research. For the qualitative questions, we conducted IDIs to confirm the answers given by the mothers in the focus groups.

However, this study is the first to assess maternal knowledge and practices of complementary feeding and their association with child anthropometrics in the Vakinankaratra region of Madagascar. To the best of our knowledge, this study is the first to systematically identify barriers and facilitators of appropriate feeding practices using a qualitative approach. Use of the mixed-methods design provides a more comprehensive evaluation of the complementary feeding situation and how it

relates to child nutritional status in a region with limited data, but with a high burden of undernutrition.

In conclusion, stunting and underweight rates were very high in children aged <2 y in the Vakinankaratra region. Although only 1 IYCF indicator was significantly associated with child growth, efforts are needed to improve complementary feeding practices. The identified barriers and facilitators support the need for integrating agricultural interventions with a behavioral change component to improve feeding practices. Also, strengthening the local community health worker structure and training has potential benefits.

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