Original Article

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Complementary Feeding: Food Group Diversity and Probability of Nutrient Adequacy among 6-12-Month-Old Infants in Southern Thailand

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Abstract:

Objective: To determine complementary food intake, food group diversity and nutritional adequacy of 6-12-month-old infants in southern Thailand.

Material and Methods: A total of 120 healthy infants, aged 6-12 months, were enrolled: from December 2020 to November 2021. A 24-hour food record was used to assess the type, amount and frequency of food intake in each infant. The infants' food intake was classified into seven food groups. Macronutrient and micronutrient intakes were analysed using the INMUCAL software program; the standard program for the calculation of nutrients in Thai food.

Results: Of the 120 infants, 10 (8.3%) received breast and/or formula feeding without complementary food; 30 (25%) received 1, 66 (55%) received 2, and 14 (11.7%) 3-4 received complementary meals a day. The 4 most common supplementary foods given to the infants were rice mixed with vitamin A-rich fruits or vegetables, meat, eggs, or other fruits (mostly bananas). Infants who received 1 complementary meal, with 1-3 food groups a day, had significantly higher percentages of micronutrient inadequacies (iron, magnesium, selenium and vitamin E) than those receiving at least 2 complementary meals; with at least 4 food groups a day.

Conclusion: Infants in southern Thailand who were fed <4 food groups with <2 complementary meals a day were at risk of micronutrient inadequacies; such as iron, magnesium, selenium and vitamin E. Therefore, infants aged 6-7 months should be given a minimum meal frequency (MMF) of 2 meals, with a minimum dietary diversity (MDD) of 4 food groups per day.

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Introduction

Nutritional adequacy in the first 1,000 days of life, from conception to 2 years of age, is known to be the main factor for determining healthy physical growth and neurobehavioral development. It is also the main factor in preventing nutritional and nutrition-related disorders[1]. In many developing countries, inadequate intake of macronutrients in the first year of life is the main cause of poor growth, which can result in wasting and/or stunting[2]. Inadequate intake of some particular micronutrients, such as iron, can result in iron deficiency anemia[3-5]. According to the World Health Organization (WHO) as well as the United Nations Children's Fund (UNICEF) recommendation, infants should be exclusively breastfed for the first 6 months of life. Then after 6 months, in addition to breastfeeding, infants should be fed with complementary foods 2-3 times a day between the ages of 6–8 months, and this should be increased to 3-4 times between 9-11 months. Additionally, the recommended complementary foods should include at least five of the seven food groups to meet minimum micronutrient requirements[6-9].

Thailand, a country in Southeast Asia, has been transiting from a low-income to upper middle-income country as of 2011[10] and is now facing an increase in the obesity and overweight population. In addition, under-nutrition remains a problem, and is recognized as the 'double burden of malnutrition'[11-12]. The Department of Health, Ministry of Public Health of Thailand follows the WHO and UNICEF recommendations of exclusive breastfeeding for at least 6 months and then adding complementary foods of 1-2 meals a day after 6 months of age[13]. A national survey, the Multiple Indicators Cluster Survey (MICS) of 2019, in 17 of 77 provinces in the five regions of Thailand (Bangkok, Central, North, South, and Northeast), conducted among 4,125 children aged 6–23 months, found that 92% of infants aged 6–8 months were given complementary food; with an adequate minimum meal frequency (MMF) per day of 88.8%. However, only 42.4% of them reached the minimum dietary diversity (MDD) of 5 food groups[14].There have been a limited number of studies from southern Thailand concerning infant feeding after 6 months of age, including the number of food groups and meal frequencies of complementary foods. This present study was performed with an aim to examine the complementary feeding practices of the mothers of 6-12-month-old infants in terms of nutrient intake, the number of food groups as assessed by the MDD, the number of feedings or MMF; and the mean probability of micronutrient adequacy (MPA). The secondary outcome was to determine any associations between nutrient intake and the MDD, MMF, and MPA assessments.

Material and Methods

This study was undertaken as part of a cross-sectional study of nutritional intake and vitamin D insufficiency in healthy term infants (age 6–12 months) and their mothers in the Well Child Clinic, Songklanagarind Hospital; from December 2020 to November 2021[15]. One hundred and twenty infants were enrolled, based on the sample size calculation of 30%, prevalence of vitamin D deficiency and iron deficiency anemia in young children, as reported in the South-East Asian Nutrition Surveys (SEANUTS)[16]. The details on infant feeding, growth parameters and the nutritional status of the infants were analysed to examine the feeding practices the mothers provided to their infants.

The protocol was approved by the Ethics Committee of the Faculty of Medicine, Prince of Songkla University (REC. 63-358-1-1). After the mothers gave written informed consent, they were scheduled for their study visit and given a 24-hour food record form to fill out the day before their visit.

Anthropometric measurements and nutritional status

On the scheduled day, each infant had their weight, length and head circumference measured by an experienced nurse at the Well Child Clinic. The infants were weighed, without clothing or diaper, on a digital weighing scale (Seca, Model 882 GmbH, Hamburg, Germany) to the nearest 0.01 kg. The recumbent length of the infant was measured with an infantometer to the nearest 0.1 centimeter (cm). Head circumference was measured in the occipito-frontal line using a non-elastic plastic tape to the nearest 0.1 cm. WHO weight-for-age z-scores (WAZ), length-for-age z-scores (LAZ), and weight-for-length z-scores (WLZ) were calculated according to the 2006, WHO Child Growth Standards[17]. These were then classified into normal, underweight or overweight. Underweight, stunting and wasting were defined as a WAZ score lower than -2, a LAZ score lower than -2 and a WLZ score lower than -2 of the median values of the WHO standards, respectively. Overweight was defined as a WLZ score greater than +2.

Assessment of infant feeding

The 24-hour food record used in this study was an open-ended list for quantitatively and qualitatively assessing food consumed during a complete 24-hour day (00.00 hours to 24.00 hours), prior to the scheduled Well Child Clinic visit. The mothers were instructed to fill out the details of food intake of their infant during the 24-hour period, and to specify the timing and frequency of breastfeeding, amount of formula feeding and the ingredients and amounts (size of spoon/cup/bottle) of each food item (rice/noodles/bread); meat, eggs, vegetables, fruits, snacks, and desserts or sweetened juice. Medications, such as multivitamins and iron supplements, were also included in the food intake list. At their Well Child Clinic visit, the mothers underwent a detailed interview for 10–15 minutes, by an experienced dietitian, to recheck their food records for the accuracy of the types and amounts of each food consumed.

Food group diversity

The foods consumed by the infants were classified into seven groups[18, 19]: 1) grains, roots, and tubers; 2) legumes and nuts; 3) dairy; 4) flesh meat (beef, pork, poultry, liver, and fish); 5) eggs; 6) vitamin A-rich fruits and vegetables; and 7) other fruits and vegetables.

Calculation of nutritional intake

The nutritional intake of macro- and micronutrients was analysed using INMUCAL, the standard software program for calculating the macro- and micronutrients of Thai food, created by Mahidol University, Thailand[20]. For exclusively breastfed infants, the amount of human milk was assumed to be 800 milliliter (mL)/day[13]. For formula-fed infants, the amount of milk intake was calculated from the reported amount on the 24-hour food record.

Estimating the probability of micronutrient adequacy

The calculated, total intake of each micronutrient from the 24-hour food record of each infant was transformed into a probability of adequacy (PA) figure. To calculate overall nutritional adequacy in the infant cohort, the medians to the means was preferred, because the means could introduce calculation errors with regard to nutrient over- or under-consumption. An individual intake ≥100% of the Thai RDI[13] was rated as 0.1, and an intake <100% was rated as 0[21,22]. The sum of all adequate micronutrient intakes in each infant was then calculated to a maximum of 1.0. Hence, the mean PA (MPA) for micronutrient intake in an individual had a range of 0 to 1. The food groups included in the MPA of the infants and young children (MPA-IYC) mostly reflected diet quality, with the probability of achieving minimum micronutrient adequacy containing 11 important micronutrients: vitamin A, vitamin B1 (thiamine), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B6 (pyridoxine), vitamin B12 (cobalamin), vitamin C, vitamin E, calcium, iron, and zinc. (vitamin D was not included, as the major source of vitamin D is cutaneous synthesis from direct sunlight exposure. Additionally, vitamin D intake could be affected by the type of main milk intake, as vitamin D content in breast milk is very low: 10-50 International Units Per Liter (IU/L); while vitamin D content in fortified-formula milk is very high: 400 IU/L).

Statistical analysis

The R program (R Foundation, Austria, available from http://www.r-project.org/foundation/main.html) was used for all statistical analyses. The characteristics of the infants and the mothers were described in numbers and percentages (categorical variables) or means±standard deviations (continuous variables). The nutritional intakes of the macro- and micronutrients of the infants were reported as means, medians and ranges. Comparison of the numbers of infants with inadequate nutrient intake whilst receiving different food group intakes, were compared using the chi-square test. Significance was set at a p-value <0.05. The Student's t-test was used to compare the differences of nutrient intakes between infants receiving dietary diversity <4 food groups and ≥4 food groups. Analysis of variance (ANOVA) was used to compare the nutritional intake among the infants of the 3 age groups, 6-7.9, 8-9.9, and 10-12 months of age. Spearman's rank coefficient was used to identify correlations between the MPAs and the number of food groups the infants consumed.

Results

Characteristics of the infants and their mothers

The characteristics of the study infants and their mothers are shown in Table 1. Of the 120 infants enrolled, 70 (58.3%) were male. The average age of the infants at the time of enrollment was 7.2±1.7 months. The average age of the mothers was 33.2±4.4 years. The level of maternal education was mostly a bachelor degree (77.5%). The average family income was 39,810±24,480 baht/month, which was classified as middle-class income. None of our infants received vitamin, iron or other nutrient supplementation.

Table 1 Characteristics of the 120 study infants

Characteristic	Mean±S.D.	Range
Infants		
At birth		
Gestational age (weeks)	38.6±1.0	37-41
Birth weight (kg)	3,100±380	2,600-4,100
Birth length (cm)	49.5±1.5	47-52
Head circumference (cm)	34.2±1.0	33-36
At recruitment		
Male, n (%)	70 (58.3)	
Age (months)	7.3±1.7	6-12
Weight (kg)	7.9±1.1	5.3-10.6
Length (cm)	68.2±3.3	60-77
Head circumference (cm)	43.3±1.5	39-46
Weight z-score	0.45±1.27	-2.28-3.71
Length z-score	0.56±0.99	-1.83-3.40
Weight/Length z score	0.05±0.93	-0.30-1.68
Head circumference z-score	-0.07±0.93	-2.46-2.92
Mothers		
Age (years)	33.2±4.4	22-42
Level of education, n (%)		
Secondary school	27 (22.5)	
College/university	93 (77.5)	
Family income (baht/month)	39,810±24,480	15,000-180,000

S.D.=standard deviation, kg=kilogram, cm=centimeter

Anthropometric measurements and nutritional status

The mean weight of the infants was 7.9±1.1 kg, with a mean WAZ score of 0.45±1.27. The mean length of the infants was 68.2±3.3 cm, with a mean LAZ score of 0.56 ±0.99. According to WHO definitions, only 2 infants (1.7%) were underweight and wasted (WAZ and WLZ scores <-2, none were stunted (LAZ score <-2) and 13 (10.8%) were overweight (WLZ score >2).

Food group diversity

Of the 120 infants, 69 (57.5%) were mainly breastfed, 10 (8%) received breast and/or formula feeding without complementary food, 30 (25%) received 1 complementary meal, 66 (55%) received 2, and 14 (12%) received 3-4 complementary meals a day. The median age of the infants fed with 1 meal of complementary food containing 1-3 food groups was 6.5 months. Complementary food intake gradually increased to 2-3 meals per day, with 4-5 food groups at the median age of 8 months. The 4 common food groups the mothers fed their infants were: grain (83%), vitamin A-rich fruit or vegetables (81%) (most common source was from mashed pumpkin, followed by carrot), fruits (71%, common fruits were mashed banana, orange juice and mashed papaya), and meat (67%, the common meat sources were from minced pork, poultry and fish). Dairy products and eggs were given to 45% and 44% of the infants, respectively. None of this study's infants were given nuts or legumes, desserts or sweetened juice, or instant baby food. Of the total 120 infants, 78 (65%) were given at least 4 food groups, while 32 (27%) were given 1-3 food groups and 10 (8%) received no complementary meals.

As infant feeding varies with age, this study divided the infants according to age in months into 3 groups: 6-7.9 (n=70), 8-9.9 (n=23), and 10-12 months old (n=27). Significantly increased percentages were found with age of food groups in the infants who consumed in grains, meats and eggs (Figure 1). Vitamin A-rich fruits/vegetables and other fruits were given to the infants in high percentages at 80-85 and 60-70%, respectively, while dairy products were given in only 40-50% in each age group, with no significant differences among the 3 age groups. The total food groups, as well as the feeding frequencies per day increased with the age of the infants. The median total food groups intake was 4 in infants aged 6-7.9 and 8-9.9 months, which significantly increased to 5 food groups at the age of 10-12 months. The median complementary food feeding frequency of the infants significantly increased from 1 meal in infants aged 6-7.9 months to 2 and 3 meals per day in infants aged 8-9.9 months and 10-12 months, respectively. (Figure 2.)

Calculation of nutritional intake

Nutrient intake is expressed in grams (g), milligrams (mg), or micrograms (μg). The Thai RDI and the mean, median, range and percentages of infants that consumed each nutrient intake, with ≥100% of the Thai RDI, are shown in Table 2. The mean and median caloric intakes of these infants were 761 and 722 calories/day, respectively (range 543-895); with appropriate ratios of carbohydrates (48%), proteins (10-11%), and fats (41-42%). Overall, the mean and median intakes of all macronutrients and a lot of micronutrients were ≥100% of the Thai RDI, with the exceptions of iron, magnesium, selenium, vitamin D and vitamin E, for which the intakes were lower than 100%. It is notable that the average vitamin A intake was over 2-fold greater than the Thai RDI, with the main source of vitamin A intake from mashed pumpkin or carrot mixed with rice congee; the most favored food the Thai mothers gave to their infants.

Food group diversity and nutritional adequacy

As the median number of food groups among this study's infants was 4, the nutrient intake between the infants given <4 food groups a day (n=42 or 35%, all were fed 0-1 complementary feedings a day) to those who were fed with ≥4 food groups a day (n=78 or 65%, of whom 72 or 92% were given complementary foods at least 2 times a day) was compared. It was found that infants who received complementary feedings of <4 food groups were significantly younger than those who received ≥4 food groups (6.2 and 7.4 months, respectively, p-value<0.01). The average body length and head circumference of the infants receiving ≥4 food groups were significantly higher than those receiving <4 food groups; however, these were not significantly different when adjusted for age with standard deviation scores. Nutrient intakes, both macro- and micronutrients, were significantly lower in infants receiving complementary feedings of <4 food groups than in those receiving complementary feedings of ≥4 food groups.

Using the Thai RDI as a reference, infants receiving ≥4 food groups had adequate nutrient intake, except for iron and magnesium; whereas, infants receiving <4 food groups had inadequate intake of carbohydrate and many micronutrients (iron, magnesium, selenium, zinc, all vitamin Bs, niacin and vitamin E. (Table 3)

For growth parameters, there were no significant differences between infants receiving <4 food groups and those receiving ≥4 food groups in any of the growth parameters, WAZ, LAZ, or WLZ scores, and no differences in maternal factors (age, level of maternal education and family income).

Estimating the probability of micronutrient adequacy

The percentages of participants with ≥100% of the Thai RDI for each micronutrient are shown in Table 2. Of the 11 micronutrients assessed, the median percentage intake of any micronutrient was lowest for iron (58%), followed by vitamin E (72%). After the PAs of the 11 selected micronutrients, according to the Thai RDI, were transformed to 0 or 0.1; as described above, the sum of the adequate intake of the 11 micronutrients by each infant was calculated as the MPA[20-21]. It was found that the overall average MPA for the 11 micronutrients was 0.7, and was significantly correlated with the number of food groups consumed: as shown in Figure 3 (r=0.46, p-value<0.001). Infants who were fed with <4 food groups had an MPA of 0.2-0.3; except for infants that were fed with only one food group for whom the MPA was high at 0.6: these infants were fed with infant formula. Infants fed with 5 or 6 food groups had a high MPA of 0.8-0.9.

Table 2 Nutrient intakes of the study infants shown in mean, median and range and the median percentage of intake compared to the Thai recommended daily intakes (Thai RDI)

Nutrient intake	Thai RDI 2020	Actual intake			Intake in % RDI
		Mean	Median	Range	Median
Total calories (kcal)	680	761	722	543-895	109
Carbohydrate (g)	85	94	84	66-98	101
Protein (g)	14	20	17	10-22	115
Fat (g)	-	34	33	25-41	-
Cholesterol (g)	-	95	76	28-114	-
Calcium (mg)	260	404	313	233-493	112
Phosphorus (mg)	275	309	259	138-390	107
Iron (mg)	9.0	6.0	5.3	1.5-9.5	58*
Copper (mg)	0.4	0.6	0.5	0.4-0.6	129
Magnesium (mg)	60	37	32	7-60	55*
Selenium (µg)	20	18	16	10-22	80*
Zinc (mg)	2.27	3.8	3.0	1.5-5.6	103
Vitamin A (µgRE)	250	923	617	463-1,100	254
Vitamin D (µg)	5.0	4.5	3.6	1.0-9.0	73*
Vitamin B1 (mg)	0.3	0.4	0.3	0.1-0.7	106
Vitamin B2 (mg)	0.4	0.8	0.7	0.2-1.2	162
Vitamin B6 (mg)	0.3	0.3	0.3	0.1-0.5	100
Vitamin B12 (µg)	0.5	1.0	1.6	0.4-2.9	157
Vitamin C (mg)	50	81	70	41-108	158
Niacin (mgNE)	4.0	5.3	4.5	2.8-6.5	112
Vitamin E (mgTE)	5.0	4.3	3.6	0.8-7.5	72*

kcal=kilocalorie, g=gram, mg=milligram, ug=microgram, ugRE=microgram retinol equivalent, mgNE=milligram niacin equivalent

Table 3 Comparison of nutrient intake between infants receiving dietary diversity <4 food groups and ≥4 food groups; as compared to the Thai RDI

Characteristic/Nutrient intake	Thai RDI 2020	Food groups <4 (n=42)	Food groups ≥4 (n=78)	p-value
Age (months)	-	6.2	7.4	0.002
Male, n (%)	-	27 (64%)	43 (56%)	0.44
Weight (kg)	-	7.7	8.0	0.24
Length (cm)	-	67	69	<0.01
Head circumference (cm)	-	42.9	43.5	0.04
Weight z-score	-	0.60	0.40	0.50
Length z-score	-	0.60	0.50	0.70
Head circumference z-score	-	-0.10	-0.10	0.82
Weight/Length z-score	-	0.20	0.10	0.54
Total calories (kcal)	680	545	794	<0.01
Carbohydrate (g)	85	71*	106	<0.01
Protein (g)	14	12	20	<0.01
Fat (g)	-	26	37	<0.01
Calcium (mg)	260	252	414	<0.01
Phosphorus (mg)	275	189	308	<0.01
Iron (mg)	9	1.6*	6.4*	<0.01
Copper (mg)	0.4	0.43	0.54	<0.01
Magnesium (mg)	60	21*	49*	<0.01
Selenium (µg)	20	13*	20	<0.01
Zinc (mg)	2.27	1.62*	4.22	<0.01
Vitamin A (µgRE)	250	481	708	<0.01
Vitamin D (µg)	5.0	1.3*	5.7	<0.01
Vitamin B1 (mg)	0.3	0.25*	0.50	<0.01
Vitamin B2 (mg)	0.4	0.35*	0.90	<0.01
Vitamin B6 (mg)	0.3	0.2*	0.4	<0.01
Vitamin B12 (µg)	0.5	0.47*	2.05	<0.01
Vitamin C (mg)	50	52	85	<0.01
Niacin (mgNE)	4.0	3.0*	5.4	<0.01
Vitamin E (mgTE)	5.0	1.5*	5.0	<0.01

*nutrient intake lower than Thai RDI, 2020

mgTE=milligram thiamin equivalent, µg=microgram, µgRE= microgram retinol equivalent, mg=milligram, kcal=kilocalorie, g=gram

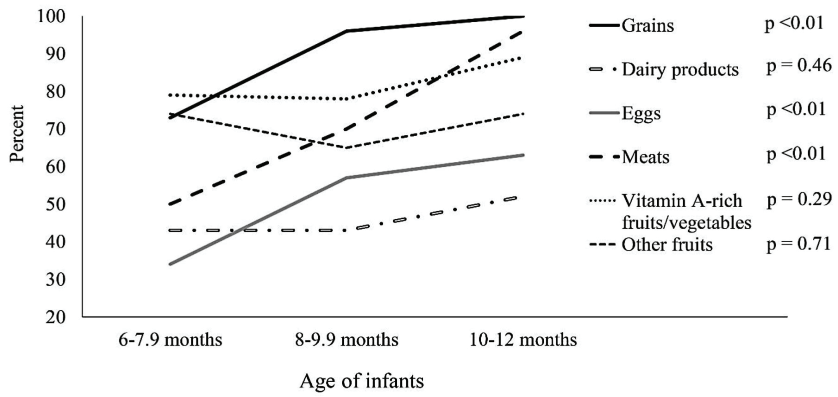

Figure 1 Percentage of each food group consumed per day according to age of the study infants

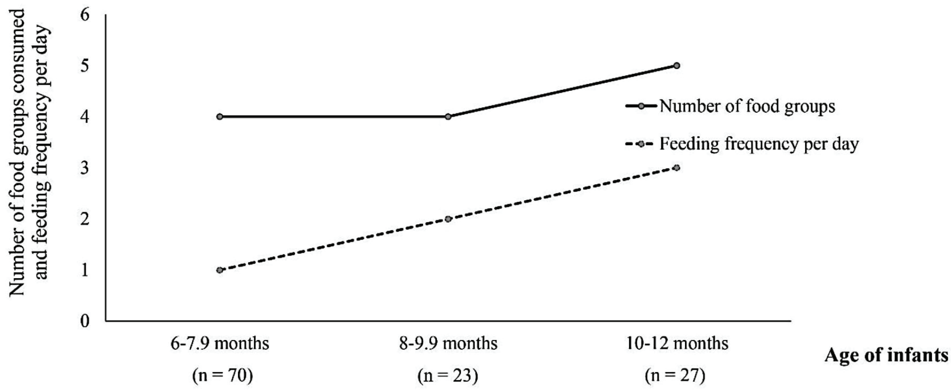

Figure 2 Number of food groups consumed and feeding frequency per day of the study infants

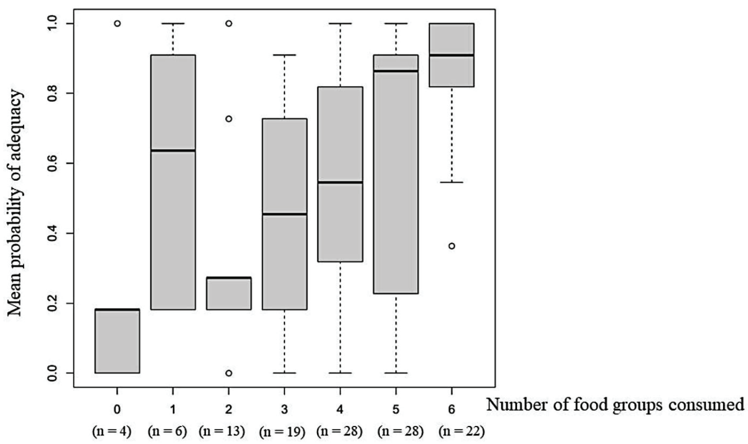

Figure 3 Increases in the mean probability of adequacy with the number of food groups consumed

Discussion

In this study, it was found that Thai mothers preferred to feed their infants with only breast milk or infant formula up to the age of 6 months. They then started to give the first complementary feedings to their infants at the median age of 6.5 months. Then they increased the complementary feedings to 2-3 meals per day, with 4-5 food groups at the median age of 8 months. Complementary food was first given to the infants at 1 meal per day with 1-3 food groups and was gradually increased to 2-3 meals per day with 4-5 food groups. Using the Thai RDI values as a reference, most infants receiving an MDD ≥4 food groups per day had adequate nutrient intake, except for iron and magnesium; whereas, infants receiving <4 food groups per day had inadequate intakes of carbohydrates and many micronutrients (iron, magnesium, selenium, zinc, all vitamin Bs, niacin and vitamin E). The overall percentage of this study's infants receiving an MDD of ≥4 food groups and an MMF of ≥2 meals a day was 65%, of whom most were over 8 months old. Also, the MPA of the infants confirmed that the infants that were fed with <4 food groups daily had a very low average MPA: 0.2-0.3, while infants who were fed with ≥4 food groups had a high average MPA: 0.7-0.9.

In this study, complementary feeding was introduced at the ages of 6-7 months, which was a later age than in a national study of 2019, and a study from Pathum Thani in which both found that complementary feedings were introduced at the ages of 4-5 months[14,23]. The common food groups of complementary foods in this study found that the Thai mothers first gave to their infants after 6 months of age were grain (rice congee) mixed with vitamin A-rich fruits or vegetables (pumpkin, carrots), which could explain the high vitamin A intake in Thai infants. This is similar to the findings of the previous by mentioned studies from Thailand[14,23]. Mashed banana was also the favorite fruit the Thai mothers gave their infants after the age of 6 months. Hence, the average complementary feeding schedule in Thai infants at the age of 6-7 months was 1 meal with 2-3 food groups per day, which both this study and anecdotal evidence indicate is a very common feeding pattern for Thai infants. At the age of 7-8 months, complementary feedings increased to an average of 2 per day, generally consisting of rice congee and pumpkin mixed with meat or egg. Many of the infants were found to have higher than recommended levels of vitamin A-rich foods, which can lead to jaundice-like yellowing of the skin or hypercarotenemia; a common, benign condition that is spontaneously resolved when vitamin A-rich food is reduced or stopped[23,24]. However, despite this high intake of vitamin A-rich foods, none of the infants had this hypercarotenemic skin color. In this study, formula-fed infants began receiving complementary food at the age of around 7 months, which was later than the breastfed infants. This could explain the high median MPA of 0.6, despite the intake of only 1 food group of formula milk intake of >1,000 mL per day) (Figure 3).

Both breast milk and infant formula have a high magnesium content of 30 mg/L, which is adequate for infants younger than 6 months old, but insufficient for 6-12-month-old infants that require magnesium 60 mg/day. For iron status, breast milk contains very little iron: only 0.5 mg/L, while fortified infant formula contains 5-6 mg/l[12]. Red meat and egg yolk contain high levels of multiple micronutrients; including iron, magnesium, selenium, and many important vitamins[13]. Therefore, complementary foods; including red meat or egg yolk, are the main sources of iron, magnesium, selenium, and many important vitamins for older infants. In this study, meats and eggs were given to 67% and 45% of the infants, respectively, with 30-50 g of meat or half an egg a day. Although this provided adequate protein intake it was an inadequate iron, magnesium or selenium intake.

Commonly consumed Thai foods having relatively high contents of selenium are eggs and meats, of which 100 g of egg, pork or poultry contains 40, 15 and 20 mg of selenium, respectively, and magnesium-rich foods are dark green leafy vegetables, cereals and some fruits[26]. Vitamin E intake was inadequate in most of our infants, which could be explained by a limited intake of the vitamin E-rich food group (nuts, seeds, legumes, and all kinds of oils), as Thai mothers do not use cooking oil for infant feeding. Also, nuts and legumes are also avoided in infant feeding in this age group, because the parents or caregivers are concerned about aspiration while feeding. This is due to nuts being known to be the most common foreign body aspirated into the respiratory tract within the infant age group[27,28]. Also, desserts, sweetened juice or instant baby food were not given to any of this studied infants, as their mothers were aware of the added sugars and preservatives in these kinds of food, which can result in poor oral hygiene and dental caries.

Wasting was found in only 1.7% of the study infants, while 10.8% were overweight. The findings of a low prevalence of wasting along with a high prevalence of overweight in this study were related to the ongoing transition of Thailand from a low-income to an upper middle-income country[10, 29]. This study's infants were mostly from middle- to high-income families and generally received an adequate nutritional intake. Moreover, the natural and locally available foods used in Thai infant feeding are simple and affordable; even for low-income families. No feeding factors with either wasting or overweight could be correlated. The low prevalence of wasting infants in this study was similar to a previous study in Thailand, conducted at Pathum Thani, a city near Bangkok, which showed prevalences of wasting infants at 3.6% and stunting at 8.2%[30].

This study had both strengths and limitations. The main strength is that it demonstrated an association between common micronutrient inadequacies and lower food group diversity along with the number of complementary feedings a day in infants aged 6-7 months; the age of introducing complementary foods besides milk intake. Second, it used a 24-hour food record to collect a complete 24-hour food intake for accurate nutrient assessment, dietary diversity and feeding frequency. It was also aware of potential errors from self-reported dietary intake; thus, it compensated for these potential errors by an in-depth interview of each mother, by an experienced dietitian to ensure the precision of the dietary intake record. Third, nutritional intakes were calculated for both macro- and micronutrients, in which some micronutrient inadequacies were significantly associated with lower dietary diversity. The main limitation was that the sample size was small: 120 infants, with 58% of them being aged at 6-8 months in addition to a small number of only 10-20 infants per MPA subdivision. Second, the infants were enrolled from a Well Child Clinic, which created a potential selection bias in favor of infants from middle- to high-income families, with higher-educated parents. However, despite this potential limitation thisstudy identified inadequate intake of some micronutrients associated with lower food diversity and lower feeding frequency.

Conclusion

this study found that infants in southern Thailand that were fed <4 food groups, with <2 complementary meals a day were at risk of micronutrient inadequacies; such as iron, magnesium, selenium and vitamin E. This suggests that in this setting, infants aged 6-7 months should be given an MMF of 2 meals containing an MDD of 4 food groups per day; as recommended by both the WHO and UNICEF.

Ethics approval

Ethical approval was obtained from the Institutional Review Board and Ethics Committee of Songklanagarind Hospital, Prince of Songkla University (REC.63-358-1-1).

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Conflict of interest

There are no conflicts of interest to declare.

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