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Original Article

Dietary intake and stunting in children aged 6-23 months in rural Sumba, Indonesia

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Abstract

Background Linear growth retardation in the first two years of life leads to numerous harmful consequences. Lack of diversity in the diet and inadequate amounts of complementary food have been associated with stunted growth in children.

Objective To assess the dietary intake and investigate for associations with stunting among children aged 6-23 months.

Methods This case-control study compared the dietary intake of children aged 6-23 months with and without stunting in the South and West Wewewa subdistricts of Southwest Sumba, East Nusa Tenggara, Indonesia. Complementary food types, dietary diversity, and nutritional intake were assessed and compared between groups. Nutrient intake sufficiency and stunting were analyzed by logistic regression.

Results A total of 200 participants were equally allocated into groups with and without stunting. Only 6% of stunted children received adequate complementary food diversity compared to 14% of non-stunted children (P=0.05). The stunted group had significantly lower consumption of flesh foods (beef, fish, poultry, organ meat, and other kinds of meat) compared to the non-stunted group (7% vs. 16% of subjects, respectively; P<0.05). The median total protein intake was also significantly lower in stunted children compared to non-stunted children [7.72 (IQR 6.46, 11.31) g *vs.* 10.02 (IQR 6.53, 13.95) g, respectively; P<0.05] although no association was found between protein intake sufficiency and stunting in the multivariate analysis. Only maternal unemployment was positively associated with stunting (OR 2.32; 95%CI 1.26 to 4.26).

Conclusion Overall, most subjects did not receive sufficient amounts of nutrients. Although dietary diversity was not found to be significantly different between those with and without stunting, a significantly lower proportion of stunted children consumed flesh food. The stunted group also received significantly lower protein from their diet although no association was found between nutrient intake sufficiency and stunting. Further studies are needed to longitudinally assess the effects of macronutrient and micronutrient intake sufficiency on linear growth in children. **[Paediatr Indones. 2022;62:341-56DOI: https://doi.org.10.14238/pi62.4.2022.341-56]**.

Keywords: *stunting; complementary feeding; dietary intake; dietary diversity; macronutrient and micronutrient; Indonesia*

It has long been recognized that early linear growth retardation in the first two years of life leads to numerous negative consequences.[1-3] Linear growth is positively associated with cognitive and motor development, especially for children living in low and middle income countries.[1] Children with stunted growth in this period are more likely to have deficits in neurocognitive and motor development skills.[1,2] They also tend to enroll in school at a later age and have worse school performance.[4] In addition, adults who had stunted growth in childhood have lower productivity levels and a higher risk of chronic diseases due to altered lipid metabolism.[2,5] Considering these potential harms, early prevention measures, such as identifying risk factors of stunting, are needed to mitigate these debilitating consequences.

East Nusa Tenggara has consistently been the province with the highest stunting prevalence in under-five children in Indonesia.[6,7] Based on a national survey, around 43.8% of under-five children in the province were classified as stunted.[7] Southwest

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Sumba, one of the regencies in the province, also faced a similar issue, with around 46% of under-five children classified as stunted.[7] Stunted growth has been associated with multiple factors including inadequate nutritional intake.[8-10]

Linear growth retardation can have profound effects in the first two years of life, mostly occurring during the complementary feeding period of 6-23 months of age.[3,11] Adequate complementary feeding is one of the essential components supporting healthy childhood growth.[2] After the age of 6 months, breastfeeding is no longer adequate to meet the child's nutritional needs, thus, adequate complementary food intake is important to fill the nutritional gap.[12] Lack of dietary diversity and inadequate amounts of complementary food have been associated with stunted growth in children.[10,13]

Dietary diversity is one of the key elements of a quality diet. A more diverse diet is highly correlated with adequate energy, protein, and micronutrient intake.[14] Inadequate intake of such essential nutrition over a long period puts children at risk of stunted growth.[13,14]

Macronutrient components such as high quality protein and essential amino acids have been recognized as important elements that support childhood growth through their regulation of IGF-1 levels. Children with inadequate protein intake have been shown to have impaired linear growth.[15] Furthermore, energy deficiency in these childen can also lead to suboptimal growth as well as loss of body fat and muscle.[15] Maintaining sufficient intake of macronutrients as well as micronutrients such as iron, zinc, phosphorus, and vitamins is essential for proper growth.[16] Deficiency in one of the micronutrients, such as zinc or phosphorus, has been associated with growth retardation.[16,17]

Considering the harms of stunted growth in the first two years of life and the importance of diverse and adequate nutritional intake in supporting proper growth of children during the complementary feeding period, we aimed to study these issues. To the best of our knowledge, no such study has been done in Southwest Sumba as one of the highly prevalent areas of stunting in Indonesia. Thus, we aimed to investigate dietary intake and possible associations with stunting among children aged 6-23 months in rural Southwest Sumba.

Methods

This case-control study was part of a previous community-based study aiming to investigate the feeding practices of children aged 6-23 months who had received complementary feeding for a minimum duration of one month in South and West Wewewa subdistricts of Southwest Sumba, East Nusa Tenggara, Indonesia.[18] A total of 370 children and their biological mothers who visited the nutrition clinic and integrated health service posts of Tena Teke Community Health Center were interviewed from February to August 2019. Children with previously diagnosed or treated nutritional disorders, acute conditions affecting oral intake, chronic diseases, congenital anomalies, and preterm, post-term or multiple birth history were excluded from the study. The final database from the previous study was used as the basis of sample selection in this study.[18]

We compared dietary intake between children aged 6-23 months with and without stunting based on length-for-age *z*-score (LAZ) of the 2006 *World Health Organization (WHO) Child Growth Standards*.[19] Children with LAZ <-2 were allocated into the case group and the others were allocated as controls. Types of complementary food and dietary diversity as well as total energy, macronutrient, and micronutrient intake of both groups were analyzed.

The minimum required sample size was calculated for an unmatched case-control study. Based on a previous study in Indonesia, the proportion of stunted children aged 1-60 months who did not receive adequate energy intake (P1) was 69%, with an odds ratio (OR) of 2.37.9 With a sample size ratio of 1:1 for case and control groups, 95%CI ($Z\alpha=1.96$), and power of 80% ($Z\beta=0.842$), the minimum required sample size was 94 for each group. Subjects were obtained secondarily by stratified random sampling method using a computerized random number generator based on chronological age (6-11 months and 12-23 months).[20] Age was chosen as the determinant because it has a central role in determining the acceptability of complementary food, types and texture of food consumed, feeding frequency, and daily nutrient requirements.[21-23]

After acquiring written parental informed consent, interviews were conducted using a pre-tested questionnaire. Complementary food types, dietary diversity, and nutritional intake were assessed using the 24-hour food recall method. Mothers were asked to recount all the foods and beverages their child had consumed during a day before the interview, including night feedings. They were also asked to mention the name of the dishes, ingredients used to make them, and steps to prepare them. The estimated portions of food and beverages consumed by the child as well as the ingredients used in composite dishes were quantified using a household food serving size according to the food atlas of the *Indonesian Ministry of Health* and/or food models, as needed.[24] Probing questions were also used by the interviewers to help the mothers in recalling their child's dietary intake. For manufactured food and beverages, mothers were asked to mention the brand names; these were further confirmed with the actual packages or pictures of the products.

Total energy, macronutrients (carbohydrate, protein, fat), and micronutrients (vitamin A, vitamin C, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron, calcium, magnesium, zinc, and phosphorus) of the food and beverages consumed by the children were estimated using the *2017 Indonesian Food Composition Table* and *2007 Nutrisurvey*, accordingly.[25] For manufactured food and beverages, nutritional content of the products were acquired from the nutrition facts labels. In addition, protein-to-energy ratio (PER) as the fraction of energy acquired from protein compared to the total energy intake was also estimated.[26]

For breastfed children, the volume of breastmilk consumption was assumed as the daily "average intake" based on their age: 600 mL for those aged 6-11 months and 550 mL for those aged 12-23 months.[27-29] The nutritional content of breastmilk was estimated based on these assumed volumes and was added to subjects' total daily nutrient intake. The nutritional content of mature breastmilk applied was based on several studies and is presented in **Table 1**.[30-32] Subjects' total nutrient intake was compared to the Indonesian recommended daily allowance (RDA) to assess sufficiency.[22] The intake of macronutrients and micronutrients was considered to be sufficient if they achieved ≥80% RDA and ≥77% RDA, respectively.[33,34]

To assess complementary food type and dietary diversity, the WHO complementary food groups was used to categorize the dietary intake.[23] Complementary food was categorized into eight groups: (1) breastmilk; (2) grains, roots, tubers, and plantains; (3) pulses (beans, peas, lentils), nuts, and seeds; (4) dairy products (milk, infant formula, yogurt, cheese); (5) flesh foods (beef, fish, poultry, organ meats, and other kinds of meat); (6) eggs; (7) vitamin-A rich vegetables and fruits (dark green leafy vegetables e.g. cassava greens and deep yellow- and orange-fleshed

Table 1. Macronutrient and micronutrient content of breastmilk consumed by subjects according to age group

Nutritional content[30]	Reference (per 1000 mL)	6-11 months (600 mL intake)[29]	12-23 months (550 mL intake)[27,28]
Total energy, kkal	674.7	404.82	371.09
Carbohydrate, g	79.3	47.58	43.62
Protein, g	9.95	5.97	5.47
Fat,g	35.3	21.18	19.42
Vitamin A, RE	212	127.2	116.6
Vitamin C, mg	31	18.6	17.05
Thiamine, mg	0.16	0.1	0.09
Riboflavin,mg	0.15	0.09	0.08
Niacin, mg	1.02	0.61	0.56
Pyridoxine[31],mg	0.05	0.03	0.028
Folic acid, mcg	8.3	4.98	4.57
Iron, mg	0.6	0.36	0.33
Calcium, mg	181	108.6	99.55
Magnesium[32], mg	31	18.6	17.05
Zinc, mg	1.2	0.72	0.66
Phosphorus, mg	158	94.8	86.9

vegetables and fruits e.g. carrot, ripe papaya, etc.); and (8) other vegetables and fruits. Children who consumed ≥5 food groups were considered as having "adequate" dietary diversity, based on the WHO minimum dietary diversity indicator.[23] In addition, the types of animal source food (ASF) consumed and frequency of consumption in the seven days prior to the interview were also assessed. The ASF consumption was defined as the consumption of eggs, flesh foods, or dairy products.[10]

In addition to dietary intake, other characteristics were compared between groups, including participants' sociodemography, sanitation level, breastfeeding status, and history of fever, diarrhea, and upper respiratory tract infection (URTI) in the previous two weeks. Sanitation was defined by the WHO as access to and use of facilities and services for safe disposal of human urine and feces.[35] "Improved" sanitation was defined as the presence of safe excreta disposal systems (toilet with septic tank or pit latrine with or without slab) in the household where the child lives and not shared with other households. If one of these conditions was not met, sanitation was labeled as "not improved".[35] For household drinking water source, "improved" and "not improved" categorization was also used. Piped water, boreholes or tubewells, protected dug wells, protected springs, and rainwater collection were classified as improved sources. Unimproved sources were unprotected dug wells and springs, as well as surface water (river, canal, etc.).[36] Exclusive breastfeeding was defined as the practice of exclusively giving breastmilk without giving any other food and beverages, including prelacteal feeds, for ≥6 months.

Characteristics of participants, complementary food type, dietary diversity, and sufficiency of nutrient intake were presented as percentages. Nutritional content of complementary food and total daily intake were presented as continuous data. Normality of continuous data was analyzed using the Kolmogrov-Smirnov test; variables that were not normally distributed were reported as median with interquartile range (IQR). Bivariate analyses of categorical data were done using Pearson's chi-square and Fisher's exact tests as appropriate, while Mann-Whitney U test was done for continuous data. To investigate for an association with stunting by multivariate analysis, participants' characteristics as well as the sufficiency of total energy, macronutrient, and micronutrient intake that had P values <0.25 were included in a logistic regression model for adjustment and shown as odds ratio (OR) with 95%CI. Results with P values <0.05 were considered to be statistically significant. Statistical analyses were done using Statistical Package for *Social Science (SPSS) version 21.0* (*SPSS Inc.*, Chicago, IL, USA). This study was approved by the National and Political Unity Unit (Kesbangpol) of the Southwest Sumba regency.

Results

A total of 200 children and their mothers were included in this study and allocated into stunted and non-stunted groups, with 100 subjects in each group. Both age groups of 6-11 months and 12-23 months were equally represented. There were no differences among subjects with regards to gender, maternal age, number of family members and under-five children at home, as well as birth order, as presented in **Table 2**. The proportion of lower maternal educational level and monthly family income, as well as the number of unemployed mothers were higher in the stunted group. No notable differences were found in sanitation level, drinking water source, history of URTI, fever, or diarrhea in the past two weeks, or exclusive breastfeeding status between the two groups.

With regards to complementary food diversity, a higher proportion of children in the control group consumed ≥5 food groups compared to the case group, although this difference did not reach statistical significance (14% *vs.* 6%, respectively; P=0.05). Only 10% of all subjects had adequate dietary diversity, as shown in **Figure 1**. The proportion of children receiving breastmilk at the time of the interview was only slightly lower in the stunted group (65% *vs.* 71%, respectively; P=0.36). Significantly fewer stunted children consumed flesh foods compared to non-stunted children (7% *vs.* 16%, respectively; P=0.04), although <20% of all subjects consumed flesh food. Almost all children received the grain, root, tuber, and plantain food group as their main dietary source. In addition, there was no significant difference in terms of egg, dairy product, and pulses, nuts, and seeds consumption, although the consumption of these food groups was lower in the stunted group. Vitamin

Table 2. Characteristics of stunted and non-stunted subjects

Variables	Stunted (n=100)	Non-stunted (n=100)	P value
Gender, %			0.77
Male	54	52	
Female	46	48	
Maternal age, %			0.20
<35 years	69	77	
≥35 years	31	23	
Maternal educational level, %			0.01*
≥Middle school	47	64	
<Middle school	53	36	
Maternal work status, %			0.001**
Employed	29	51	
Unemployed	71	49	
Family members, %			0.77
≤4	46	48	
≥5	54	52	
Birth order, %			0.89
≤2	46	47	
>2	54	53	
Monthly family income, %			0.004**
≥ Rp 1 million	33	53	
< Rp 1 million	67	47	
No. of other children <5 years at home, %			0.25[b]
≤2	100	97	
≥3	0	3	
Sanitation, %			0.29
Improved	65	72	
Not improved	35	28	
Drinking water source, %			0.39
Improved	41	47	
Not improved	59	53	
History of URTIa in previous 2 weeks, %			0.39
Present	76	81	
Not present	24	19	
History of fever in previous 2 weeks, %			1.00
Present	59	59	
Not present	41	41	
History of diarrhea in previous 2 weeks, %			0.40
Present	11	15	
Not present	89	85	
Exclusive breastfeeding,%			0.48
Yes	50	45	
No	50	55	

[a]upper respiratory tract infection; bFisher's exact test; *P<0.05; **P<0.01

A-rich vegetables and fruits were preferred, with more than 60% of children consuming them one day prior to data collection.

Compared to other types of staple foods, rice and rice-based porridge were still the main diet of subjects. Only <2% consumed commercial infant cereal, as shown in **Table 3**. For plant-based protein sources, soy products like tofu and tempeh were preferred over other beans and nuts, but their consumption was still <10% in total. Around 35% of children received ASF, most commonly dairy products. Lower proportion of ASF consumption was found in the stunted group compared to the control (29% *vs*. 41%, respectively; P=0.08). The consumption of fish, eggs, or poultry

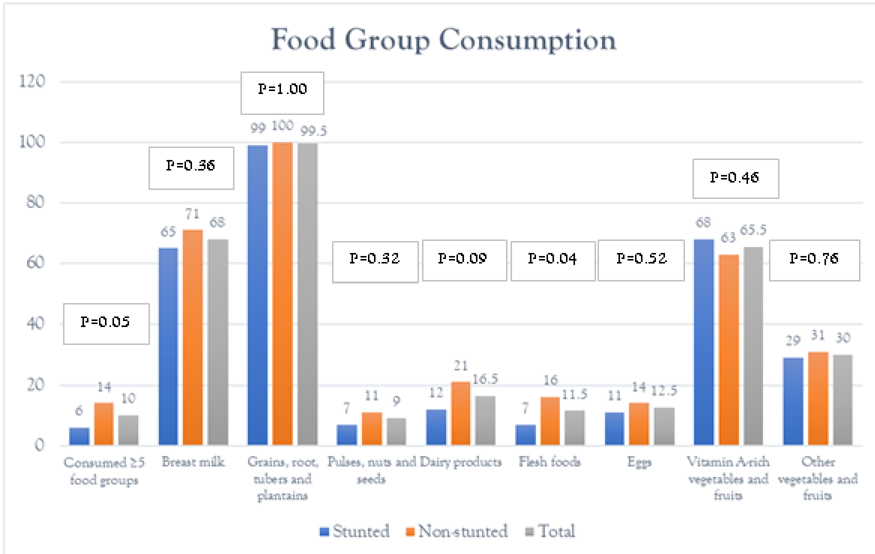

Figure 1. Complementary food consumption and dietary diversity between stunted and non-stunted children based on WHO food group categorization

was significantly less frequent in the stunted group. More than half of stunted children did not receive fish, eggs, or poultry in the previous seven days. There was no significant difference in consumption frequency of meat and dairy products. Nevertheless, more than 80% of subjects did not receive any of these foods in the previous seven days. Coconut oil, followed by coconut milk, was still the most common source of fat, although overall consumption was <20%. In addition, we found that children had received snacks and sweets like biscuits or cakes as part of their dietary intake.

When the total nutrient intake from complementary food and breastmilk was calculated, we found a significantly lower protein intake in the stunted group (**Table 4**). Median total protein intake in the stunted group was 7.72 grams (IQR 6.46-11.31), compared to 10.02 grams (IQR 6.53-13.95) in the control group (P=0.03). However, the difference in protein intake between the two groups was not significant when only intake from complementary food was consideredThe stunted group also had lower PER from complementary food than the control group, although the difference did not reach statistical significance (7.91% *vs.* 9.46%, respectively; P=0.06). When breastmilk was added to the total daily intake, PER was reduced in both groups. Total energy intake was not significantly different between groups, although stunted children tended to consume less energy than non-stunted children (456.73 kcal *vs.* 490.07 kcal, respectively; P=0.09).

Our comparison of nutrient intake from complementary food and assumed from breastmilk revealed that breastmilk could potentially be a great source of nutrition. Daily total energy and macronutrient intake were almost 2-3 times higher in both groups when breastmilk was added. This effect was quite similar for micronutrients, except for pyridoxine, iron, and folic acid.

Most subjects did not receive sufficient amounts of macronutrients and micronutrients (**Table 5**). Both groups had similar proportions of insufficient nutrient intake, except for protein and riboflavin. Less than 10% of subjects received sufficient daily energy; this finding was similar for carbohydrate and fat intake. However, 20% of children received sufficient protein, but the proportion was significantly lower in the stunted group (13% *vs.* 29%, respectively; P<0.01). For micronutrients, around 20% of the children received sufficient amounts of vitamin A and pyridoxine and more than 30% received sufficient magnesium. These proportions were far greater compared to other micronutrients. Less than 10% of the children received sufficient amounts of folic acid, zinc, and phosphorus, while only less than 5% received sufficient iron and niacin. In addition, a lower proportion of children in the stunted group received

Table 3. Comparison of dietary intake and frequency of consumption between stunted and non-stunted groups

Variables	Stunted (n=100)	Non-stunted (n=100)	Total (%)	P value
Types of staples, %				
Rice	97	99	98	0.62[a]
Corn	2	0	1	0.50[a]
Roots and tubers	2	2	2	1.00[a]
Noodles	1	0	0.5	1.00[a]
Rice-based noodles	0	2	1	0.50[a]
Commercial infant cereal	2	1	1.5	1.00[a]
Types of plant-based protein source, %				
Soy products	6	11	8.5	0.21
Mung beans	0	1	0.5	1.00[a]
Peanuts	1	0	0.5	1.00[a]
Consuming any ASF, %				
Yes	29	41	35	0.08
No	71	59	65	
Types of ASF, %				
Dairy products	12	21	16.5	0.09
Eggs	11	14	12.5	0.52
Flesh foods	7	16	11.5	0.04*
Fat source food, %				
Coconut oil	18	17	17.5	0.85
Margarine	4	1	2.5	0.37[a]
Coconut milk	9	4	6.5	0.15
Snacks and sweets, %				1.00
Biscuits	20	20	20	0.37[a]
Breads and cakes	4	1	2.5	0.50[a]
Extruded snacks	0	2	1	
Frequency of fish/egg/poultry consumption, %				
≥4 days/week	1	9	5	
1-3 days/week	48	50	49	0.02*
0 days/week	51	41	46	
Frequency of meat consumption, %				
≥4 days/week	0	0	0	
1-3 days/week	10	16	13	0.21
0 days/week	90	84	87	
Frequency of milk consumption, %				
≥4 days/week	10	19	14.5	
1-3 days/week	3	2	2.5	0.19
0 days/week	87	79	83	

[a]Fisher's exact test; *P<0.05

sufficient amounts of riboflavin compared to the control group (10% *vs.* 21%, respectively; P=0.03).

Multivariate analysis revealed that sufficient intake of several macronutrients and micronutrients was not associated with stunting (**Table 6**). Although in bivariate analysis protein and riboflavin intake sufficiency was found to be significantly associated with stunting, this association was not found in the multivariate analysis. Maternal work status was the only factor associated with stunting. Unemployed mothers were 2.32 times (95%CI 1.26 to 4.26) more likely to have a stunted child.

Discussion

Most of the children aged 6-23 months in our study received insufficient amounts of nutrients. They also did not receive an adequately diverse diet and had insufficient intake of ASF, especially flesh foods. Maternal unemployment was the only maternal social characteristic associated with stunting. Also, the stunted group had a significantly lower protein intake compared to the non-stunted group. However, neither diverse diet nor sufficient intake of specific macronutrients or micronutrients were significantly associated with stunting in the multivariate analysis, despite finding that stunted children tended to receive lower amounts of energy, as well as several macronutrients and micronutrients.

Dietary diversity has been associated with a higher likelihood of meeting daily nutrient requirements to promote childhood growth.[14,37] Eating less diverse food has been associated with undernutrition events, such as stunting and being underweight.[37] However, the majority of subjects lacked diverse complementary food sources to fulfill their nutritional needs. Both stunted and non-stunted

Table 4. Nutritional intake from complementary food and total daily nutrient intake between groups

Variables	Complementary food (CF)			Total daily intake (CF + breastmilk)		
	Stunted P50 (IQR)	Non-stunted P50 (IQR)	P value	Stunted P50 (IQR)	Non-stunted P50 (IQR)	P value
Total energy, cal	169.66 (60.06-314.09)	173.87 (59.91-307.85)	0.94	456.73 (385.59-580.27)	490.07 (424.39-609.69)	0.09
Carbohydrate, g	32.07 (11.94-59.16)	27.00 (9.93-60.13)	0.80	63.95 (53.62-81.95)	65.85 (53.81-88.80)	0.40
Protein, g	4.02 (1.27-8.17)	5.04 (1.05-10.87)	0.40	7.72 (6.46-11.31)	10.02 (6.53-13.95)	0.03*
Fat, g	0.79 (0.09-4.58)	1.58 (0.10-4.90)	0.54	21.18 (6.86-22.49)	21.18 (17.01-23.15)	0.28
PER, %	7.91 (6.67-11.53)	9.46 (6.85-17.29)	0.06	6.79 (6.12-8.96)	7.28 (6.09-10.45)	0.24
Vitamin A, RE	83.94 (23.02-170.55)	84.05 (2.15-209.42)	0.97	169.99 (127.20-280.05)	164.35 (127.20-302.82)	0.60
Vitamin C, mg	5.34 (0.75-12.14)	5.33 (0.05-15.58)	0.98	19.02 (15.20-24.36)	19.36 (17.89-29.08)	0.33
Thiamine, mg	0.06 (0.02-0.15)	0.05 (0.02-0.14)	0.69	0.13 (0.10-0.20)	0.13 (0.11-0.23)	0.52
Riboflavin, mg	0.01 (0-0.10)	0.01 (0-0.20)	0.33	0.09 (0.08-0.15)	0.09 (0.09-0.27)	0.11
Niacin, mg	0.46 (0.20-0.99)	0.41 (0.16-0.89)	0.40	0.92 (0.66-1.40)	0.87 (0.70-1.25)	0.76
Pyridoxine, mg	0.10 (0.03-0.23)	0.11 (0.04-0.25)	0.75	0.13 (0.06-0.25)	0.13 (0.06-0.27)	0.65
Folic acid, mcg	21.51(5.97-44.58)	18.25 (4.78-38.46)	0.79	22.90 (10.52-44.98)	22.85 (8.73-41.42)	0.93
Iron, mg	0.88 (0.28-1.88)	0.81 (0.13-2.05)	0.57	1.19 (0.58-1.92)	1.07 (0.45-2.21)	0.70
Calcium, mg	45.25 (13.13-88.69)	37.79 (6.30-95.20)	0.48	126.66 (106.04-160.06)	122.87 (109.00-169.03)	0.85
Zinc, mg	0.45 (0.14-0.98)	0.42 (0.13-0.93)	0.85	0.89 (0.78-1.29)	1.00 (0.78-1.51)	0.34
Phosphorus, mg	59.63 (16.67-104.45)	60.20 (19.15-128.84)	0.60	113.84 (99.16-165.64)	129.69 (102.36-181.63)	0.08
Magnesium, mg	21.63 (6.34-46.37)	22.03 (6.94-48.69)	0.84	34.91 (22.98-53.64)	38.07 (23.58-61.65)	0.48

*P<0.05

Table 5. The proportion of children receiving sufficient macronutrients and micronutrients, based on the Indonesian RDA

Variables	Stunted (%)	Non-stunted (%)	Total (%)	P value
Total energy	5	8	6.5	0.39
Carbohydrate	9	5	7	0.26
Protein	13	29	21	0.005**
Fat	7	8	7.5	0.78
Vitamin A	16	24	20	0.15
Vitamin C	11	18	14.5	0.16
Thiamine	13	16	14.5	0.54
Riboflavin	10	21	15.5	0.03*
Niacin	0	2	1	0.49[a]
Pyridoxine	20	20	20	1.00
Folic acid	4	8	6	0.23
Iron	1	5	3	0.21a
Calcium	6	7	6.5	0.77
Zinc	4	10	7	0.09
Phosphorus	5	11	8	0.11
Magnesium	32	38	35	0.37

Table 6. Multivariate analysis of stunting with macronutrient and micronutrient intake as well as characteristics of participants

Variables	OR	95% CI	P value
Protein intake			0.06
Insufficient	2.10	0.96 to 4.55	
Sufficient	1.00	Ref.	
Vitamin A intake			
Insufficient	0.96	0.41 to 2.24	0.92
Sufficient	1.00	Ref.	
Vitamin C intake			
Insufficient	1.03	0.39 to 2.72	0.94
Sufficient	1.00	Ref.	
Riboflavin intake			
Insufficient	1.13	0.36 to 3.50	0.83
Sufficient	1.00	Ref.	
Folic acid intake			
Insufficient	0.84	0.16 to 4.29	0.84
Sufficient	1.00	Ref.	
Iron intake			
Insufficient	2.74	0.26 to 28.24	0.39
Sufficient	1.00	Ref.	
Zinc intake			
Insufficient	1.23	0.29 to 5.21	0.77
Sufficient	1.00	Ref.	
Phosphorus intake			
Insufficient	0.91	0.19 to 4.35	0.84
Sufficient	1.00	Ref.	
Maternal age			
<35 years	0.66	0.33 to 1.31	0.24
≥35 years	1.00	Ref.	
Maternal education			
< Middle school	1.74	0.95 to 3.19	0.06
≥ Middle school	1.00	Ref.	
Maternal work status			
Unemployed	2.32	1.26 to 4.26	0.006*
Employed	1.00	Ref.	
Monthly family income			
< Rp 1 million	1.75	0.94 to 3.25	0.07
≥ Rp 1 million	1.00	Ref.	

*P<0.01

groups had similar proportions of children who did not achieve adequate dietary diversity, although this was more prominent in the stunted group. In accordance to our findings, an Indonesian cohort study showed that dietary diversity as well as frequent consumption of a diverse diet were not associated with height-for-age Z score (HAZ) of under-five children.[14] However, the matter is remains unsettled, as another Indonesian study concluded that better dietary diversity was associated with decreased likelihood of stunting in this age group.38 A higher household dietary diversity score, which depicts better dietary diversity, was found to be a protective factor of stunting.[38] Considering these conflicting results, further studies are needed to rigorously investigate a possible association between dietary diversity and stunting, especially in the complementary feeding period.

Subjects' main diet source was the grains, roots, tubers, and plantains food group, with rice-based dishes as the main staple food. This finding was in agreement with several Indonesian studies.[14,38] Although commercial infant cereals have been fortified and are easier-to-use, they were not commonly given, possibly due to their higher cost and relative unavailability compared to other staples. We also found that the stunted group received significantly less flesh foods compared to the control. In addition, stunted subjects received fish, poultry, and eggs in their diet significantly less frequently. Flesh foods, especially meat consumption, play a vital role in the growth process due to their high biological value of protein and several important micronutrients, such as vitamin A, vitamin B, iron, and zinc.[39] A Zambian study showed that meat consumption was associated with a 36% reduced risk of stunting in under-two children.[40] Despite the clear benefits, meat was not routinely given to our subjects. Regular meat consumption should be encouraged since it could improve dietary quality, along with the adequacy of several important nutrients.[39,40]

A multinational study which analyzed dietary data from 39 countries showed an association between ASF consumption and stunting in children aged 6-23 months, with a higher rate of stunting in children who did not consume any ASF.[10] In contrast, we found ASF consumption to be similar across both groups. In addition, there was low ASF intake among all subjects, of whom only around one-third received it. An Indonesian study had confirmed this finding showing that ASF consumption was similar between children with and without stunting. The study also concluded that ASF consumption was not a significant predictor of a child's HAZ.[14] Despite these conflicting results, the role of routine ASF consumption should not be downplayed due to its nutrient density in fulfilling nutritional requirements for growth. Egg consumption, for example, has been associated with protein intake adequacy. In addition, dairy product consumption was associated with vitamin A, calcium, and zinc sufficiency.[14] A previous study showed that consuming ≥300 mL growing-up milk per day was associated with lower odds of stunting in children aged 1-3 years (OR 0.28; 95%CI 0.13 to 0.63).[41] Although there was no significant difference in dairy product consumption between our groups, milk and its products were still the most common ASF consumed. Considering that milk protein was superior in supporting linear growth due to its positive association with IGF-1 concentration and height, increasing milk consumption, especially growing-up formula, could be a way to improve protein intake and growth in the complementary feeding period.[38,41] In addition, milk is a main source of calcium which is essential for bone development.[38]

The consumption of ASF protein was higher than that of plant-based protein, such as legumes and nuts. In our study, soy products were the main plant protein source; intake was similar in both groups. An Indonesian study showed that plant-based protein contributed less to total protein intake of Indonesian children compared to animal protein sources. Only around 25% of total protein consumed by children aged 6-12 months and 39% of total protein consumed by those aged 13-36 months were derived from plants. A study also found no association between protein source, either from animals or plants, and stunting.[42] Although plant-based protein sources are important in fulfilling children's nutritional needs, animal protein is better due to its higher biological value.[42]

In our study, stunted children received significantly less protein compared to the control group. Similarly, a previous study showed that mean protein intake of stunted children was significantly lower compared to the non-stunted participants [30.7 (SD 8.5) g *vs.* 37.8 (SD 8.5) g, respectively; P<0.05].[34] Yet, these results conflicted with those of Ruhmaniah *et al.*[43] who showed similar mean protein intake between stunted and non-stunted children [20.08 (SD 2.15) g *vs.* 21.51 (SD 2.56) g]. Nevertheless, we would like to highlight the higher mean protein intakes of both of these studies, which were at least twice the median protein intake in our study (7.72 g in the stunted *vs.* 10.02 g in the non-stunted group). This discrepancy might be due to the very low consumption of animal-based food in the area, which is still a common practice in East Nusa Tenggara Province. According to the World Food Programme report, only 42% of animal-based food requirements were met by the people in the province, suggesting that consumption of an animal-based diet was not a regular practice.[44]

A daily PER of 5% or greater is needed for proper childhood growth.26 In our study, median PER from total daily intake was above the optimal value for both groups, indicating that children's diets had a sufficient proportion of protein. In addition, when only complementary food was considered, PER improved in both groups (**Table 4**). This might have been due to a relatively lower PER from breastmilk, which was only approximately 5% in our study, compared to the complementary food.[30] Although higher PER of 8.9-11.5% has been suggested to promote catch-up growth of lean and fat mass in children,[45] PER was not significantly different between stunted and non-stunted children, in accordance with another Indonesian study.[46] A better designed study to determine the effect of PER on stunting and the optimal PER to prevent height faltering is needed to further address this issue.

Aside from protein intake, we found no significant differences in other nutrient components between the children. A study in urban and rural settings of South Africa showed that mean dietary intake of energy, macronutrients, and micronutrients was similar between stunted and non-stunted children aged 12-24 months.[47] A Zambian study also yielded similar results, except for vitamin C, which was significantly higher in stunted toddlers compared to control ($P=0.012$). They also found that stunted children tended to receive lower energy from complementary food, although the finding was not statistically significant, which was in agreement with our result.[48] In contrast, an Indonesian study reported that stunted children received significantly lower energy, fat, and protein, as well as several micronutrients such as vitamin A, vitamin D, zinc, iron, calcium, and phosphorus.[34] The reasons behind this discrepancy remain unclear, but may be due to differences in sociodemographic background and local tradition, complementary feeding practices, types of complementary food given, and food availability between settings.[49,50]

The majority of our subjects did not receive sufficient nutrient intake based on the Indonesian RDA. Protein and riboflavin intake sufficiency was associated with stunting in bivariate analysis . However, after multivariate analysis, no association was found between sufficiency of energy, macronutrient, or micronutrient intake and stunting. Although adequacy of specific macronutrients and micronutrients is commonly recognized as one of the factors impacting child growth, several studies reported no association between sufficient nutrient intake and stunting, especially in the complementary feeding period.[9,43,46,47,51-53] More specifically, several Indonesian studies conducted in parts of Java island showed that sufficient energy and protein intake were not associated with stunting in children aged 6-23 months.[43,46,53] Another Indonesian study also showed similar results, except for phosphorus intake, which was associated with stunting in children aged 12-24 months. A previous study found that inadequate phosphorus intake increased the odds of being stunted (OR 18.9; 95%CI 1.68 to 213.63).[34] However, this result conflicts with a cohort study from Bangladesh which showed no association between sufficient micronutrient intake and stunting in the same age group. Another study reported that children with and without stunting consumed a similarly nutrient deficient diet, which was similar to our findings.[51] In addition, they found that in settings where poor micronutrient adequacy affected stunted and non-stunted children equally, improving nutritional quality of complementary food in terms of micronutrient adequacy was essential for optimal growth, but may not be adequate to mitigate undernutrition.[51] These studies were conducted in urban and rural areas, suggesting that the association is likely unaffected by the place of residence.

Although we did not find an association between nutrient sufficiency and stunting, the role of sufficient nutrient intake should not be underestimated. Nutrients provide important substrates for optimal cellular function and tissue growth, and are involved in multiple systems such as the metabolic, immune, and endocrine systems.[54] They may even affect childhood neurocognitive development.[55,56] Macronutrient sufficiency is essential for brain development, especially in the first 1,000 days of life. The failure to provide sufficient macronutrients or key micronutrients at critical periods of brain development can cause lifelong effects, such as poor cognitive skills.[55] Nutritional deficiency can also lead to potentially harmful conditions, such as blindness, anemia, and even death.[57] In Indonesian children, the proportion of insufficient dietary intake increased with age. The proportion of children with insufficient energy intake, for example, increased from 4.9% in children aged 6-11 months to 34.8% in those aged 12-23 months. This was also true for vitamin A, vitamin C, folic acid, calcium, and phosphorus.[58] Low maternal education, low socioeconomic status, and living in a rural area increased the proportion of insufficient nutrient intake.[58] Considering the harmful effects and the high proportion of nutritional insufficiency in our setting, specific public health interventions are needed to improve children's nutritional sufficiency.

We found that breastmilk could be a great source of nutrition for children in rural areas who tended to receive insufficient nutrients from complementary food. Breastmilk may provide a substantial proportion of energy, macronutrient, and certain micronutrient requirements. More than 50% of a child's fat requirement can be fulfilled by breastmilk consumption. Breastmilk intake would also increase energy intake.[30,48] A study showed that breastmilk can provide up to 31% of energy, 22% of carbohydrate, 18% of protein, and 62% of fat requirements, as well as 58% of preformed vitamin A and 41% of niacin requirements to children in the complementary feeding period.[30] However, because it provides only 5% of a child's iron requirement, consumption of iron-rich food, such as organ meat, is essential to prevent iron deficiency.[30,47,48] Considering the nutritional value of breastmilk and its added health benefits, such as a reduced risk of gastrointestinal infections, continuing breastfeeding into the second year of life is highly recommended to ensure optimal growth of the children. Although it does not guarantee adequate nutritional intake, it is, at the very least, a cost-free measure to supplement complementary food in fulfilling children's nutritional needs.

Stunting is generally assumed to result from chronic undernutrition.[54] However, stunting may be due to the complex interplay of multiple factors aside from health, namely, social, economic, environmental, and political factors.[54,59] Household food insecurity, unhealthy living environment, inadequate health services, and even disadvantageous physical, economic, social, or behavioral conditions could lead to stunting.[54,59] Of the maternal factors we analyzed, only maternal work status was associated with stunting. Unemployed mothers had 2.32 higher odds to have a stunted child (95%CI 1.26 to 4.26). Accordingly, we also found that stunted children came from families with lower monthly income and lower maternal educational level. This result conflicts with an Indonesian study which showed a higher odds of having stunted children in mothers who work in the agricultural sector compared to those who did not work (OR 3.77; 95%CI 1.17 to 12.1). Working in the agricultural sector could cause poor childhood dietary intake by taking mothers' time away from home, and leaving less time for cooking and child care.[53] Several studies from various settings also showed that numerous factors may affect stunting, such as lack of access to healthcare facilities, poor sanitation and drinking water sources, maternal height, and even unmodifiable factors, such as age and gender of the children.[43,60,61] In addition, underlying health conditions, such as environmental enteric dysfunction and diarrheal diseases, which are common in children living in unhygienic environments, should also be considered as causes of stunting in a community. These conditions can disrupt nutrient absorption, eventually leading to stunting.[9,54] As such, the complexity of the problems need to be considered for implementation of appropriate interventions to stunting.[47,54] Policymakers should develop sustainable strategies to improve various social and enviromental factors that are closely related to chronic undernutrition.[52]

Our study had several limitations. Since the sample was obtained secondarily from a previous study that used a non-probability sampling method, generalizability of our results is limited. We also relied on information from mothers obtained by the recall method, which is subject to biases. In addition, instead of using several 24-hour food recalls from non-consecutive days, we used a single, 24-hour recall method, which could not perfectly capture the dietary habits of the children. We also could not quantify the volume of breastmilk consumed by the children and could only assume its nutritional content based on similar studies, potentially causing errors in our estimates. However, to avoid overestimating nutrient intake from breastmilk, we used reference values from studies that assessed non-supplemented low income women, which was similar to our subjects' mothers.[30] Since stunting is a continuing process, we suggest a longitudinal study with a probability sampling method that uses multiple 24-hour food recalls or a designated food diary to periodically assess children's dietary intake and growth. This method would better depict patterns of dietary intake as well as more accurately assess the association with height faltering that may eventually lead to stunting. In addition, a pilot study that evaluates breastfeeding patterns and breastmilk nutritional content in the area will give additional information on the role of breastmilk in fulfilling nutritional requirements of children.

We conclude that most children aged 6-23 months in the Wewewa subdistrict of Southwest Sumba, Indonesia did not receive sufficient nutrient intake. Stunted children received significantly lower protein from their diet than their non-stunted counterparts. Although dietary diversity was not significantly different between children with and without stunting, a significantly lower proportion of flesh foods consumption was found in the stunted children. Breastmilk could potentially be a great additional source of nutrients in the complementary feeding period and continuing the practice of breastfeeding until the second year of life should be encouraged. Although no association between nutrient sufficiency and stunting was found, sufficient nutrient intake still needs to be encouraged due to its beneficial effects on childhood growth, development, and health. Since stunting is a result of chronic undernutrition, further studies are needed to longitudinally assess the effects of macronutrient and micronutrient intake sufficiency on pediatric linear growth. Efforts to enhance nutritional intake through improvements of complementary feeding practices, household food security, and agricultural systems of the area are needed to ensure children's optimal health and growth. Since stunting is due to a complex interplay of diverse factors, multidimensional approaches are needed. Improved environmental and sociodemographic conditions, as well as children's overall health are needed to mitigate the risk of stunting.

Conflict of interest

None declared.

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