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Relationship between dietary patterns and stunting in preschool children: a cohort analysis from Kwale, Kenya

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ABSTRACT

Objectives: Stunting is a significant cause of poor cognitive performance and lower school achievement. Stunting is observed among pre-school children in several areas in Africa; however, not all children are affected, and children with and without stunting are seen in the same communities. Therefore, this study aimed to identify nutritional and other factors that prevent stunting that may exist in local communities.

Study design: This is a prospective cohort study.

Methods: Data were extracted from the Health and Demographic Surveillance System conducted in Kwale County, Kenya. The cohort consisted of all households with children less than five years old, within a radius of 2.2 km from a local health centre. A dietary pattern (DP) survey with a semi-quantitative food frequency questionnaire was conducted on caretakers of children who were voluntary participated from the cohort between June 2012 and August 2012. Using cluster analysis, the children were assigned to a DP group. Logistic regression analysis was applied to calculate the adjusted odds ratios (aORs) of DPs for stunting controlling for other factors.

Results: In total, 402 children were included in the analysis. By cluster analysis, three DPs were identified: protein-rich DP; traditional DP; and traditional DP complemented by breastfeeding. The aOR of a child becoming stunted from a normal height during the study period among children who received a traditional DP compared with those who had a protein-rich DP was 2.78 (95% confidence interval [CI]: 1.02–7.55). However, the aOR for

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children who were already stunted at the start of the study and had a traditional DP was 1.49 (95% CI: 0.82–2.72). Increased aORs of stunting were observed among children aged over 12 months compared with children aged 6–11 months, and the effects of DPs were modified by age in months from 12 to 35 months; however, the effects were near the null value for children over 36 months of age, although these were not statistically significant.

Conclusions: We found that the traditional DP showed a higher risk for stunting compared with the protein-rich DP, and the most vulnerable age range for stunting was between 12 and 35 months. Interventions to prevent stunting should focus on providing 12- to 35-month-old children with locally available, protein-rich foods.

Introduction

Stunting refers to impaired growth and development among children under five years of age. According to the World Health Organization (WHO) definition, children whose length/height-for-age Z-scores is more than two standard deviations below the WHO child growth standard median are defined as stunted.[1] The World Bank estimated that 24.6% of children under five years old in low- and middle-income countries were stunted in 2017.[2] Stunting is a significant cause of poor cognitive performance and lower school achievement in middle childhood;[3] therefore, prevention of stunting among children under the age of five years is listed as a target goal of sustainable development by the WHO.[45]

Reported causes of stunting include intrauterine growth restriction, inadequate nutrition in infants and young children and frequent infection during the early stage of life.[6] Stunting is observed among preschool children in several areas in Africa; however, not all children are affected, and children with and without stunting are seen in the same communities.[7,8] Therefore, nutritional and other factors that prevent stunting may exist locally in communities where stunting is endemic, and these factors may avert stunting without any additional outside support.

Although detailed nutritional surveys are important to clarify the role of nutrients in child growth, it is difficult to interpret the relationship between health outcomes and the synergistic effects of single dietary nutrients or food items in complex combinations,[9] especially in nutritional studies in developing countries.[10,11] Dietary pattern (DP) analysis (i.e. analysis of the pattern of food intake) can provide clues for local solutions to prevent stunting; however, little is known about the relationship between the DPs and stunting in low- and middle-income countries.[12] Therefore, this study aimed to identify the relationship between DPs and other factors related to stunting among preschool children in one region of Africa.

Methods

This study was conducted as part of the Health and Demographic Surveillance System (HDSS) operated by the Kenya Medical Research Institute in collaboration with Nagasaki University in Kwale County, Kenya.[13] A cohort study was established as part of the HDSS to prospectively follow-up children under five years old and their caretakers as pairs living in a geographically defined area from June 2011 to August 2012 (Fig. 1).

Data from all households within a 2.2-km radius of the Kizibe Health Centre were extracted from the HDSS database, and households with children aged less than five years and their caretakers were selected for follow-up of the children's growth and health status. The radius was determined by considering the accessibility of the health facility and assuming that this radius would include caretakers and children who walked 30 min to access the health centre. Data for children aged 6–59 months were included in the present analysis. In total, 710 children and 458 caretakers were registered in the cohort, and all 458 caretakers agreed to participate in the cohort study. We collected anthropometric data by measuring children's height and weight and collected demographic information (e.g. ethnic background, religion, caretaker education level and frequency of breastfeeding) using a questionnaire. We also collected data on malaria status (malaria rapid diagnostic test [SD BIOLINE Malaria Ag P.f/Pan test: Standard Diagnostics, Inc., Hagal-Dong, Korea]), soil-transmitted helminth (STH) infection status (Kato–Katz technique) and haemoglobin level (Hemocue; HemoCue Inc., Mission Viejo, CA) from the cohort, a maximum of six times during the study period. Stunting was defined as a height less than two standard deviations below the 2006 WHO child growth standards using length/height-for-age Z-scores.[14] Anaemia was defined as a haemoglobin concentration below 11.0 mg/dl.[15]

Using this cohort and follow-up programme data, a DP survey was conducted on caretakers of 441 children aged between 6 and 59 months who voluntary participated from the cohort between June 2012 and August 2012 to clarify the relationship between the DPs and child stunting.

Prior to the DP survey, we developed a list of locally available foods for a semi-quantitative food frequency questionnaire (FFQ). First, a simple 24-h dietary interview was performed with the caretakers of 50 children who were randomly selected from the 441 children included in the study. This identified 50 food items that were available in this locality and subsequently enabled the creation of a food list (Table 1).

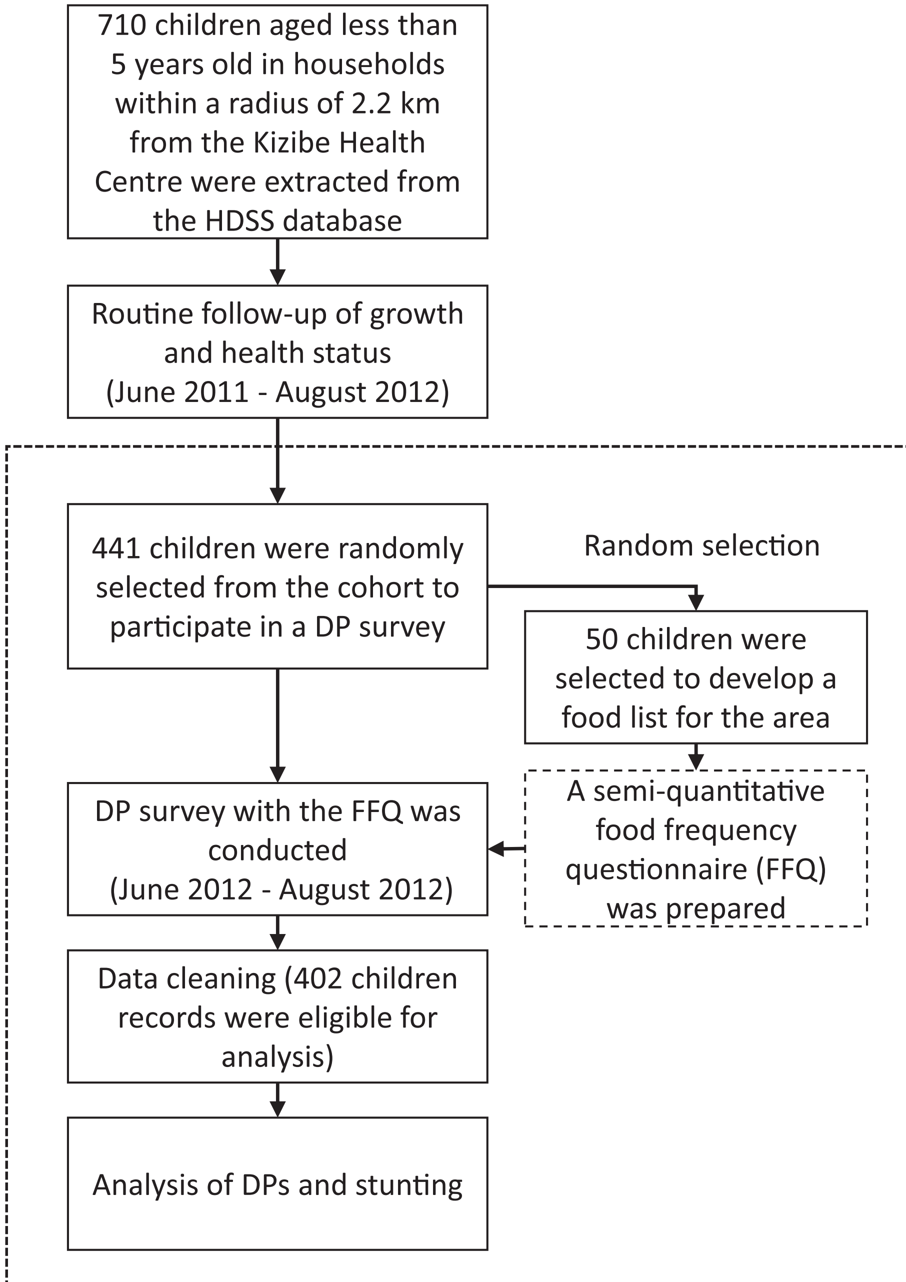

Fig. 1 – Schematic description on the selection and analysis used in this study, from the selection of participants from the health and demographic surveillance (HDSS) database to data analysis of dietary patterns (DPs) and stunting.

Using this food list, we conducted a DP survey using the FFQ with the caretakers of all 441 children. We asked the caretakers to estimate the frequency and portion size of their children's habitual dietary intake of the 50 items on the food list during the four weeks prior to the survey. All interviews were conducted by trained interviewers. Frequencies were categorised as ‘never’, ‘1–3 times per month’, ‘once per week’, ‘2–4 times per week’, ‘5–6 times per week’, ‘once per day’, ‘2–3 times per day’, ‘4–5 times per day’ and ‘six times per day or more’. Portion sizes were recorded for each food item using measuring devices such as a spoon, cup or plate; for fruit, the number of pieces was recorded.

From the FFQ data collected, we calculated gram intake per day for each of the 50 food items using the frequency of intake and the portion sizes obtained. We then calculated dietary nutritional intakes and generated 17 food group categories according to the food composition tables compiled by Lukmanji et al.[16] and summed up the total gram intake per day of the food items categorised by the food group.

Following data processing, we cleaned up the data for the DP analysis and final analysis of the relationship between the DPs and stunting. During data cleaning, we removed the records of five children whose height was recorded as a negative growth, and the records of 24 children who were aged less

Table 1 – List of food items included in each of the food groups used in cluster analysis.

Food groups (n = 17)	Food items (n = 50)
Maize foods	Maize porridge (thin porridge), ugali (thick porridge), cooked green maize, roasted maize
Cereals	Finger millet porridge, chapati, rice
Beans	Cowpea beans, kidney beans with coconut milk, maize and kidney beans
Fish	Fried finger fish, fresh fish, fried fish
Meats	Fried goat, fried beef, fried chicken
Potatoes	Roasted cassava, cassava boiled with coconut milk, boiled sweet potato
Fried foods	Fried potatoes, mandazi (African doughnuts), potato samosa
Eggs	Eggs (chicken)
Leafy vegetables	Hare's lettuce (thistle), sukuma (kale), mchicha (amaranth), cassava leaf, pumpkin leaf, cowpea leaf, sweet potato leaf
Other vegetables	Cooked pumpkin, okra, eggplant
Fruits	Orange, papaya, tangerine, mango, passion fruit, cooked banana, ripe banana
Nuts	Cashew nuts
Snacks	Candy, biscuits
Tea	Tea without milk
Juice	Orange juice, coconut water
Soda	Soda
Dairy products	Cow's milk, goat's milk, tea with milk

than six months during the study period. Finally, the FFQ and cohort data for 402 children were included in this study.

For further analysis of the relationship between DPs and stunting, we categorised the 402 children into the following four groups: (1) children within a normal height range (within minus two standard deviations of the WHO standard length/height-for-age Z-score); (2) children who became stunted (less than minus two standard deviations of the WHO standard length/height-for-age Z score) from a normal height range during the study period; (3) children who were stunted throughout the study period; and (4) children whose height fluctuated between normal and stunted.

DPs were defined by cluster analysis using the 17 food group categories. The number of clusters was decided using hierarchical cluster analysis, which was performed with a squared Euclidean distance matrix, and Ward's method as the clustering method. The Duda–Hart Je(2)/Je(1) stopping rule index was also used to stop the programme to select the number of clusters.[17] Using the results of cluster analysis, all children were assigned to one of the DP groups to analyse the relationship between DPs and stunting.

To analyse the relationship between the DPs and stunting, we performed logistic regression analysis to calculate crude and adjusted odds ratios (ORs) comparing children within a normal height range and children who became stunted from a normal height range, as well as children within a normal height range and children who were stunted throughout the study period.

For multivariate analysis to estimate adjusted ORs, we used the stepwise backward selection procedure to remove factor variables with a significance level of 0.2 from the model. DP variables were forcibly added to the model and were not subjected to selection. Variables considered in the model were age, sex, malaria status, STH infectious status, ethnic background, religion, frequency of breastfeeding, and energy intake per day, which were calculated from FFQ data. In addition, children with the same caretaker were treated as a cluster in the logistic regression analysis.

Additionally, in order to confirm the interactions between the DPs and months of age, crude ORs of DPs separated by months of age were calculated for children who had become stunted and who were already stunted, compared with children within a normal height range without adjustment of other factors.

Statistical analyses were performed using Stata MP version 15.1 software (Stata Corporation, College Station, TX, USA).

Ethical considerations

Informed consent from all caretakers was obtained after they were provided with a full written and verbal explanation of the study purpose and the possible consequences of participation, such as invasion of privacy or breach of confidentiality. This research was approved by the Ethical Review Committee of Nagasaki University Institute of Tropical Medicine on June 15, 2010 (Research permit No. 10061551) and the Ethical Review Committee of Kenya Medical Research Institute (Research permit SSC No. 1964) on March 24, 2011.

Results

Among the 402 children analysed, 197 children were within a normal height range throughout the study period, 52 became stunted from a normal height, 111 were stunted throughout the study period and 42 showed heights that fluctuated between the normal range and stunting. Follow-up data for height of the 402 children are shown in Fig. 2, along with the regression line showing the general overall growth curve among the children in this study. The results of other factors included in this study are shown in Table 2.

According to cluster stop analysis, three DPs were statistically defined. The characteristics of each DP are shown in Table 3, along with the mean dietary intake and standard deviation values for each food group. The three DPs were as follows: (1) a protein-rich DP represented by a diet based on maize with a variety of foods, and tendency towards a higher protein intake than the other groups (mean protein intake per day: 43.4 g, mean fat intake per day: 43.5 g, and mean iron intake per day: 8.7 g); (2) a traditional DP, represented by a diet based on high maize foods with low dietary diversity and few

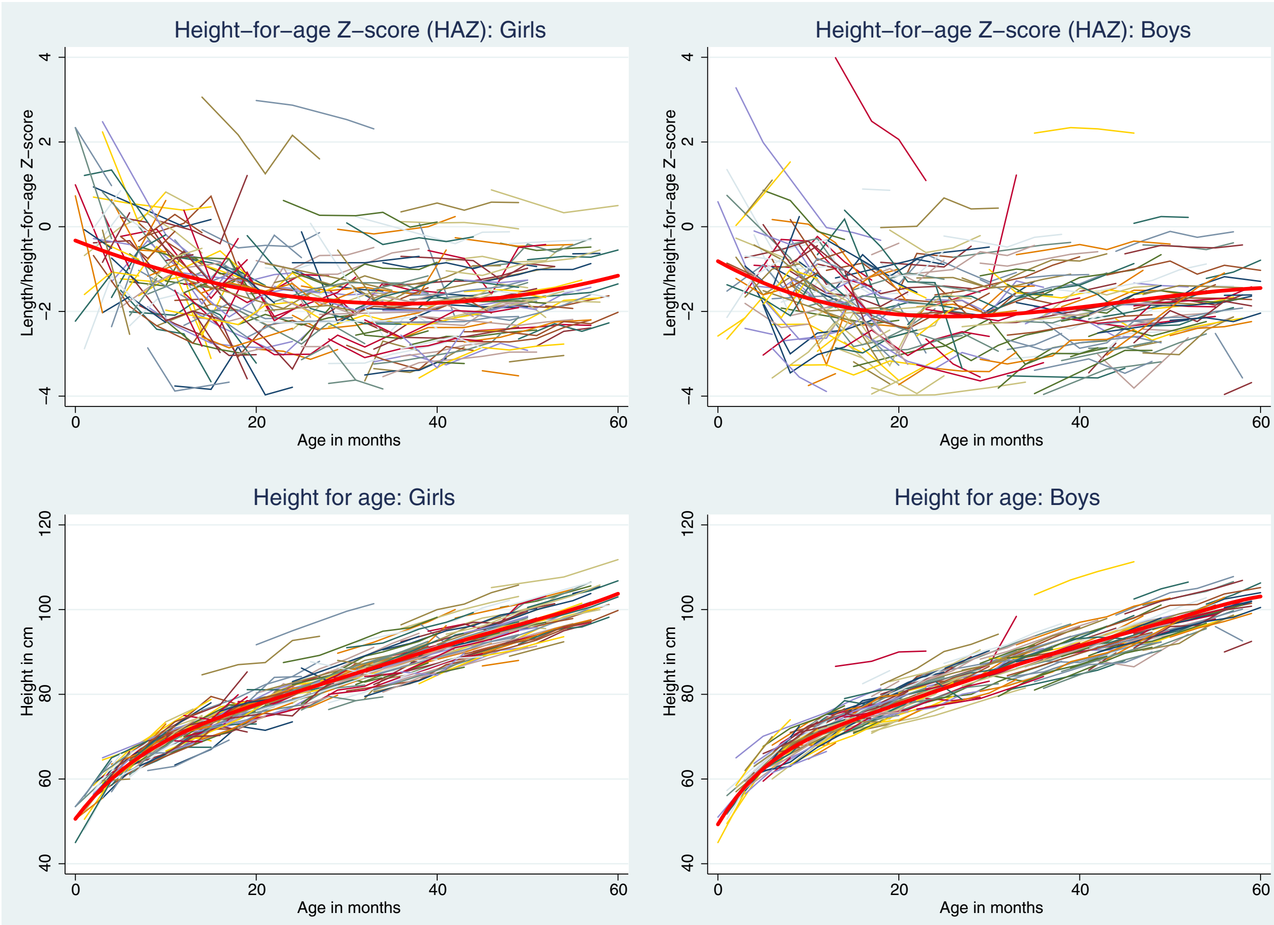

Fig. 2 – Follow-up data of height among 402 children and regression lines of the general growth curve among the children in this study.

foods from animal sources in accordance with a previous study[18] (mean protein intake per day: 28.7 g, mean fat intake per day: 23.9 g and mean iron intake per day: 5.7 g); and (3) a traditional DP complemented by breast milk (mean protein intake per day: 10.7 g, mean fat intake per day: 9.0 g and mean iron intake per day: 2.4 g), with younger children of breast-feeding age included in this group.

The logistic regression results using the data of children who became stunted from normal height and children within a normal height range throughout the study period are shown in Table 4. Using the protein-rich DP as the reference, crude ORs for children of normal height who became stunted compared with children within a normal height range throughout the study were 2.78 (95% confidence interval [CI]: 1.02–7.55) for the traditional DP and 2.58 (95% CI: 0.91–7.30) for the traditional DP complemented by breast milk. Adjusted ORs for the same comparison were 2.49 (95% CI: 0.90–6.87) and 3.10 (95% CI: 1.03–9.33), respectively. Adjusted ORs for age in months using children aged 6–11 months as the reference were 5.54 (95% CI: 1.72–17.83) for children aged 12–23 months, 2.96 (95% CI: 0.79–11.06) for children aged 24–35 months, 3.13 (95% CI: 0.80–12.35) for children aged 36–47 months and 0.42 (95% CI: 0.07–2.66) for children aged 48–59 months. The only other significant adjusted OR was observed for hookworm infection (OR: 2.68; 95% CI: 1.09–6.59).

The analysis of results using data for children who were stunted and within a normal height range throughout the study is shown in Table 5. Using the protein-rich DP as the reference, crude ORs for children who were stunted throughout the study compared with children within a normal height range were 1.49 (95% CI: 0.82–2.72) for the traditional DP and 0.62 (95% CI: 0.29–1.32) for the traditional DP complemented by breast milk. Adjusted ORs for the same comparison were 1.54 (95% CI: 0.82–2.89) and 1.08 (95% CI: 0.48–2.44), respectively. Adjusted ORs for age in months using children aged 6–11 months as the reference were 1.91 (95% CI: 0.56–6.47) for children aged 12–23 months, 3.85 (95% CI: 1.22–12.13) for children aged 24–35 months, 7.99 (95% CI: 2.65–24.07) for children aged 36–47 months and 3.31 (95% CI: 1.04–10.58) for children aged 48–59 months. The only other significant adjusted OR was that for males (OR: 2.45; 95% CI: 1.47–4.07).

Table 6 shows the effect of the interaction of age in months over the three DPs with the ORs of DPs using the protein-rich DP as the reference by age in months for children who became stunted, those who were stunted throughout the study, and both of these groups combined compared with children within a normal height range throughout the study. Although not statistically significant, there was a tendency for the ORs of stunting in children aged 12–23 months and 23–35 months

Table 2 – Characteristics of the children included in this study (n = 402).

Characteristics	No. of children	Normal height (n)	Normal height to stunted (n)	Stunted (n)	Fluctuated between normal and stunted (n)
Dietary pattern					
Protein rich	79	44	5	22	8
Traditional	221	95	30	71	25
Traditional complemented by breast milk	102	58	17	18	9
Age group (months old)					
6–11	44	31	4	5	4
12–23	101	51	27	15	8
24–35	78	35	10	25	8
36–47	93	34	9	39	11
48–59	86	46	2	27	11
Anaemia					
Normal range	123	63	10	40	10
Anaemic	279	134	42	71	32
Caretaker education level					
No education	196	86	27	60	23
Primary school	189	101	21	49	18
Secondary school	17	10	4	2	1
Sex					
Female	203	114	24	45	20
Male	199	83	28	66	22
Hookworm					
Negative	333	174	41	89	29
Positive at least once	69	23	11	22	13
Round worm					
Negative	389	191	51	109	38
Positive at least once	13	6	1	2	4
Frequency of breast milk feeding (times/day)					
0	276	124	27	93	32
1–3	1	6	2	2	1
4–5	10	11	4	3	2
6 or more	20	56	19	13	7
Malaria					
Negative	326	167	39	88	32
Positive at least once	76	30	13	23	10
Ethnic background					
Duruma	256	122	37	70	27
Digo	115	59	12	32	12
Other	31	16	3	9	3
Caretaker religion					
Christianity or other	73	33	8	25	7
Muslim	329	164	44	86	35
Total	**402**	**197**	**52**	**111**	**42**

to be higher than those of children aged 6–11 months. Furthermore, the ORs of stunting in children over 36 months of age were near the null value.

Discussion

The aim of this study was to clarify the relationship between the DPs and stunting in preschool children aged 6–59 months using cohort study data from a rural area in Kenya. Based on the results of the analyses, three main findings were clarified regarding the relationship between DPs and stunting: (1) the risk of becoming stunted increases significantly in children between the ages of 12 and 35 months; (2) children with a traditional DP have approximately a 2.5 to 3.1 times higher risk of becoming stunted compared with those with a protein-rich DP; and (3) DPs and children's age in months may have an interaction, with children aged 6–35 months, especially up to 24 months of age, being the most vulnerable to stunting caused by DP. The first finding of increased risk for stunting between 12 and 35 months of age was concordant with a previous study in Northwest Ethiopia,[12] although the relationship between stunting and age in months differed by area. Therefore, there is no further discussion in this article on the timing of stunting in children. Because the second and third findings are novel, we will focus our discussion on these two topics.

The present study found that DPs were related to child stunting. We assumed that some caretakers may start giving their children traditional foods that are complementary to breastfeeding after six months of age and they may continue the same food pattern even after they stop breastfeeding. This pattern may increase the risk of their children becoming stunted. However, the risk of a traditional DP was not

Table 3 – Mean dietary intake (g/day) for the three dietary patterns among Kenyan preschool children aged 6–59 months.

Food group	Total (n = 402)		Dietary pattern					
			Protein rich (n = 79)		Traditional (n = 221)		Traditional complemented by breast milk (n = 102)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Maize foods	307.0	191.0	280.4	137.1	369.3	206.0	192.5	124.7
Cereals	33.2	63.6	101.8	108.8	18.3	27.0	12.3	27.1
Beans	18.6	31.8	44.9	57.5	14.6	17.0	7.1	10.6
Fish	16.0	39.2	42.8	75.0	12.7	20.9	2.5	5.4
Meats	4.3	7.6	9.5	12.1	4.1	6.0	0.5	1.6
Potatoes	18.8	45.1	47.2	79.0	16.4	32.6	2.1	4.9
Fried foods	49.0	46.6	72.2	51.3	52.3	46.1	23.9	29.5
Eggs	6.4	22.2	17.1	43.3	5.2	13.1	0.8	2.2
Leafy vegetables	29.9	47.2	52.4	63.9	31.1	46.5	9.7	13.7
Other vegetables	23.3	93.3	60.2	185.1	19.9	54.4	2.1	11.3
Fruits	341.0	328.1	352.0	226.2	432.5	371.4	134.1	160.8
Nuts	0.7	3.4	2.7	7.1	0.3	1.1	0.0	0.1
Snacks	16.1	27.0	24.9	25.2	18.2	31.3	4.6	8.5
Tea	104.8	82.1	113.2	68.8	125.6	88.1	53.2	50.5
Juice	18.3	46.3	55.9	86.4	9.5	20.0	8.3	22.8
Soda	2.4	9.4	9.5	18.8	0.9	3.4	0.2	1.2
Dairy products	61.4	125.8	167.6	224.1	37.7	61.1	30.4	70.4
Average age (months)	24.1	15.3	30.1	14.8	26.1	14.2	15.2	14.2

SD, standard deviation.

increased for already-stunted children compared with children within the normal height range, as shown in Table 5. These results seem to be discordant with the increased risk of stunting with a traditional DP.

The DP survey with the FFQ in this study was conducted only once during the follow-up period for 402 children aged 6–59 months. Although the survey was conducted only one time, we can assume that the responses reflect the participants' past food patterns because it is not realistic to suspect that caretakers would have drastically changed their children's DP over the short study period. Furthermore, most of the children in our cohort were not stunted at birth (Fig. 2); therefore, after birth, especially after weaning from breastfeeding, some children quickly became stunted from normal growth levels before we began the follow-up survey of the cohort. Hence, DPs and stunting seem to be related.

As shown in Table 5, age in months was significantly related to stunting in already-stunted children, although the risk of stunting based on DP was not increased. If children who were already stunted at the start of the study became stunted at some point before the start of our observation, already-stunted children should have the same risk of stunting as other children with the traditional DP. Because of the short study period, the age in months of already-stunted children was relatively high compared with children who became stunted during the study period. If we assume children have different sensitivities to DPs based on age in months (i.e. if DP and age in months have a mutual interaction or if DP has a different effect on child growth based on age in months), the result of no association between the traditional DP for normal and stunted children may be explained. According to this hypothesis, we added an analysis to show the interaction between the DPs and months of age on stunting (Table 6). The results showed the tendencies of the interaction of DP and age in months, although they were not statistically significant due to the small observation numbers by month of age and DPs. However, from these results, we may be able to conclude that children aged between 12 and 35 months are highly vulnerable to stunting with a traditional DP compared with those who are over 36 months of age.

A sensitivity to food intake of children in this age range has also been reported for child obesity,[19,20] although similar reports about stunting are limited.[21] The nutritional sensitivity for both stunting and obesity can be explained by the enhanced degree of child growth during these months of age. Child growth rate increases quickly during this age range,[22] and the lack of protein causes stunting and the surplus of protein causes obesity in children.

Factors other than DP and age in months were also found to impact the risk of stunting in our study. The results revealed a higher risk of stunting in males than females. A systematic review of sex differences in stunting among children less than five years old across 10 countries in sub-Saharan Africa reported male children are consistently more likely to become stunted than their female counterparts.[8] Biological, cultural or behavioural factors may influence this difference. However, consensus on the sex differences in stunting has not yet been reached. Hookworm infection was another factor that affects the risk of stunting in children in this study. This may be because hookworm infection is reported to cause protein losses in the host's body, which can cause children to become stunted.[23]

The study also demonstrates that the DPs of children had an association with the stunting levels and that the children in the protein-rich dietary group were less likely to become stunted. Maternal compliance to children's diet may be related to their educational level and the nutrition information they possess. Therefore, there is an opportunity to curb stunting by enhancing maternal knowledge regarding the necessity of providing a diverse DP to children aged under five years.[24]

From the results of this study, we can conclude that local solutions for stunting prevention are preferable because the study area is uniformly poor, as we reported in a previous HDSS report.[13] Locally available, protein-rich food should be provided to children, especially those aged 12–35 months. In order to provide information on child nutrition, a community-led training programme should be organised locally.

Several limitations must be considered in the interpretation of results from this study. First, we used the FFQ in this study to assess mothers' feeding practices to their children. We used the FFQ because it assesses long-term diet and it is suitable to analyse one or more foods (or groups of foods) of research interest with less respondent burden compared with a 24-h recall survey.[25,26] In this context, the FFQ was suitable for the DP categorisation of children. However, we have not validated the FFQ with 24-h recall survey because of consideration of the rural setting of the study area and reduction on the respondent burden. This is the limitation of our study; however, we have not focussed on nutrient

Table 4 – Crude and adjusted[a] odds ratios (ORs) of factors related to becoming stunted[b] from normal height compared with children within a normal height range throughout the study period.

Factor	No. of children (n = 249)	Crude OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Dietary pattern							
Protein rich	49	**Ref.**			**Ref.**		
Traditional	125	**2.78**	(1.02–7.55)	0.045	**2.49**	(0.90–6.87)	0.079
Traditional complemented by breast milk	75	**2.58**	(0.91–7.30)	0.074	**3.10**	(1.03–9.33)	0.045
Age group (months old)							
6–11	35	**Ref.**			**Ref.**		
12–23	78	**4.10**	(1.38–12.24)	0.011	**5.54**	(1.72–17.83)	0.004
24–35	45	**2.21**	(0.67–7.35)	0.194	**2.96**	(0.79–11.06)	0.106
36–47	43	**2.05**	(0.59–7.08)	0.256	**3.13**	(0.80–12.35)	0.102
48–59	48	**0.34**	(0.06–1.87)	0.213	**0.42**	(0.07–2.66)	0.361
Anaemia							
Normal range	73	**Ref.**					
Anaemic	176	**1.97**	(0.94–4.15)	0.073			
Caretaker education level							
No education	113	**Ref.**					
Primary school	122	**0.66**	(0.34–1.29)	0.228			
Secondary school or above	14	**1.27**	(0.34–4.83)	0.722			
Sex							
Female	138	**Ref.**			**Ref.**		
Male	111	**1.60**	(0.88–2.93)	0.125	**1.93**	(1.00–3.73)	0.112
Hookworm							
Negative	215	**Ref.**			**Ref.**		
Positive at least once	34	**2.03**	(0.89–4.61)	0.091	**2.68**	(1.09–6.59)	0.031
Round worm							
Negative	242	**Ref.**					
Positive at least once	7	**0.62**	(0.07–5.32)	0.666			
Frequency of breast milk feeding (times/day)							
0	151	**Ref.**					
1–3	8	**1.53**	(0.17–13.69)	0.703			
4–5	15	**1.67**	(0.49–5.64)	0.409			
6 or more	75	**1.56**	(0.79–3.07)	0.200			
Malaria							
Negative	206	**Ref.**					
Positive at least once	43	**1.86**	(0.86–3.99)	0.113			
Ethnic background							
Duruma	159	**Ref.**					
Digo	71	**0.67**	(0.33–1.37)	0.273			
Other tribe	19	**0.62**	(0.18–2.15)	0.449			
Caretaker religion							
Christianity or other	41	**Ref.**					
Muslim	208	**1.11**	(0.47–2.59)	0.815			
Total energy intake per day of foods other than breast milk							
Per kcal	**249**	1.00	(1.00–1.00)	**0.524**			

CI, confidence interval.

[a] Selection of factors (variables) was performed using the backward stepwise selection method with 0.2 as the significance level for removal from the model. Factors not described in the adjusted OR column were removed by the stepwise selection criteria.

[b] Stunting was defined as a height less than minus two standard deviations of the World Health Organization standard length/height-for-age Z-score.

Table 5 – Crude and adjusted[a] odds ratios (ORs) of factors for children who were stunted[b] and children within a normal height range throughout the study.

Factor	No. of children (n = 308)	Crude OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Dietary patten							
Protein rich	66	**Ref.**			**Ref.**		
Traditional	166	**1.49**	(0.82–2.72)	0.187	**1.54**	(0.82–2.89)	0.175
Traditional complemented by breast milk	76	**0.62**	(0.29–1.32)	0.214	**1.08**	(0.48–2.44)	0.851
Age group (months old)							
6–11	36	**Ref.**			**Ref.**		
12–23	66	**1.82**	(0.53–6.32)	0.343	**1.91**	(0.56–6.47)	0.297
24–35	60	**4.43**	(1.36–14.44)	0.014	**3.85**	(1.22–12.13)	0.021
36–47	73	**7.11**	(2.25–22.46)	0.001	**7.99**	(2.65–24.07)	0.000
48–59	73	**3.64**	(1.10–12.01)	0.034	**3.31**	(1.04–10.58)	0.043
Anaemia							
Normal range	103	**Ref.**					
Anaemic	205	**0.83**	(0.52–1.34)	0.457			
Caretaker education level							
No education	146	**Ref.**			**Ref.**		
Primary school	150	**0.70**	(0.42–1.15)	0.160	**0.66**	(0.39–1.15)	0.142
Secondary school or above	12	**0.29**	(0.06–1.47)	0.134	**0.27**	(0.05–1.47)	0.130
Sex							
Female	159	**Ref.**			**Ref.**		
Male	149	**2.01**	(1.25–3.25)	0.004	**2.45**	(1.47–4.07)	0.001
Hookworm							
Negative	263	**Ref.**			**Ref.**		
Positive at least once	45	**1.87**	(0.97–3.60)	0.061	**1.71**	(0.83–3.54)	0.146
Round worm							
Negative	300	**Ref.**					
Positive at least once	8	**0.58**	(0.12–2.93)	0.513			
Frequency of breast milk feeding (times/day)							
0	217	**Ref.**					
1–3	8	**0.44**	(0.09–2.25)	0.327			
4–5	14	**0.36**	(0.10–1.32)	0.123			
6 or more	69	**0.31**	(0.16–0.62)	0.001			
Malaria							
Negative	255	**Ref.**					
Positive at least once	53	**1.45**	(0.75–2.83)	0.269			
Ethnic background							
Duruma	192	**Ref.**					
Digo	91	**0.95**	(0.54–1.65)	0.843			
Other tribe	25	**0.98**	(0.40–2.38)	0.965			
Caretaker religion							
Christianity or other	58	**Ref.**					
Muslim	250	**0.69**	(0.37–1.29)	0.249	**0.59**	(0.28–1.22)	0.155
Total energy intake per day of food other than breast milk							
per kcal	308	**1.00**	(1.00–1.00)	0.077			

CI, confidence interval.

[a] Selection of factors (variables) was performed using the backward stepwise selection method with 0.2 as the significance level for removal from the model. Factors not described in the adjusted OR column were removed by the stepwise selection criteria.

[b] Stunting was defined as a height less than minus two standard deviations of the World Health Organization standard length/height-for-age Z-score.

evaluation, instead, the FFQ data are used to categorise the children according to DP to understand the long-term behaviour of feeding patterns of mothers to their children.

Assuming that feeding patterns do not change frequently in the rural setting of Africa, we categorised the children in the study into three groups using cluster analysis for grouping.

Additionally, reliability or reproducibility must be considered in a nutrition epidemiological investigation. In this study, we have not strictly confirmed to reproducibility of our data from FFQ because the purpose of this study is to determine the relation of the DP on child growth rather than to evaluate the effect of each nutrient on child growth. FFQ may not be strictly reproducible due to reporting bias and availability of various foods in different seasons and also recall bias of the respondent. Therefore, it may be difficult to have a completely reproducible FFQ. However, the FFQ can adequately give a DP and categorise participants into different food intake groups (as it was used to do in the present study).

Conclusions

We found that the traditional DP has a higher risk for stunting compared with the protein-rich DP, and there is a sensitive age for stunting between the ages of 12 and 35 months.

Table 6 – Interaction between dietary patterns and age in months.

Age group (months old)	Normal vs normal to stunting		Normal vs stunting		Normal vs both groups[a]	
	OR	95% CI	OR	95% CI	OR	95% CI
6–11	–	–	–	–	–	–
12–23	4.8	0.58–222.72	3.3	0.35–157.54	4.1	0.72–42.70
24–35	2.1	0.33–22.88	2.3	0.56–9.96	2.1	0.60–7.78
36–47	1.3	0.19–14.56	1.0	0.31–3.39	1.1	0.34–3.39
48–59	–	–	1.6	0.45–6.01	1.7	0.48–6.29

OR, odds ratio; CI, confidence interval.
[a] Both groups included children who became stunted from normal height and children who were stunted throughout the study period. This was analysed to confirm the interaction between dietary pattern and age in months.

Interventions to prevent child stunting should focus on providing locally available, protein-rich foods to children aged between 12 and 35 months. Caretaker education will also help enhance knowledge of a protein-rich diet with foods that are locally available within the community.

Author statements

Author contributions

S.K., J.T., M.K., M.S.C. and V.W. conceived and designed the study. J.T., S.K. and M.S.C. managed the study and contributed to the data collection. J.T. and S.K. analysed the data. J.T. and S.K. wrote the article. S.K., K.Y., K.H. and V.W. provided supervisory support to the study.

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Ethical approval

Informed consent from all caretakers was obtained after they were provided with a full written and verbal explanation of the study purpose and the possible consequences of participation, such as invasion of privacy or breach of confidentiality. This research was approved by the Ethical Review Committee of Nagasaki University Institute of Tropical Medicine on June 15, 2010 (Research permit No. 10061551) and the Ethical Review Committee of Kenya Medical Research Institute (Research permit SSC No. 1964) on March 24, 2011.

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Competing interests

The authors declare that they have no competing interests.

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