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Prevalence and factors associated with undernutrition among Dayak children in rural areas of Sarawak, Malaysia

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ABSTRACT

Background: Undernutrition among children has become a major public health issue due to the high risk of morbidity and mortality involving this vulnerable age group. This study focused on the rural population, especially among the Dayak children in Sarawak, Malaysia. **Methodology:** This community-based cross-sectional study was conducted in Sarawak's rural areas using a multistage stratified cluster sampling technique. Data were collected through face-to-face interviews using an interviewer-guided questionnaire. The nutritional status of the under-five children was measured according to the World Health Organization guidelines. The nutritional indicators were calculated as z-scores. Multivariate logistic regression analyses were performed using SPSS to identify the factors associated with nutritional status. **Results:** The prevalence of undernutrition among the under-five Dayak children in the rural areas of Sarawak was 39.6%. The analysis suggested that wasting was predominantly associated with parental education levels of primary and below, poor wealth index, environmental and sanitation issues, children with history of low birth weight, shorter duration of exclusive breastfeeding, and poor appetite. Stunting was high within the age group of <3 years old and was associated with parents' occupation and household wealth index. Low parental education, poor wealth index, environmental and sanitation issues, poor appetite, and the children's recent illness predicted underweight. **Conclusion:** These findings imply that a multi-sectoral and multi-dimensional approach is essential to address undernutrition in rural settings. Improvement on households' socioeconomy, environment and sanitation should be emphasised to reduce undernutrition among the children.

Keywords: undernutrition, wasting, stunting, underweight, under-five children, Dayak, Sarawak

INTRODUCTION

Undernutrition among children has always been a major public health issue. The World Health Organization (WHO) reported that globally 170 million children were underweight in 2020 (WHO, 2020a). At the other end of the spectrum, more than 40 million children under the age of five years were overweight, and almost half of the cause of mortality among under-five children was related to malnutrition (Mekonnen *et al.*, 2005). Several indicators have been developed to assess

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the nutritional status of children, such as the dietary diversity of individual and household level suggested by the Food and Nutrition Technical Assistance III Project (FANTA, 2006), household food security by Coates, Swindale & Bilinsky (2007), and level of vitamins and minerals adequacy, and anthropometric measurements (WHO, 2010). In this study, anthropometric measurements were the important indicators that had been used to determine the prevalence of undernutrition in a population of under-five children (Kassa *et al.*, 2017). The WHO defined wasting, stunting, and underweight as z-scores <-2 standard deviation (*SD*) for weight-for-height, height-for-age, and weight-for-age, respectively (WHO, 2020b). Worldwide, it was reported that wasting prevalence was 7.3%, stunting 21.3%, and underweight 13.4% (Dukhi, 2020).

In Malaysia, the prevalence of malnutrition in children has been decreasing over the past decade. The latest report by the National Health and Morbidity Survey (NHMS) 2019 stated that the prevalences of wasting, stunting, and underweight among Malaysian children under five years were 9.4%, 21.8%, 14.1%, respectively (IPH, 2019). In comparison with another local study, Cheah *et al.* (2012) reported an alarming prevalence of undernutrition among the under-five Orang Asli children in the rural areas of Kelantan with 69.0% stunting, 40.0% wasting, and 63.4% underweight. A few studies had been conducted among the Dayak community children in Sarawak. There was a reportedly high prevalence of stunting and underweight among the under two Penan children in Belaga, Kapit (Bong, Karim & Ismail, 2018). Eunice, Cheah & Lee (2014) reported 20.9% underweight, 10.2% wasting, and 11.9% stunting, respectively, among children below five years in a Bidayuh community in Sarawak, Malaysia.

Many factors had been identified as being associated with undernutrition. Parental literacy, family size, duration of breastfeeding, health status, and history of the children's recent illnesses were among the variables associated with undernutrition (Gebre *et al.*, 2019). Sociodemographic and socioeconomic variables also have important influences on childhood malnutrition. Environmental factors such as sources of drinking water, types of sanitation, household built-up materials, and wealth index of households were reported to influence nutritional status (Kassie & Workie, 2020).

Despite high prevalence of undernutrition, specific studies on the factors affecting the nutritional status of under-five rural Dayak children have not been extensively carried out. The Dayak indigenous communities are among the majority ethnic groups that reside in the rural areas of Sarawak. Because of the remoteness of the Dayak community, differences in sociodemographic and socioeconomic backgrounds could pose some patterns to the children's nutritional status. Thus, this study focused on the prevalence of undernutrition and its determining factors among under-five children in the rural areas of Sarawak, Malaysia.

MATERIALS AND METHODS

Study setting and population

This was a cross-sectional community-based study conducted in Sarawak, Malaysia. Five divisions were randomly selected from 12 administrative divisions in the state. From each selected division, two districts were randomly selected. Then, five villages of Dayak communities were selected from each district. A total of 50 villages were involved in this study. The households in each village were selected through systematic random sampling based on

the total number of households in the respective village, using the headman's house as the starting point. Sample size was calculated with a base population proportion of children with malnutrition of 43% (Eunice *et al.*, 2014), with 1.96 standard values for two-tailed tests and 4% absolute precision. The sample size was further inflated, multiplying by a design effect of 2 and 15% non-response rate. So, the final sample size was 860. The study respondents consisted of both parents, having at least one under-five child in their households. Respondents who were residents of the study area <6 months, seriously ill, had communication difficulties, and had children with special needs and physical deformities that hindered height measurements at the time of data collection, were excluded from the study. In cases where there was >1 under-five child in the household, only one child was randomly chosen for data collection.

Data collection instrument

The instrument had several components based on the objectives of the study. It was prepared in the form of a booklet for easy handling during the interview. The instrument consisted of respondent's sociodemographic characteristics, such as parental age, level of education, type of occupation, size of the family, and household expenditure. Household assets consisted of 22 items that were intended to measure the respondent's economic status. The household environment and sanitation questions had 32 items. These questions were adapted from Lin *et al.* (2013). Children's characteristics and health status were also included in the questionnaire with 11 items, including their age, gender, upbringing, and medical history. Lastly, the child's body weight (kg) and height (cm) were measured following standard guidelines (WHO, 2008). Children were measured for standing height without shoes using a SECA portable body meter (SECA 206, Germany) to the nearest 0.1 cm. For children 6–23 months of age, recumbent length was measured. Body weight of infants and young children was measured using a digital weighing scale (Tanita 1583, Japan) to the nearest 0.01 kg. Children who were able to stand upright were weighed using a digital lithium-battery weighing scale (Tanita 318, Japan) to the nearest 0.1 kg. The measurements were recorded in the WHO Anthro version 3.2.2 software, which was downloaded from the WHO website.

Measurement

Nutritional status

Height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) *z*-scores of the children were calculated by WHO Anthro 3.2.2 software according to age and gender. Anthropometric classifications were based on global standards: ≤3 *SD*, ≤2 *SD*, and ≥2 *SD*. Children with WHZ, HAZ, and WAZ below -2 *SD* of the reference population's median were considered wasted, stunted, and underweight, respectively (WHO, 2020b).

Wealth quintile

Wealth index was calculated based on usable household assets by Principal Component Analysis (PCA). Initially, 22 assets were included in the wealth index calculation. The household item with a frequency of <5% or >95% and communality sources <0.3 were excluded from the model. Finally, 18 assets entered a model with Kaiser-Meyer-Olkin (KMO) and Bartlett's Test that yielded the household's percentage distribution based on quintiles of wealth index. The scores were labelled as poorest for the lowest quintile and the highest quintile as the richest.

Household characteristics
A proxy economic status of the household was calculated based on in-house facilities and construction materials. The in-house facilities included the source of water supply, lighting, and type of sanitation. The construction materials were pertaining to the material composition of the walls, floor, ceiling, and roofing of the house described by Yakubu, Akaateba & Akanbang (2014). Based on the majority frequency of usage, the items were further classified into items, i.e., 'yes' for having the proper items and 'no' for improper items in the house. It yielded a total of seven items. Therefore, out of seven items, the score of 4 or less was considered Poor, 5-Satisfactory, 6-Good, and 7 - Excellent (Morris *et al.*, 2000).

Data collection procedure
A pilot test was conducted among 30 respondents. The purpose of this test was to determine whether the wordings used were clear and whether there was a need to further refine the questionnaire. Domain-wise, Cronbach's alpha was calculated, and it varied from 0.688 to 0.890. The interviewers were trained for one week to ensure high quality data were collected. Prior to data collection, a briefing session was held by the researcher and his team. This session was made compulsory to clearly understand the study objectives, selection criteria of the respondents, sampling methods, and proper manner for conducting interview to ensure everyone was tailored to their roles in data collection. The questionnaires were checked to make sure that relevant questions had been responded to and coded accordingly. The questionnaire distribution and collection was done between April 2019 till February 2020. At the end of the study period, a total of 920 questionnaires were distributed according to the divisions, districts and villages, and 808 complete responses were received, yielding a response rate of 88.2%. Data were collected by face-to-face interviews at a comfortable time. Three attempts were made to get the sampled respondents.

Ethical issues
Participation in this study was entirely voluntary. Respondents were briefed about the confidentiality of the information given. Informed written consent was obtained from the participants. No financial or any other incentives were provided for their participation. The study received ethical approval from the Ethics Committee of the Faculty of Medicine and Health Science, Universiti Malaysia Sarawak (UNIMAS) [UNIMAS/NC-21.02/03-02 Jld.3 (80)] and the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia [KKM/NIHSEC/P19-877 (6)].

Data analysis
Any missing information in the questionnaire was corrected on the same day or the next day. Data coding and verification of response was made on the same day immediately after the interview. Complete data were entered into Microsoft Office Excel 2010 with a validation check. From Microsoft Excel, the data were exported to IBM Statistical Package for Social Science (SPSS) version 22.0. They were then validated for any inconsistencies, missing values, and duplication. The analysis output was presented in the form of mean, median, minimum and maximum values, and standard deviation for continuous data, and percentages for categorical data. All continuous variables were then transformed into categorical data for further analysis. Binomial logistic regression analysis was used to predict

the factors that affected the nutritional status of under-five children. Before interpreting the results, Chi-square goodness of fit, Nagelkerke R^2, predictive accuracy and classification were checked for model fit adequacy. A *p*-value of ≤0.05 was considered statistically significant.

RESULTS

Sociodemographic and socioeconomic of the respondents

A total of 808 household data were analysed in this study. Almost half of the fathers (45.6%) were 25 to 34 years old, followed by the age group of 35 to 44 years (35.4%). The mean age for fathers was 35.37 (8.28) years old. The mean age for mothers was 32.42 (7.63) years old, with the majority (56.9%) from the age group of 25 to 34 years old. Nearly four-fifths (78.3%) of the fathers had secondary level and above of education, while 73.0% of the mothers attained secondary level and above of education. One-third (35.5%) of the fathers were unemployed, followed by self-employed (32.9%), and working in private sectors (21.2%). The unemployment rate among the mothers was 69.7%, with only 30.3% being employed either as self-employed or working in private or government sectors. The median family size was six persons, with a minimum of two persons and a maximum of 15 persons in the household. The percentage distribution of the wealth quintile of the households was almost equal among the five groups, with a little extra percentage among the richest quintile (22.3%) or 180 households. The good score for household characteristics was the highest among the four categories at 30.7% or 248 households, followed by the poor score at 27.3% (221 households), excellent score at 17.6% (142 households), and 24.4% or 197 households with a satisfactory score (Table 1).

Characteristics of children and their health status

Among the under-five children, slightly more than half were boys (51.1%). The children's mean age was 30.35 months, with a minimum age of six months and a maximum age of 59 months. About one-fifth (22.2%) of children were born low birth weight (<2.5 kg). More than half were in the second to fourth birth order among their siblings. Seven-tenths (71.0%) of the children were exclusively breastfed six months or less, while 29.0% were breastfed for >6 months. A high percentage of children had a good appetite in the past week (78.5%). Although majority of the children had no illness in the past 14 days, 12.5% or 101 children had a fever, 40 children (5.0%) had respiratory illness, and 27 (3.3%) children had experienced gastrointestinal illness (Table 2).

Nutritional status of the children

Weight-for-height indicated that 1.2% were severely wasted, while 5.7% were wasted. Normal weight-for-height was 87.8%, and 5.3% were having a risk of being overweight. As for the height-for-age indicator for stunting, 2.8% were severely stunted, 16.1% were stunted, while 81.1% were within the normal category. Weight-for-age nutritional status showed that 14.2% were underweight, 0.4% were severely underweight, while 85.4% had normal weight-for-age (Table 3).

Patterns of undernutrition problems

Table 4 illustrates the patterns of standalone and co-occurrence of nutritional problems in children. It was found that the highest percentage of children with standalone forms of malnutrition were stunted (9.4%), followed by 2.8% being wasted, and 2.4% underweight. However, the total percentage of co-occurrence of

Table 1. Characteristics of the respondents and households

Characteristics	*n*	*%*	*Statistics*
Father's age in years			
<25	53	6.6	
25-34	367	45.4	Mean±*SD* = 35.37±8.28
35-44	286	35.4	Min = 21, Max = 63
≥45	102	12.6	
Mother's age in years			
<25	85	10.6	
25-34	460	56.9	Mean±*SD* = 32.42±7.63
35-44	199	24.6	Min = 20, Max = 60
≥45	64	7.9	
Father's level of education			
Primary and below	175	21.7	
Secondary and above	633	78.3	
Mother's level of education			
Primary and below	217	26.9	
Secondary and above	591	73.1	
Occupation of father			
Unemployed	287	35.5	
Government jobs	84	10.4	
Private jobs	171	21.2	
Self-employed	266	32.9	
Occupation of mother			
Unemployed	563	69.7	
Government jobs	77	9.5	
Private jobs	71	8.8	
Self-employed	97	12.0	
Family size			
2-3	75	9.4	
4-5	284	35.1	Mean±*SD* = 6.1±2.1
6-7	263	32.5	Median = 6
8-9	107	13.2	Min, Max = 2, 15
≥10	79	9.8	
Wealth quintile			
Poorest	161	19.9	
Poor	151	18.6	
Middle	158	19.6	
Rich	158	19.6	
Richest	180	22.3	
Household characteristics			
Poor (≤ 4)	221	27.3	
Satisfactory (5)	197	24.4	
Good (6)	248	30.7	
Excellent (7)	142	17.6	

Table 2. Characteristics of the children

Characteristics	*n*	*%*	*Statistics*
Age (months)			
<11	107	13.2	
11 – 23	204	25.3	Mean±*SD* = 30.35±16.16
24 – 35	169	20.9	Median = 29
36 – 47	144	17.8	Min = 6; Max = 59
48 – 59	184	22.8	
Gender			
Male	413	51.1	
Female	395	48.9	
Birth weight (kg)			
≥2.5	629	77.8	
<2.5	179	22.2	
Birth order			
First	297	36.8	Mean±*SD* = 2.23±1.33
2nd to 4th	455	56.3	Median = 2, Min = 1; Max = 9
5th or higher	56	6.9	
Duration of exclusive breastfeeding (months)			
≤6 months	574	71.0	Mean±*SD* = 3.97±1.69
>6 months	234	29.0	Median = 4, Min = 1; Max = 8
Parents' perception on child's eating appetite			
Good	634	78.5	
Moderate	148	18.3	
Poor	26	3.2	
Types of illness in the past 14 days			
No illness	640	79.2	
Fever	101	12.5	
Respiratory	40	5.0	
Gastrointestinal	27	3.3	

undernutrition problems involving stunting was 18.1%, followed by underweight 14.2%, and wasting (6.6%).

Factors associated with undernutrition: Multivariate analysis

Parental age, family size, and children's gender were factors excluded in the multivariate analysis as these variables were not statistically significant in the Chi-square test of independence.

Wasting

The multivariate analysis showed that fathers with education level of primary and below (AOR=1.139, 95% CI: 0.448-2.405), mothers with education level of primary and below (AOR=7.489, 95% CI: 3.275-17.122), poorest wealth index (Quintile 1) (AOR=4.835, 95% CI: 1.251-18.681), poor environment and sanitation score (AOR=2.603, 95% CI: 0.973-5.361), birth weight of <2.5 kg (AOR=2.106, 95% CI: 1.084-4.090), and poor eating appetite in the past one week (AOR=2.376, 95% CI: 0.108-1.306) were independent positive predictors for wasting among the children, while the duration of exclusive breastfeeding of six months and above

(AOR=0.397, 95% CI: 0.202-0.780) was the only negative predictor for wasting among the children (Table 5). Children whose fathers had an education level of primary and below were 1.139 times more likely to be wasted, and mothers with similar education levels were 7.489 times more likely to be wasted than fathers and mothers with an education level of secondary and above. The poorest wealth index households increased the likelihood of children being wasted at 4.835 times compared to the richest wealth index households. Children with poor environment and sanitation were 2.603 times more likely to be wasted than those with excellent environment and sanitation, while children with a history of low birth weight were 2.106 times more likely to be wasted compared to those with a birth weight of >2.5kg. Children who experienced a duration of exclusive breastfeeding for >6 months had 0.397 times of prevalence in wasting than those breastfed six months and less. Children with poor eating appetite were 2.376 times likelier to be wasted compared to those with good eating appetite.

Stunting

The independent predictors for stunting among the children were the unemployment status of fathers (AOR=1.726, 95% CI: 1.014-2.938) and mothers (AOR=2.888, 95% CI: 1.301-6.412), and each of the household wealth indices, from the poorest (AOR=5.895, 95% CI: 2.377-14.623), poor (AOR=5.221, 95% CI: 2.199-12.400), middle (AOR=3.477, 95% CI: 1.506-8.029) to rich (AOR=3.243, 95% CI: 1.405-7.484) households. Children whose fathers and mothers were unemployed were 1.726 times and 2.888 times more likely to be stunted, respectively. Based on wealth index, children with poor household scores were more likely to be stunted compared to those with richer household scores. Apart from that, the age of the children had a significant association as well,

Table 3. Nutritional status of the children

Nutritional status	*n*	*%*
†Weight-for-height (wasted)		
Severely wasted	10	1.2
Wasted	46	5.7
Normal	709	87.8
Risk of overweight	43	5.3
‡Height-for-age (stunted)		
Severely stunted	23	2.8
Stunted	130	16.1
Normal	655	81.1
§Weight-for-age (underweight)		
Severely underweight	3	0.4
Underweight	115	14.2
Normal	690	85.4

†Weight-for-height: severely wasted (≤-3*SD*), wasted (≤-2*SD*), normal (>-2*SD* to <2*SD*), overweight (≥2*SD*) and obese (≥3*SD*)
‡Height-for-age: severely stunted (≤-3*SD*), stunted (≤-2*SD*) and normal (>-2*SD* to <2*SD*)
§Weight-for-age: severely underweight (≤-3*SD*), underweight (≤-2*SD*) and normal (>-2*SD* to <2*SD*)

notably the age groups of 36 months to 47 months (AOR=0.469, 95% CI: 0.263-1.336) and 48 months to 59 months (AOR=0.592, 95% CI: 0.324-1.079). Children in these two age groups were 0.469 times and 0.592 times more likely to be stunted, respectively, compared to children <11 months old (Table 5).

Underweight

The multivariate analysis showed that the independent variables that were associated with the prevalence of underweight were: fathers (AOR=1.453, 95% CI: 0.510-2.977) and mothers (AOR=3.192, 95% CI: 1.646-6.191) with education level of primary and below; wealth index of households, from the poorest (AOR=3.634, 95% CI: 1.362-9.694), poor (AOR=2.565, 95% CI: 1.001-6.574) to rich (AOR=1.405, 95% CI: 0.894-3.246), and having poor environment and sanitation within the household (AOR=1.429, 95% CI: 0.840-2.432). Poor eating appetite in the past one week (AOR=2.213, 95% CI: 1.787-4.334) and fever as an illness in the past 14 days (AOR=2.537, 95% CI: 1.158-5.368) were also important variables that influenced underweight status among the children (Table 5). In comparison, fathers and mothers with an education level of primary school and below were 1.453 times and 3.192 times more likely to have children who were underweight than parents with an education level of secondary school and above.

In general, children who lived in poor households were more likely to be underweight compared to rich households. Children with poor environmental and sanitation scores were 1.429 times more likely to be underweight than children from households with excellent scores. Besides that, children with poor eating appetite were 2.213 times more likely to be underweight than those with a good eating appetite. Children with a history of fever were 2.537 times more likely to be underweight too compared to children with no history of illness.

DISCUSSION

Child malnutrition continues to be a major public health problem in developing countries, including Malaysia. Children are the most vulnerable to be malnourished due to multiple factors (Rikimaru *et al.*, 1998). The socioeconomic status of a household is one of the contributing factors. Socioeconomic status is also associated with occupation, which is indirectly related to the level of education in the household. In this study, several factors were found to influence undernutrition

Table 4. Distribution patterns of undernutrition problems among children

	Underweight	*Wasted*	*Stunted*	*Wasted & stunted*	*Total*
Underweight	2.4(A)	3.1(D)	8.0(E)	0.7(G)	14.2(H)
Wasted	3.1(D)	2.8(B)	0.7(F)		6.6(I)
Stunted	8.0(E)	0.7(F)	9.4(C)		18.1(J)
Wasted and stunted	0.7(G)				0.7(G)
Total	14.2(H)	6.6(I)	18.1(J)	0.7(G)	39.6(K)

A = underweight only
B = wasted only
C = stunted only
D = underweight + wasted
E = underweight + stunted
F = wasted + stunted
G = underweight + wasted + stunted
H = total underweight
I = total wasted
J = total stunted
K = total undernutrition

Table 5. Factors associated with nutritional status of under-five children: Multivariate analysis

Characteristics	*Weight-for-height (Wasted) n= 56*			*Height-for-age (Stunted) n= 153*			*Weight-for-age (Underweight) n=118*		
	AOR	*95 CI*		*AOR*	*95 CI*		*AOR*	*95 CI*	
		LL	*UL*		*LL*	*UL*		*LL*	*UL*
Level of education (Fathers)									
Secondary and above (RC)	1.000			1.000			1.000		
Primary and below	1.139**	0.448	2.405	1.274	0.658	2.465	1.453*	0.510	2.977
Level of education (Mothers)									
Secondary and above (RC)	1.000			1.000			1.000		
Primary and below	7.489**	3.275	17.122	0.800	0.436	1.469	3.192*	1.646	6.191
Occupation (Fathers)									
Self-employed (RC)	1.000			1.000			1.000		
Unemployed	1.452	0.679	3.105	1.726*	1.014	2.938	1.251	0.694	2.258
Government jobs	1.144	0.246	5.329	0.391	0.105	1.455	0.577	0.185	1.802
Private jobs	1.017	0.351	2.941	1.348	0.710	2.558	1.039	0.507	2.127
Occupation (Mothers)									
Self-employed (RC)	1.000			1.000			1.000		
Unemployed	1.414	0.456	4.390	2.888*	1.301	6.412	1.824	0.725	4.590
Government jobs	0.855	0.123	5.963	1.028	0.231	4.571	1.672	0.411	6.808
Private jobs	0.511	0.079	3.309	1.099	1.077	4.916	1.654	0.485	5.638
Wealth Index									
Quintile 5 (RC)	1.000			1.000			1.000		
Quintile 4	2.313	0.663	8.072	3.243*	1.405	7.484	1.405*	0.894	3.246
Quintile 3	2.438	0.697	8.534	3.477*	1.506	8.029	1.779	0.704	4.496
Quintile 2	2.650	0.731	9.603	5.221**	2.199	12.400	2.565*	1.001	6.574
Quintile 1	4.835*	1.251	18.681	5.895**	2.377	14.623	3.634*	1.362	9.694
Environment and sanitation score									
Excellent (RC)	1.000			1.000			1.000		
Good	1.178	0.452	3.073	0.746	0.409	1.363	1.155	0.689	1.936
Satisfactory	1.406	0.506	3.905	0.783	0.409	1.497	1.330	0.766	2.309
Poor	2.603*	0.973	5.361	0.758	0.408	1.407	1.429*	0.840	2.432

Table 5. Factors associated with nutritional status of under-five children: Multivariate analysis (continued)

Characteristics	*Weight-for-height (Wasted) n= 56*			*Height-for-age (Stunted) n= 153*			*Weight-for-age Underweight) n=118*		
		95 CI			*95 CI*			*95 CI*	
	AOR	*LL*	*UL*	*AOR*	*LL*	*UL*	*AOR*	*LL*	*UL*
Age of children in months									
≤11 (RC)	1.000			1.000			1.000		
12-23	0.840	0.292	2.411	0.739	0.359	1.518	1.279	0.689	2.375
24 – 35	0.733	0.304	1.769	0.793	0.437	1.439	1.261	0.755	2.106
36 – 47	0.733	0.302	1.781	0.469*	0.263	1.336	1.527	0.923	2.526
48 – 59	0.592	0.226	1.549	0.592*	0.324	1.079	1.093	0.642	1.861
Birth weight									
≥2.5 kg (RC)	1.000			1.000			1.000		
<2.5 kg	2.106*	1.084	4.090	0.700	0.452	1.084	1.828	1.239	2.698
Duration of exclusive breastfeeding									
≤6 months (RC)	1.000			1.000			1.000		
>6 months	0.397*	0.202	0.780	1.234	0.751	2.028	1.184	0.686	2.042
Parents' perception on child's eating appetite									
Good (RC)	1.000			1.000			1.000		
Moderate	1.569	1.172	2.343	2.093	1.337	3.531	1.174	1.068	1.946
Poor	2.376*	1.108	4.106	2.126	1.804	4.121	2.213*	1.787	4.334
Type of illnesses in the past 14 days									
No illness (RC)	1.000			1.000			1.000		
Fever	2.298	0.362	4.335	2.060	0.791	4.167	2.537*	1.158	5.368
Respiratory	1.568	0.144	3.334	1.948	0.673	3.742	1.490	0.585	2.479
Gastrointestinal	1.545	0.581	3.250	2.154	0.615	4.330	1.386	0.324	2.168
Classification		94.8			84.6			74.8	
Hosmer-Lemeshow		0.189			0.385			0.381	
Pseudo R-square		0.132			0.096			0.113	
LR test Chi-Square	45.478; df(27), $p<0.05$*			46.459; df(27), $p<0.05$**			63.161; df(27), $p<0.001$***		

*$p<0.05$, **$p<0.01$, ***$p<0.001$
AOR - Adjusted Odds Ratio; CI – Confident Interval
LL - Lower Limit; UL – Upper Limit
RC – Reference category; LR - Likelihood ratio

among Dayak children in the rural areas of Sarawak, Malaysia. The prevalence of undernutrition, which comprised of wasting, stunting, and underweight, were assessed to determine the extent of this public health issue among the children in rural areas. The current study revealed that 5.7%, 16.1%, and 14.2% of the under-five children were wasted, stunted, and underweight, respectively. However, these observed prevalences were lower than the UNICEF/WHO/ The World Bank Group joint child malnutrition estimates in 2021 (WHO, 2021).

In comparison with the other upper middle-income countries such as Thailand, it was reported that the prevalences of wasting, stunting, and underweight among the under-five children in rural areas were 4.8%, 17.4%, and 11.0%, respectively (UNICEF, 2018). NHMS 2019 reported that the prevalences of wasting, stunting, and underweight among Malaysian children under five years in the rural areas were 8.5%, 22.2%, and 15.6%, respectively, with wasting and stunting noted to be significantly higher compared to the current study. However, this is taking into consideration the high prevalence of undernutrition contributed by the Orang Asli children in rural areas of Peninsular Malaysia, as reported by Cheah *et al.* (2012), and the rural districts of Sabah by How *et al.* (2020). On the other hand, the prevalence of underweight in the current study was slightly higher compared to the national prevalence of underweight. This could be the small margin of difference between children who lived in rural and urban settings, whereby urban children have more issues of overweight and obesity than underweight (Agbozo *et al.*, 2016).

The pattern of nutritional status with stunting predominating over wasting indicated long nutritional deficiency among the under-five children, with underweight that signified acute and chronic nutritional deficiency. Chronic malnutrition is common among rural children as compared to urban children. However, not many studies have pointed to the co-occurrence of malnutrition; thus, the current study revealed the seriousness of nutritional deficiency periods experienced by the rural children that needs urgent medical interventions to treat those that are affected.

Among the factors that influenced wasting were the parents' level of education, poor household wealth index, environmental and sanitation factor, birth weight of <2.5 kg, shorter breastfeeding period, and poor eating appetite among the children. The household's socioeconomic status that were related to children's growth included parents' education, wealth index, and environmental and sanitation factors. These findings are consistent with Amare, Ahmed & Mehari (2019), where poor socioeconomic background was strongly related to malnourished children. Perceived child size at birth significantly determined the nutritional status of a child. Low birth weight can lead to a high risk of undernutrition in children (Rahman *et al.*, 2016). The current study showed that prolonged breastfeeding of >6 months reduced the risk of wasting among the children. The parent's perception of their children's poor appetite also reflected wasting among the children, whereby children experienced weight loss due to acute malnutrition (Gebre *et al.*, 2019). Poor eating appetite was almost similar to the loss of eating appetite, where the parents perceived that their children were unable to finish their usual portion of foods per meal (Scaglioni *et al.*, 2018). Apart from the parent's status of being unemployed, the prevalence of undernutrition was also associated with household wealth index, as well as environmental and sanitation factors.

Several studies indicated that a poorer wealth index was associated with a higher risk of undernutrition in children due to the lower priority for intra-household investment and resource-constrained households (Wali, Agho & Renzaho, 2020). The wealth index factor also influenced the adequacy of nutrition and proper living conditions (Wali *et al.*, 2020).

The risk of stunting was reduced when the children were in the age group of three years to five years old, in comparison with children in the age group of <3 years old. It is quite common for stunting to start increasing before the age of three years. This is because stunting is a sign of chronic undernutrition, and therefore, takes time to manifest compared with other undernutrition indicators. However, this finding varies in different countries. The prevalence of stunting was the highest among the age group of <2 years old in India, but a lower prevalence was reported in Maldives (Wali *et al.*, 2020). Jiang *et al.* (2015) reported a similar finding among the children in mid-western rural areas of China. This is probably because children >3 years old would have already established their feeding pattern, whereas children <3 years old were still at their transition feeding period.

Subsequent analysis showed that parental education and occupation affected the prevalence of underweight in children. Low levels of parental education had increased the risk of children with underweight. These findings were consistent with Hossain and Khan in Bangladesh (Hossain & Khan, 2018), where the higher the parental education, the lesser the risk of malnutrition. Better education ensured job security and better occupation and thus, improved the socioeconomic of the household. The wealth index in this study also proved that it had affected the nutritional status of the children. Low wealth index was associated with a higher risk of being underweight, while moderate to the wealthiest had reduced malnutrition risk in the households (Kassie & Workie, 2020).

Environmental and sanitation were seen as important variables that influenced undernutrition among the children. Poor sanitation and household environment led to an increased risk of 1.5 times in underweight compared to excellent sanitation and environment. Better sanitation and environment leads to reduced risk of diarrhoea-associated infections, including intestinal worms that can result in insufficient nutrient intakes and undernutrition among the vulnerable groups, particularly the under-five children. Improvement of water supply and cooked foods in the households have also been reported to reduce the risk of food-borne disease among the children and thus, lower the risk of undernutrition (Muoki *et al.,* 2008; Mshida *et al.,* 2018).

In our study, parents' perception of poor appetite among their children also revealed an increased risk of underweight by 2.2 times compared to children with good eating appetite. Eating appetite is responsive to external stimuli associated with the presence of food, smell or taste (Freitas *et al.*, 2018). Good eating appetite was also influenced by eating behaviour, food availability prepared in the households, parental factors, and family environment support (Scaglioni *et al.*, 2018). A recent fever resulted in the increased risk of underweight by 2.5 times compared to children without such history. It was also noted that poor eating appetite reduced the nutrient adequacy of children during such illness. Similar findings had been reported previously (Kassie & Workie, 2020).

In this research, both husband and wife were the respondents in each household to improve the recall of

history. Other important factors that might be associated with nutritional status need to be included in the study, such as maternal characteristics like body mass index and history of any antenatal risk factors. Apart from that, parents might not have given accurate information about their children's birth history and health status compared to the mothers in the households. Therefore, it is recommended that researchers assess medical history records and antenatal documents to verify their findings in future research.

CONCLUSION

The prevalence of undernutrition among the under-five Dayak children in the rural areas of Sarawak was low compared to the national and WHO levels. Wasting was predominantly associated with low parental education levels, poor wealth index, environmental and sanitation issues, low birth weight, shorter duration of exclusive breastfeeding, and perception of poor eating appetite among the children. Apart from parental occupation, the prevalence of stunting was associated with household wealth index and within the age group of <3 years old. The prevalence of underweight was influenced by low parental education levels, poor environment and sanitation, perception of poor eating appetite, and recent illness in children. These findings would contribute to the effort of tackling childhood undernutrition as a high priority public health issue. Government and non-government organisations should focus on prevention and an integrated approach to assist the rural poor, especially by creating more job opportunities in the rural areas, which may subsequently improve household wealth, environment, and sanitation. Awareness through health education among mothers pertaining to the importance of exclusive breastfeeding and child nutrition needs to be emphasised by health educators with support from the surrounding community.

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Authors' contributions

RMM, principal investigator, conceptualised and designed the study, analysed the data, prepared the draft of the manuscript and reviewed the manuscript; KA, conceptualised and designed the study, and reviewed the manuscript; SNR, led the data collection, advised on data entry, analysis and interpretation, and reviewed the manuscript.

Conflict of interest

The authors declare no potential conflicts of interest concerning the research, authorship, and publication of this article.

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