Associations between maternal and child characteristics, child feeding practices, food insecurity, and malnutrition among children aged 6-24 months in Kudat, Sabah

Mohamad Kamal bin Mohamed Lazi[1], Woon Fui Chee[1*] & Muhammad Lokman Bahar[2]

[1]*Department of Public Health Medicine, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia;* [2]*Kudat District Health Office, Ministry of Health Malaysia, Kudat, Sabah, Malaysia*

ABSTRACT

Introduction: Malnutrition is a common health issue in the first two years of life. This study aimed to determine the associations between maternal and child characteristics, child feeding practices, food insecurity, and malnutrition among children aged 6-24 months in Kudat, Sabah. **Methods:** This cross-sectional study involved 342 mother-child pairs from four government health clinics. Data on maternal and child characteristics, child feeding practices, and food insecurity were collected through interviews. Malnutrition was assessed based on anthropometric measurements extracted from medical records and classified using WHO Child Growth Standards 2006. Multiple logistic regression was used for analysis. **Result:** Of 342 children, 18.1% were stunted, 18.1% were underweight, 7.9% were wasted, and 2.9% were overweight. Children of working mothers were less likely to be stunted (*OR*=0.19; 95% *CI*=0.06-0.57) but more likely to be overweight (*OR*=4.15; 95% *CI*=1.09-15.87). Increased maternal age was associated with higher odds of child wasting (*OR*=1.08; 95% *CI*=1.01-1.15). Children of obese mothers were more likely to be stunted (*OR*=2.93; 95% *CI*=1.36-6.31) and overweight (*OR*=6.48; 95% *CI*=1.16-36.16). Having a higher number of siblings was associated with increased odds of underweight (*OR*=1.26; 95% *CI*=1.07-1.49) but reduced odds of wasting (*OR*=0.17; 95% *CI*=0.06-0.50). No association was found for child feeding practices and food insecurity. **Conclusion:** Maternal factors, including employment status, age, obesity, and number of siblings, were significantly associated with child malnutrition. Targeted interventions focusing on maternal and household characteristics are recommended to effectively address malnutrition in young children.

Keywords: demographic factors, child feeding practices, food insecurity, malnutrition, mother

INTRODUCTION

The first two years of life are a critical period for growth and cognitive development, where adequate nutrition is essential to prevent malnutrition and its lifelong consequences, including impaired neurodevelopment, increased morbidity, and higher risks of obesity and non-communicable diseases (Kirolos *et al.*, 2022; Soliman *et al.*,

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*Corresponding author: Dr Woon Fui Chee
Department of Public Health Medicine, Faculty of Medicine and Health Sciences,
Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia
Tel: (6)016-5262192; Fax: (6)(088)329237; E-mail: fuichee@ums.edu.my

2021). Globally, malnutrition accounted for 45% of under-five deaths in 2021 (Kaforau *et al.*, 2023), with 2022 estimates showing stunting at 22.3%, underweight at 12.3%, wasting at 6.8%, and overweight at 5.6% (UNICEF, WHO & The World Bank, 2023).

In Malaysia, the National Health and Morbidity Survey (NHMS) 2022 reported worsening child undernutrition compared to 2015, with stunting (21.2%), underweight (15.3%), and wasting (11.0%) all rising (IPH, 2023). Rates are even higher in Sabah, where stunting (25.3%) and underweight (17.2%) exceed national levels (IPH, 2023). Rural Borneo remains particularly affected, with prevalence reaching 42.3% in Tenom (How *et al.*, 2020) and 61.0% in rural Sarawak (Kiyu *et al.*, 1991). Despite this, little research has focused on children aged 6–24 months in remote areas such as Kudat, Sabah. Kudat's coastal, island, and inland communities often face infrastructural challenges, limited healthcare access, and socioeconomic vulnerabilities that likely contribute to persistent malnutrition. However, disaggregated and district-specific data are lacking, limiting the ability to design targeted interventions.

The aetiology of malnutrition is multifactorial, with maternal factors, such as age, body mass index (BMI), education, and employment, shown to influence child nutrition (Akpinar & Teneler, 2022; Félix-Beltrán, Macinko & Kuhn, 2021; Pavlidou *et al.*, 2023). Local studies in Pahang and Kelantan found links between maternal education, employment, and age with child undernutrition (Cheah *et al.,* 2010; Nargis *et al.*, 2014). However, such mother–child relational studies remain scarce in Sabah and Borneo, where socio-cultural and geographic contexts may differ.

Beyond maternal and child characteristics, child feeding practices and household food insecurity are also crucial contributors to malnutrition. The World Health Organization (WHO) recommends exclusive breastfeeding for the first six months, followed by timely introduction of complementary foods, continued breastfeeding for up to two years or beyond, and achieving minimum dietary diversity from five out of eight food groups to support adequate nutrition and healthy growth in children (WHO & UNICEF, 2021). Poor child feeding practices, such as delayed complementary feeding, inadequate dietary diversity, and poor-quality diets, have been shown to increase the risk of malnutrition (Sirkka *et al.*, 2022).

Food insecurity remains a major challenge for many households, particularly in low- and middle-income countries. It can lead to inadequate dietary intake, essential nutrient deficiencies, and poor growth outcomes, as well as other nutritional deficiencies in young children. Food insecurity also affects the quality, quantity, and frequency of complementary foods introduced to young children, resulting in insufficient nutrient intake and reduced dietary diversity, both of which contribute to malnutrition (Ahmed, Sadeta & Lembo, 2022). Food insecurity remains a pressing issue in rural Malaysia, with prevalence reported at 70.8% in Sarawak (Tan, Cheah & Law, 2023), 77.0% in rural Kuantan (Roselawati *et al.*, 2017), and 64.7% in Pitas, Sabah (Farhadian, Chan & Farhadian, 2015). Despite this, research on food insecurity in Sabah and its association with child nutritional outcomes remains limited.

In this study, we aimed to determine the associations between maternal and child characteristics, child feeding practices, food insecurity, and

malnutrition among children aged 6-24 months in Kudat, Sabah. The evidence garnered will be used to support efforts to combat the malnutrition crisis in Malaysia, particularly in Sabah.

METHODOLOGY

Study setting and subjects
This cross-sectional study was conducted at four government health clinics in Kudat, Sabah, selected using a cluster sampling method. The sampling frame comprised 16 government clinics in the district that provided maternal and child health services, out of a total of 21 clinics. These 16 clinics were considered as eligible clusters; four clinics were randomly selected from this list. All eligible mother–child pairs from the selected clinics were then invited to participate in the study. The inclusion criteria were infants aged 6 to 24 months and healthy children without a history of chronic complications. The exclusion criteria included non-Malaysian citizens, twins, preterm infants (<37 weeks gestation), and children born with congenital abnormalities.

Sample size was calculated using the single proportion formula for cross-sectional studies. Based on an expected stunting prevalence of 21.2% from NHMS 2022 (IPH, 2023), with a 95% confidence level and a margin of error of 0.05, the minimum required sample size was 285 mother–child pairs. Accounting for a 20% non-response rate, a total of 340 eligible mother–child pairs were invited to participate in the study.

Prior to data collection, ethical approval was obtained from Medical Research Ethics Committee (MREC), Ministry of Health Malaysia (Ref. no.: NMRR ID-24-00235-L2T) and the Ethics Committee for Research, Universiti Malaysia Sabah [Ref. no.: JKEtika 1/24(6)]. Permission to conduct the study in selected health clinics was obtained from the Sabah State Health Department and the Kudat District Health Office.

Data collection
Data collection was conducted from 27th March to 1st June 2024 by trained research enumerators at the selected health clinics. Prior to data collection, information sheets explaining the purpose of the study were distributed to mothers. The research enumerators also provided verbal explanations and ensured that adequate information was conveyed. Written informed consents were obtained from mothers who agreed to participate. Data were collected through face-to-face interviews by trained enumerators using a set of pre-tested questionnaires. Each interview took approximately 20 minutes to complete.

Measurements
The questionnaire consisted of four sections: socio-demographic characteristics, child feeding practices, food insecurity, and anthropometric measurements. Although originally developed in the Malay language using existing validated instruments, forward and backward translations were conducted to adapt the content to the local Malay dialect spoken in Sabah. The adapted questionnaire was pre-tested among 50 respondents to assess face validity, clarity, and ease of understanding. A pilot study was conducted in non-study clinics to evaluate the clarity and relevance of the questionnaire. Participants generally found the items understandable. Minor adjustments were made to better reflect the local context, for example, expanding ethnicity options (e.g., Ubian, Bajau, and Sino) and including "months" as a response option for breastfeeding duration. Overall, the questionnaire demonstrated good face validity.

Socio-demographic characteristics

Detailed information on maternal characteristics was collected, including maternal age (in years), ethnicity (Rungus, Ubian, Bajau, Dusun, or Others), working status (working or not working), education level (no formal education/not completed primary, primary, secondary, post-secondary, or tertiary), monthly household income (<RM1,000, RM1,000–1,999, or >RM2,000), living area (urban or rural), and current BMI, which was calculated from measured height and weight and categorised as underweight (<18.5 kg/m²), normal (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), or obese (≥30.0 kg/m²). Child characteristics collected included child's age (in months), birth weight (in kilograms), sex (male or female), mode of delivery (normal vaginal delivery or Caesarean section), gestational age at birth (in completed weeks), and number of siblings.

Child feeding practices

Child feeding practices, including ever breastfed, breastfeeding duration, age at complementary feeding, and minimum dietary diversity (MDD), were assessed using the questionnaire adapted from the NHMS III (IPH, 2016) and WHO Infant and Young Child Feeding (IYCF) Indicators (WHO & UNICEF, 2021). Mothers reported breastfeeding initiation and cessation, age at complementary feeding, and foods given in the past 24 hours from a provided list. Reported items were categorised into eight food groups: (1) breast milk, (2) grains, roots, tubers and plantains, (3) pulses, nuts and seeds, (4) dairy products, (5) flesh foods, (6) eggs, (7) vitamin A-rich fruits and vegetables, and (8) other fruits and vegetables. Scores for each food group were summed to calculate the total score. Child feeding practices were treated as independent variables and comprised four components: ever breastfed (yes/no), breastfeeding duration (in months),

age at introduction of complementary feeding (categorised as 6 months or >6 months), and MDD. Consumption of five or more groups was categorised as meeting MDD, while fewer than five indicated not meeting MDD.

Food insecurity

Food insecurity was assessed as an independent variable using the validated 10-item Radimer/Cornell Food Insecurity questionnaire (Mohamadpour, Sharif & Keysami, 2012; Radimer, Olson & Campbell, 1990). Responses classified households into four categories: food secure, household food insecure, individual food insecure, and child hunger. Respondents were categorised as food secure if they answered "not true" to all ten items. Household food insecurity was identified if respondents answered "sometimes true" or "often true" to one or more of items 1-4. Individual food insecurity was determined if respondents answered "sometimes true" or "often true" to one or more of items 5-7. Child hunger was indicated if respondents answered "sometimes true" or "often true" to one or more of items 8-10.

Anthropometric measurements

Body weight and height of children were taken from their medical records at the health clinics. Weight-for-age, length-for-age, weight-for-length, and BMI-for-age were determined using WHO Anthro version 3.2.2 software. The nutritional status of children was then categorised based on z-scores according to the WHO Child Growth Standards (WHO, 2006). Nutritional status was classified as follows: stunting [length-for-age z-score, LAZ < -2 standard deviations (SD)], underweight (weight-for-age z-score, WAZ < -2 SD), wasting (weight-for-length z-score, WLZ < -2 SD), and overweight (BMI-for-age z-score, BAZ > 2SD). These four indicators were used as categorical dependent variables in the analysis.

Statistical analyses

The IBM SPSS Statistics for Windows version 29.0 (IBM Corporation, Armonk, New York, USA) was used for statistical analysis. For descriptive analysis, continuous variables were reported as mean and standard deviation, while categorical variables were reported as frequency and percentages. Simple logistic regression (SLR) analysis was used to determine the association between each independent variable and malnutrition. Variables with a *p*-value <0.25 in the SLR model were included in the multiple logistic regression model. The backward likelihood ratio variable selection method was used in the multiple logistic regression analysis to determine the associations between selected independent variables and malnutrition in children. All assumptions for multiple logistic regression analysis were met, in which, the *p*-value for the Omnibus test was <0.05, the overall classification accuracy was >80%, the *p*-value for the Hosmer and Lemeshow test was >0.05, and the *p*-values for multicollinearity and interaction were >0.8. Results were presented as odds ratio (*OR*), with 95% confidence interval (*CI*) and the level of significance set at *p*<0.05.

RESULTS

Table 1 shows the socio-demographic characteristics of the mother-child pairs. Mothers had a mean age of 30.9±5.7 years, with most being Rungus (37.4%), unemployed (78.9%), and educated to secondary level (55.8%). Nearly half had normal BMI (45.3%), while 29.2% were overweight and 18.7% obese. Over 40% of households earned RM1,000–1,999 monthly; 60.5% resided in rural areas. Children had mean age of 14.9±5.1 months, mean birth weight of 3.0±0.4 kg, and mean gestational age of 38.6±1.1 weeks. Most were delivered vaginally (79.2%) and were females (58.8%), with an average of two siblings.

Table 2 shows the prevalence of malnutrition among children. A total of 18.1% were stunted, with mean height-for-age z-score of -0.95±1.42. Similarly, 18.1% were underweight, with mean WAZ of -0.88±1.14. Only a small proportion of children were wasted (7.9%), with mean WLZ of -0.66±1.21, and 2.9% were overweight, with mean BAZ of -0.55±1.25.

The prevalence of food insecurity among mother-child pairs is shown in Table 1. Overall, about 67.8% experienced food insecurity. Of these, 38.9% reported household food insecurity, 14.9% reported individual food insecurity, and 14.0% reported child hunger.

As shown in Table 3, most children were ever breastfed (97.4%), with an average duration of 11.7±6.5 months; 82.2% were breastfed beyond six months. Complementary feeding was introduced at mean age of 6.0±0.3 months, with 96.2% starting at six months. Overall, 73.7% met minimum dietary diversity, mainly through grains (99.2%), vitamin A-rich produce (98.8%), flesh foods (96.0%), and eggs (84.1%).

Table 4 presents the simple logistic regression model assessing the associations between maternal nutritional status and child malnutrition. Obese mothers were more likely to have children who were stunted (*OR*=2.16, 95% *CI*=1.10-4.22) and overweight (*OR*=6.48, 95% *CI*=1.22-34.34) as compared to mothers with normal weight. No associations were found between maternal underweight and overweight with any form of child malnutrition.

Multiple logistic regression analysis was conducted to determine the associations between selected variables and malnutrition (Table 5). Children of working mothers were less likely to be stunted (*OR*=0.19; 95% *CI*=0.06-0.57) but more likely to be

Table 1. Characteristics of the mothers and children and distribution of respondents by food security status (*N*=342)

Characteristics	Mean±SD	n (%)
Maternal characteristics		
Maternal age (years)	30.9±5.7	
Maternal ethnicity		
Rungus		128 (37.4)
Ubian		64 (18.7)
Bajau		43 (12.6)
Dusun		33 (9.6)
Others[a]		74 (21.6)
Maternal work status		
Non-working		270 (78.9)
Working		72 (21.1)
Maternal education level		
No formal education / not completed primary		24 (7.0)
Primary		39 (11.4)
Secondary		191 (55.8)
Post-secondary		66 (19.3)
Tertiary		22 (6.4)
Monthly household income		
< RM 1,000		107 (31.3)
RM 1,000 – RM 1,999		150 (43.9)
>RM1999		85 (24.9)
Living area		
Rural		207 (60.5)
Urban		61 (17.8)
Coastal		74 (21.6)
Current body mass index (kg/m^2)	25.5±5.3	
Underweight (<18.5)		23 (6.7)
Normal weight (18.5-24.9)		155 (45.3)
Overweight (25.0-29.9)		100 (29.2)
Obese (≥30.0)		64 (18.7)
Child characteristics		
Age (months)	14.9±5.1	
Birth weight (kg)	3.0±0.4	
Sex		
Male		141 (41.2)
Female		201 (58.8)
Mode of delivery		
Normal		271 (79.2)
Caesarean		71 (20.8)
Gestational age at birth (week)	38.6±1.1	
Number of siblings	2±2	
Food security status		
Food secure		110 (32.2)
Household insecurity		133 (38.9)
Individual insecurity		51 (14.9)
Child hunger		48 (14.0)

[a]Other ethnic groups include Benadan, Bisaya, Brunei, Bugis, Chinese, Cocos, Dusun Banggi, Iban, Irranun, Jawa, Kegayan, Melanau, Murut, Suluk, and Sungai.

Table 2. Prevalence of malnutrition and mean anthropometric z-scores among children (*N*=342)

Malnutrition	Mean±SD	n (%)
Stunting (HAZ<-2SD)	-0.95±1.42	62 (18.1)
Underweight (WAZ<-2SD)	-0.88±1.14	62 (18.1)
Wasting (WLZ<-2SD)	-0.66±1.21	27 (7.9)
Overweight (BAZ>2SD)	-0.55±1.25	10 (2.9)

HAZ: Height-for-age z-scores; WAZ: Weight-for-age z-scores; WLZ: Weight-for-length z-scores; BAZ: BMI-for-age z-scores

overweight (*OR*=4.15; 95% *CI*=1.09-15.87). Increased maternal age was associated with higher odds of wasting in children (*OR*=1.08; 95% *CI*=1.01-1.15). Children of obese mothers were more likely to be stunted (*OR*=2.93; 95% *CI*=1.36-6.31) and overweight (*OR*=6.48; 95% *CI*=1.16-36.16). Increasing child age was associated with an increased likelihood of stunting (*OR*=1.12; 95% *CI*=1.05-1.19) and overweight (*OR*=1.17; 95% *CI*=1.00-1.36). Higher birth weight was linked to lower odds of stunting (*OR*=0.13; 95% *CI*=0.05-0.33) and underweight (*OR*=0.19; 95% *CI*=0.08-0.41). An increase in the number of siblings was associated with increased odds of underweight (*OR*=1.26; 95% *CI*=1.07-1.49) but lower odds of wasting (*OR*=0.17; 95% *CI*=0.06-0.50).

DISCUSSION

This study found stunting and underweight to be the most common forms of malnutrition among children aged 6-24 months in Kudat, with two-thirds of households experiencing food insecurity. Most children were ever breastfed and met minimum dietary diversity. Stunting was linked to maternal employment, obesity, child's age, and low birth weight; underweight to low birth weight and more siblings; wasting to older maternal age and fewer siblings; and overweight to maternal employment, obesity, and older child age. These findings underscore the multifactorial influences on child malnutrition.

The prevalences of stunting (18.1%), wasting (7.9%), and overweight (2.9%)

Table 3. Distribution of children according to child feeding practices (*N*=342)

Child feeding practices	Mean±SD	n (%)
Ever breastfeed		
No		9 (2.6)
Yes		333 (97.4)
Breastfeeding duration (months)	11.7±6.5	
<6 months		61 (17.8)
≥6 months		281 (82.2)
Age at introduction of complementary foods (months)	6.0±0.3	
6 months		329 (96.2)
>6 months		13 (3.8)
Minimum dietary diversity (groups)	5.3±1.4	
Not met (<5 groups)		90 (26.3)
Met (≥5 groups)		252 (73.7)

Table 4. Simple logistic regression analysis of associations between maternal nutritional status and child malnutrition (*N*=342)

Variable	Stunting					Underweight					Wasting					Overweight				
	Yes n (%)	No n (%)	OR	95% CI	p-value	Yes n (%)	No n (%)	OR	95% CI	p-value	Yes n (%)	No n (%)	OR	95% CI	p-value	Yes n (%)	No n (%)	OR	95% CI	p-value
Maternal body mass index																				
Underweight (<18.5 kg/m²)	2 (0.6)	21 (6.1)	0.45	0.10-2.04	0.30	6 (1.8)	17 (5.0)	1.53	0.55-4.22	0.40	3 (0.9)	20 (5.8)	1.40	0.37-5.26	0.61	1 (0.3)	22 (6.4)	3.48	0.30-39.96	0.32
Normal weight (18.5-24.9 kg/m²)	27 (7.9)	128 (37.4)	1	ref	—	29 (8.5)	126 (36.8)	1	ref	—	15 (4.4)	140 (40.9)	1	ref	—	2 (0.6)	153 (28.7)	1	ref	—
Overweight (25.0-29.9 kg/m²)	13 (3.8)	87 (25.4)	0.71	0.35-1.45	0.35	17 (5.0)	83 (24.3)	0.89	0.46-1.72	0.72	5 (1.5)	95 (27.8)	0.49	0.17-1.39	0.18	2 (0.6)	98 (28.7)	1.56	0.22-11.27	0.66
Obesity (≥30.0 kg/m²)	20 (5.8)	44 (12.9)	2.16	1.10-4.22	0.03*	10 (2.9)	54 (15.8)	0.80	0.36-1.76	0.58	4 (1.2)	60 (17.5)	0.62	0.19-1.95	0.41	5 (1.5)	59 (17.3)	6.48	1.22-34.34	0.03*

in this study were lower than national rates, while underweight was higher (18.1% vs. 15.3%) (IPH, 2023). These differences may relate to the narrower age range studied (6-24 months). Breastfeeding practices were stronger in Kudat, with 97.4% ever breastfed and 82.2% continuing ≥6 months, exceeding national rates (IPH, 2023), likely due to local breastfeeding promotion efforts and increased awareness. Nearly all mothers (96.2%) introduced complementary foods at six months; 73.7% of children met minimum dietary diversity, surpassing national figures (IPH, 2023), possibly reflecting better local food variety from agriculture and coastal resources.

Food insecurity affected 67.8% of respondents in this study, which was higher than in Pitas, Sabah (64.7%), but lower than rural Kuantan (77.0%) and Sarawak (70.8%) (Farhadian *et al.*, 2015; Tan, Cheah & Law, 2023; Roselawati *et al.*, 2017). This may reflect post-COVID-19 economic instability, with most households earning <RM2000 and facing challenges such as unemployment or added dependents. These conditions likely limit access to diverse, nutrient-rich foods, making undernutrition a greater concern than overnutrition in the first two years of life.

Consistent with previous studies, children of obese mothers were more likely to be stunted or overweight (Félix-Beltrán *et al.*, 2021). In contrast, a study from Nigeria reported that obese mothers were less likely to have stunted children (Lawal *et al.,* 2023). The co-occurrence of maternal obesity and child undernutrition may reflect shared household dietary patterns characterised by energy-dense but nutrient-poor foods or a genetic predisposition to fat accumulation.

In this study, maternal employment was linked to lower stunting but higher overweight in children. Similar trends were reported by Pavlidou *et al.* (2023), whereas an Indonesian study found the opposite, with maternal employment positively associated with stunting (Rahayuwati *et al.*, 2023). Employment may improve food security through increased income but reduced time for optimal feeding, leading to greater reliance on convenience foods. This highlights the double-edged influence of maternal employment on child nutritional status.

Table 5. Multiple logistic regression model of factors associated with malnutrition in children (*N*=342)

Variable	Stunting[a]			Underweight[a]			Wasting[a]			Overweight[a]		
	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value
Maternal work status												
Non-working	1									1		
Working	0.19	0.06-0.57	<0.01**							4.15	1.09-15.87	0.04*
Maternal age							1.08	1.01-1.15	0.04*			
Maternal education level												
No formal education/not completed primary	1.74	0.57-5.35	0.33									
Primary	0.34	0.11-1.08	0.07									
Secondary	1											
Post-secondary	1.52	0.67-3.46	0.32									
Tertiary	0.30	0.03-2.76	0.29									
Maternal body mass index												
Underweight (<18.5 kg/m^2)	0.39	0.08-1.94	0.25							5.91	0.45-77.00	0.18
Normal weight (18.5-24.9 kg/m^2)	1									1		
Overweight (25.0-29.9 kg/m^2)	1.06	0.48-2.33	0.88							1.41	0.19-10.57	0.74
Obesity (≥30.0 kg/m^2)	2.93	1.36-6.31	<0.01**							6.48	1.16-36.16	0.03*
Child's age (months)	1.12	1.05-1.19	<0.01**	1.06	0.99-1.12	0.06				1.17	1.01-1.36	0.04*
Birth weight (kg)	0.13	0.05-0.33	<0.01**	0.19	0.08-0.41	<0.01**						
Gestational age at birth (weeks)				1.26	1.07-1.49	<0.01**	0.17	0.06-0.50	<0.01**			
Number of siblings										0.58	0.31-1.09	0.59
Minimum dietary diversity												
Not met (<5 groups)	0.50	0.23-1.09	0.08									
Met (≥5 groups)	1											

OR: Odds ratio; CI: Confidence interval

[a]Tested using multiple logistic regression (method: Backward LR), *p<0.05, **p<0.01

This study found that an increase in maternal age was positively associated with wasting in children. Mixed findings have been reported; one study supported this association (Akpinar & Teneler, 2022), while another found that children born to younger mothers were more likely to be wasted (Yu *et al.*, 2016). Possible explanations include health or dietary challenges associated with advanced maternal age that may reduce the nutritional quality of breast milk or decreased access to nutritious foods due to lower employment rates among older mothers.

Consistent with a previous study, the present study revealed that a child's age was associated with both stunting and overweight (Muche *et al.*, 2021). It is possible that older children may face increased risk due to inappropriate child feeding practices, including overfeeding by caregivers in response to stunted growth, which could lead to excess weight gain. These findings highlight the need for age-specific feeding guidance for caregivers.

This study also found that higher birth weight was associated with lower odds of stunting and underweight in children, in line with the findings from a previous study (Halli, Biradar & Prasad, 2022). Children with normal birth weight typically have better nutritional reserves and a stronger immune system, which support healthy growth and development and help prevent infections that can contribute to malnutrition. This underscores the importance of maternal nutrition during pregnancy to prevent low birth weight and its long-term consequences.

This study also revealed that a higher number of siblings increased the odds of underweight but reduced the odds of wasting. Similar findings were reported by Raj, McDougal & Silverman (2015), where more sisters increased underweight risk. Underweight reflects both chronic and acute malnutrition, whereas wasting is a more specific indicator of acute nutritional stress. The association with underweight is consistent with the "resource dilution effect", where larger families limit per-child resources (Blake, 1981). In contrast, the lower odds of wasting may indicate fewer recent nutritional shocks or sibling support buffering short-term deficits.

Consistent with findings from Harper *et al.* (2022), this study found no significant association between food insecurity and child undernutrition. One explanation may be that food-insecure households prioritise feeding young children, or that mild, short-term insecurity does not produce measurable deficits in a cross-sectional design. It is also possible that maternal characteristics played a stronger role, overshadowing food insecurity effects in multivariable models.

Unlike a previous study (Sirkka *et al.*, 2022), this study found no significant associations between child feeding practices and malnutrition, likely due to the small number of non-compliant cases and the limitations of standard indicators that overlooked food quality, portion size, hygiene, and caregiver behaviours. The high prevalence of underweight and stunting suggests stronger influences from structural factors, such as poor sanitation, limited healthcare access, and regional disparities, which are common challenges in rural and underserved areas like Kudat, Sabah.

This study has several limitations. As it was conducted using cross-sectional design, it cannot establish causality. Child feeding practices were self-reported, thus introducing potential recall and social desirability biases; data on food quantity and portion size were also lacking. The focus on mother–infant pairs in Kudat with uneven ethnic representation limited generalisability, while the small number of overweight cases reduced statistical power.

Despite these limitations, this is the first study to determine the

associations between maternal and child characteristics, child feeding practices, and food insecurity with malnutrition in children aged 6-24 months in Kudat, Sabah. It also provides the latest prevalence data on malnutrition and child feeding practices among children in this age group in Sabah. The significant findings from this study offer useful evidence for policymakers and health practitioners aiming to prevent childhood malnutrition.

CONCLUSION

Malnutrition remains a concern among children aged 6-24 months in Kudat, with undernutrition more prevalent than overnutrition. Despite high breastfeeding and complementary feeding compliances, one-third of children did not meet minimum dietary diversity, while two-thirds of households faced food insecurity. Maternal factors, such as work status, age, and BMI, along with child's age, birth weight, gestational age, and number of siblings, were significant predictors of nutritional outcomes, while food insecurity and feeding practices showed no direct associations.

These findings underscore the critical role of mothers in preventing childhood malnutrition, often exerting a stronger influence than child feeding practices and food insecurity. Community-level interventions should prioritise empowering mothers through targeted nutritional education and social support programmes, especially for vulnerable groups such as older and obese mothers. Behaviour change models should be incorporated into community nutrition programmes to enhance knowledge, shift attitudes, and support sustained healthy behaviours. Policies that support maternal employment, including paid maternity leave, flexible working hours, and access to childcare, can help working mothers manage employment while ensuring proper child nutrition.

Future research should adopt a cohort study design to better understand the long-term determinants of malnutrition and include larger, more diverse populations across various districts to improve generalisability. In addition, future studies should explore additional environmental and behavioural factors, such as sanitation and hygiene, food availability, maternal mental health, cultural aspects, and decision-making dynamics within households, which may contribute to child nutrition outcomes.

Authors' contributions

Mohamad Kamal ML, led the data collection, contributed to the design and conduct of the study, data analysis and interpretation, prepared the draft of the manuscript, and reviewed the manuscript; Muhammad Lokman B, contributed to the data collection of the study; Woon FC, led the project, contributed to the design of the study, supervised the study, advised on data analysis and interpretation, and reviewed the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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