ORIGINAL ARTICLE

Factors Associated with Dietary Diversity Among Preschool Children Aged Two to Six From Low-income Households in Seremban, Malaysia

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ABSTRACT

Introduction: Dietary diversity is crucial for children's growth, development, and overall health status, particularly for those aged two to six. However, studies on dietary diversity among young children in Malaysia are limited. This cross-sectional study aimed to determine the factors associated with dietary diversity among preschool children aged two to six years old from low-income households in Seremban. **Materials and methods:** A total of 245 children from 10 randomly selected *Taska* KEMAS and 30 randomly selected *Tabika* KEMAS in Seremban were participated in this study. Mothers completed a questionnaire on socio-demographic background and food security status. Anthropometric measurements, including weight and height, were taken following standardized procedures. A 3-day 24-hour dietary recall of the children was conducted through online interviews with their mothers to assess dietary diversity and nutrient intake. **Results:** Food insecurity was experienced by 53.9% of the households. The prevalence of underweight, stunting, and wasting among children were 23.3%, 29.4%, and 23.7%, respectively. The mean Dietary Diversity Score (DDS) was 6.34±0.64, with 20.0% were in the lowest DDS tertile. Multiple linear regression analysis showed that mother's age (β=-0.019, 95% CI=-0.035, -0.002, $p<0.05$), protein intake (β=0.023, 95% CI=0.012, 0.033, $p<0.001$), and fat intake (β=-0.023, 95% CI=-0.032, -0.013, $p<0.001$) were significantly associated with dietary diversity among preschool children. **Conclusion:** These findings highlight the importance of targeted interventions to address food insecurity, promote balanced diets, and educate mothers to include a variety of nutrient-rich foods to improve dietary diversity of preschool children in low-income households.
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INTRODUCTION

Dietary diversity refers to the variety of foods consumed over a period of time, including different food groups that provide essential nutrients for health and development (1). To support optimal growth, it is important to consume food items from various food groups, such as cereals; fruits; vegetables; meat/poultry; eggs; fish; legumes; and milk and milk products, within the recommended energy requirements (2). Dietary diversity is important for children as it directly affects their growth, development, and overall health (3). Higher dietary diversity is associated with improved nutrient intake and reduced risk of deficiencies and associated health problems (4). Conversely, insufficient dietary diversity can lead to nutrient deficiencies, stunted growth, increased susceptibility to infections and chronic diseases, and greater economic burden (5, 6).

Globally, the proportion of children achieving adequate dietary diversity remains low, at only 21% in 2010 and 24% in 2020 (7). Many countries, particularly low- and middle-income countries, report low levels of dietary diversity among children, ranging from 47.9% to 85.8% (8-10). However, most studies have primarily focused on young children aged 6 to 23 months who are in the complementary feeding phase (11-13), leaving a gap in understanding dietary diversity in preschool children who are developing lifelong eating habits. Children aged two to six years are particularly vulnerable during this critical transition from infant to family feeding as they begin to rely on a more diverse diet. Unlike infants under 2 years of age, preschool children are establishing lifelong eating habits and experiencing continued physical and cognitive growth, which increases their nutritional needs. Ensuring dietary diversity during these years is critical to preventing nutrient deficiencies, especially in low-income households where children

are more vulnerable to malnutrition. Yet this age group is often overlooked, highlighting the importance of studying their dietary diversity.

Urban poor children are particularly at risk for poor dietary diversity due to socioeconomic constraints, including limited access to a variety of nutritious foods, high cost of healthy food options, and a lack of nutrition knowledge (14). Financial constraints often lead the urban poor families to choose calorie-dense but nutrient-poor foods, limited their ability to maintain a healthy diet (15). Food insecurity is common in urban poor areas, affecting both the quality and quantity of food available to children and resulting in inadequate nutrient intake (15). A lack of dietary diversity can lead these children to develop unhealthy eating habits that may persist into adulthood, increasing their risk of undernutrition and diseases such as diabetes and heart disease (6). In addition, poor nutrition is associated with poor cognitive development and academic performance, limiting children's potential to succeed in school and beyond (16). Therefore, addressing dietary diversity in this group is essential to identify health disparities and inform nutrition programs tailored to their specific needs. Such interventions can help reduce health disparities and improve the overall well-being of urban poor children, potentially breaking the cycle of poverty and malnutrition.

Several factors have been associated with dietary diversity among young children, including household income (17), maternal education (18), and food security (19). However, research on factors associated with dietary diversity in Malaysia remains limited, with most published studies focusing on specific groups such as indigenous populations (20, 21) and adults with diabetes (22). A previous local study by Chua et al. (20) of Orang Asli children aged one to six years identified several factors associated with dietary diversity scores (DDS), but these were limited to sociodemographic factors. Therefore, further research is needed to determine additional factors such as food security and meal frequency that may be associated with dietary diversity in children.

In general, children are particularly vulnerable to malnutrition, with the burden being higher in low-income households due to inequities in food availability and accessibility (15). Despite this, few studies have explored dietary diversity among children from low-income families in Malaysia, and research on the factors associated with their dietary diversity is lacking. Therefore, this study aimed to assess dietary diversity and its associated factors among children aged two to six years old from low-income households. Understanding these factors is crucial for developing effective strategies to promote healthier eating habits and ensure that all children have the opportunity to thrive regardless of their socioeconomic background.

MATERIALS AND METHODS

Study design and mother-child pairs

This cross-sectional study was carried out among children aged two to six years in Seremban, Negeri Sembilan, Malaysia, from November 2021 to May 2022. The sample size for this study was determined using the Two Population Proportions formula (23). After accounting for the design effect of 1.3 and response rate of 66% (24), a total of 242 participants were required for the study. The inclusion criteria of the participants in this study included Malaysian children aged two to six years from B40 families, defined as those with a monthly household income of less than RM4210 (25). Those children with learning disabilities or chronic illnesses, including conditions such as cancer, asthma and heart disease as reported by teachers or caregivers were excluded from the study. This is to minimize potential effects on dietary diversity and nutritional status as these conditions may significantly influence a child's dietary intake, growth patterns, and overall nutritional needs, making it challenging to isolate the impact of the studied variables.

This study was conducted at *Taska* and *Tabika* KEMAS in Seremban, which are administered by *Jabatan Kemajuan Masyarakat* (KEMAS). KEMAS aims to improve the quality of life in rural areas through various community development programs, including early childhood education. KEMAS operates *Taska* (childcare centers for children aged two to four years) and *Tabika* (preschools for children aged four to six years) throughout the country, providing education and care for young children in underserved communities. These centers are part of the Malaysian government's efforts to ensure equitable access to early education and to promote the development of children in line with national education standards. A detailed list of *Taska* (n=10) and *Tabika* (n=104) in Seremban was obtained and a total of 40 preschools (10 *Taska* and 30 *Tabika*) were randomly selected from the list. Given the limited number of *Taska* in Seremban, all *Taska* children were recruited to meet the required sample size. All children (177 from *Taska* and 272 from the selected *Tabika*) were invited to participate in this study.

Ethical approval for this study was obtained from the Ethics Committee for Research Involving Human Subjects Universiti Putra Malaysia (*Jawantankuasa Etika Universiti Penyelidikan Melibatkan Manusia* [JKEUPM], Reference Number: JKEUPM-2021-145). Additionally, permission to conduct the study at the selected *Taska* and *Tabika* KEMAS was obtained from the KEMAS and the management offices of the selected preschools in Seremban. Data collection was conducted during the Covid-19 pandemic period. Strict standard operating procedures were followed for fieldwork and research activities in the preschools.

Measurements

Sociodemographic profile

Child, mother, and household information were collected through online interviews using Zoom platform with the mothers due to the Covid-19 pandemic. This information included the child's age, sex, ethnicity, and number of sibling(s); the mother's age, marital status, educational level, and employment status; and household size, number of children under five, and monthly household income.

Food security

Food security was assessed using the 2012 U.S. Household Food Security Survey Module (Six-Item Short Form) (26), which included six questions about food security over the past 12 months. Affirmative responses such as 'often true,' 'sometimes true,' and 'yes' were scored as 1, while non-affirmative responses such as 'never true,' 'don't know,' and 'no' were scored as 0. The household's raw score on the scale was determined by summing the affirmative responses to the six questions. A raw score of zero to one indicated high or marginal food security; a score of two to four indicated low food security; and a score of five to six indicated very low food security. For reporting purposes, households with a raw score of zero to one were classified as food secure, while the categories of 'low food security' and 'very low food security' were combined into a single category referred to as food insecure, encompassing households facing various degrees of food security challenges.

Anthropometric assessment

The children's weight and height were measured in preschools by the researchers in duplicate following WHO guidelines (28). Weight was recorded to the nearest 0.1 kg using a TANITA Digital Weight Scale HD662 (TANITA, Japan). Height was measured to the nearest 0.1 cm with a SECA stadiometer model 213 (SECA, Hamburg, Germany). Z-scores for weight-for-age (WAZ), height-for-age (HAZ), weight-for-height (WHZ) and BMI-for-age (BAZ) were determined using the WHO AnthroPlus software version 1.0.4 (Geneva, Switzerland). Children with WAZ, HAZ, WHZ, and BAZ less than 2 SD were classified as underweight, stunted, and wasted, respectively, while those with BAZ greater than 2 SD were classified as overweight (28, 29).

Dietary intake

Dietary intakes including energy, macronutrients, and micronutrients, were assessed using three-day 24-hour dietary recalls covering two weekdays and one weekend. Dietary intake data of children during school hours were collected through interviews with teachers or kitchen staff who regularly interact with the children during mealtimes, while intake data for non-school hours were obtained through online interviews via the Zoom platform with the children's mothers. Estimated portion sizes were determined based on mothers' estimates using standard household measures. Information such as the time and place of consumption, types and quantities of foods and beverages consumed, and methods of preparation was collected and recorded. Dietary intakes were analysed using Nutritionist ProTM Nutrition Analysis Software version 3.1.0 (First Data Bank, San Francisco, CA, USA) along with the Malaysian food composition databases (30, 31) and Singapore food composition databases (32). If a food item was not available in these databases, the information on the food packaging label was used.

Meal frequency

The data from the three-day 24-hour dietary recalls were used to determine the child's frequency of meal in a day. Meal frequency (i.e., the number of meals and snacks consumed per day) of the child was determined by calculating number of daily eating episodes (33). In the preschools, breakfast was served from 8:00am to 8:30am, morning tea was offered around 10:00am, lunch was provided between 12:00pm and 12:30pm, and afternoon tea was served around 3:00pm.

Dietary diversity

Dietary diversity of the children in this study was measured by using a dietary diversity score (DDS) (2) based on the three-day 24-hour dietary recalls reported by their mothers. Following the FAO guidelines for measuring individual dietary diversity, children's dietary diversity was assessed based on nine food groups: (1) starchy staples; (2) dark green leafy vegetables; (3) other vitamin A rich fruits and vegetables; (4) other fruits and vegetables; (5) organ meat; (6) meat and fish; (7) eggs; (8) legumes, nuts, and seeds; and (9) milk and milk products. If a child consumed food from a specific food group, they were given a score of "1" to indicate its presence in their diet. Conversely, if they did not consume food from that group, they were given a score of "0" to indicate its absence. Each food group was assigned a score of 1 point for each intake, counted only once even if the child consumed different types of foods from the same food group, resulting in scores ranging from 0 to 9 points. The mean score for each child was calculated by averaging their scores across three days of dietary recalls. A higher DDS indicated a more balanced and varied diet. The DDS were then categorized into tertiles of low, moderate, and high levels of dietary diversity.

Statistical analysis

Statistical analyses were performed by using the IBM SPSS version 25 (SPSS Inc., Chicago, IL, USA). The normality of data was determined by using skewness value between -2 and +2. The descriptive data for continuous variables were presented as mean and standard deviation, while for categorical variables were presented as frequency and percentage. For the linear regression analysis, the initial step involved conducting univariate analyses to identify factors associated with dietary diversity among preschool children. Variables with a p-value of less than 0.200 in the univariate analyses were considered

significant and included in the subsequent multiple linear regression model. The multiple linear regression analysis identified the predictors of dietary diversity, controlling for potential confounders. The significance level was set at $p<0.05$.

RESULTS

Table I summarizes the characteristics of the mother-child pairs. Most of the children were female (53.1%), aged between 5.0 to 5.9 years (60.8%) and Malay (97.1%). The majorities of the mothers aged 25 to 34 years (53.1%), married (96.3%), completed secondary education (52.7%), and were employed (52.2%). Most households consisted of 4 to 5 family members (56.7%) and monthly household income was predominantly within the range of MYR 2,400 to 2,799 (30.6%).

Table I: Characteristics of the study participants (*n*=245).

Variables	*n* (%)	Mean ± SD
Child's age (months)		56.17 ± 12.78
2.0 - 2.9 years	11 (4.5)	
3.0 - 3.9 years	74 (30.2)	
4.0 - 4.9 years	11 (4.5)	
5.0 - 5.9 years	149 (60.8)	
Child's sex		
Male	115 (46.9)	
Female	130 (53.1)	
Child's ethnicity		
Malay	238 (97.1)	
Chinese	1 (0.4)	
Indian	3 (1.2)	
Others	3 (1.2)	
Number of sibling(s) (person)		2.31 ± 1.21
0	10 (4.1)	
1	53 (21.6)	
2	85 (34.7)	
≥ 3	97 (39.6)	
Mother's age (years)		34.60 ± 4.73
< 25 years	-	
25 - 34 years	130 (53.1)	
35 - 44 years	105 (42.9)	
≥ 45 years	10 (4.1)	
Mother's marital status		
Married	236 (96.3)	
Others	9 (3.7)	
Mother's educational level		
No formal education	2 (0.8)	
Secondary education	129 (52.7)	
Tertiary education	114 (46.5)	
Mother's employment status		
Employed	128 (52.2)	
Unemployed	117 (47.8)	
Household size (person)		5.14 ± 1.31
≤ 3	17 (6.9)	
4 - 5	139 (56.7)	
≥ 6	89 (36.3)	
Number of children under age of five		1.50 ± 0.90
0	33 (13.5)	
1	90 (36.7)	
2	90 (36.7)	
3	30 (12.2)	
4	2 (0.8)	
Monthly Household Income (MYR)[a]		
≤ 2,399 (B1)	66 (26.9)	
2,400 - 2,799 (B2)	75 (30.6)	
2,800 - 3,429 (B3)	43 (17.6)	
3,430 - 4,209 (B4)	61 (24.9)	

CONTINUE

Table I: Characteristics of the study participants (*n*=245). (CONT.)

Variables	*n* (%)	Mean ± SD
Food security		2.04 ± 2.04
Food secure (high/marginal)	113 (46.1)	
Food insecure	132 (53.9)	
Low food insecure	87 (35.5)	
Very low food insecure	45 (18.4)	
Anthropometric measurement		
Weight (kg)		15.46 ± 3.27
WAZ (z-score)		-1.13 ± 0.94
Underweight	57 (23.3)	
Normal	188 (76.7)	
Height (cm)		102.57 ± 8.99
HAZ (z-score)		-1.06 ± 0.97
Stunted	72 (29.4)	
Normal	173 (70.6)	
BMI (kg/m^2)		14.58 ± 1.61
BAZ (z-score)		-0.66 ± 1.23
Wasted	58 (23.7)	
Normal	187 (76.3)	
Dietary Intake		
Energy (kcal/day)		994 ± 320
Carbohydrate (% of energy)		57.9 ± 15.1
< 50%	34 (13.9)	
50 - 65%	186 (75.9)	
≥ 65%	25 (10.2)	
Carbohydrate (g/day)		141.9 ± 48.0
Protein (% of energy)		17.8 ± 2.2
< 10%	1 (0.4)	
10 - 20%	212 (86.5)	
≥ 20%	32 (13.1)	
Protein (g/day)		43.5 ± 12.7
Fat (% of energy)		24.7 ± 6.3
< 25%	137 (55.9)	
25 - 30%	63 (25.7)	
≥ 30%	45 (18.4)	
Fat (g/day)		27.3 ± 11.9
Meal frequency (time/day)		4.95 ± 0.68
≤ 3	12 (4.9)	
4 - 5	201 (82.0)	
≥ 6	32 (13.1)	

Monthly household income was categorised according to income distribution of Negeri Sembilan (Department of Statistics Malaysia, 2020).

More than half (53.9%) of the households reported facing food insecurity issues. In terms of nutritional status, the prevalence of underweight, stunting, and wasting among children were 23.3%, 29.4%, and 23.7%, respectively. The mean percentages of energy from carbohydrates, proteins, and fats were found to be 57.9%, 17.8%, and 24.7%, respectively. Specifically, the mean daily intake was 994 ± 320 kcal for energy, 141.9 ± 48.0 g for carbohydrates, 43.5 ± 12.7 g for proteins, and 27.3 ± 11.9 g for fats. Most of the children (82.0%) had four to five meals daily and the mean meal frequency for all children was 4.95 ± 0.68 times of meal daily.

Results showed that five food groups (starchy staples, other vitamin A rich fruits and vegetables, other fruits and vegetables, meat and fish, and milk and milk

products) were consumed by all the children over the three-day survey period (Table II). The mean DDS for the children was 6.34 ± 0.64, in which 20.0% were in the lowest DDS tertile, while 78.8% were in the middle tertile. Only 1.2% of the children were in the highest DDS tertile.

Table II: Dietary diversity of the study participants (n=245).

Food groups	*n* (%)	Mean ± SD
Starchy staples	245 (100.0)	
Dark green leafy vegetables	213 (86.9)	
Other vitamin A rich fruits and vegetables	245 (100.0)	
Other fruits and vegetables	245 (100.0)	
Organ meat	1 (0.4)	
Meat and fish	245 (100.0)	
Eggs	225 (91.8)	
Legumes, nuts, and seeds	197 (80.4)	
Milk and milk products	245 (100.0)	
Dietary diversity score (DDS)		6.34 ± 0.64
Lowest tertile (4 - 5)	49 (20.0)	
Middle tertile (6 - 7)	193 (78.8)	
Highest tertile (8 - 9)	3 (1.2)	

Variables included in the multiple linear regression model were child's age, number of siblings, mother's age, household size, number of children under five, food security score, WAZ, HAZ, BAZ, meal frequency, energy intake, protein intake, carbohydrate intake, and fat intake. The multiple linear regression model showed that mother's age (β=-0.019, 95% CI=-0.035, -0.002, p<0.05), protein intake (β=0.023, 95% CI=0.012, 0.033, p<0.001), and fat intake (β=-0.023, 95% CI=-0.032, -0.013, p<0.001) were significantly associated with dietary diversity among preschool children in this study (Table III). A higher mother's age and a higher fat intake of the preschool children were associated with lower dietary diversity, while higher protein intake of the preschool children was associated with higher dietary diversity.

Table III: Univariate and multivariate regression analyses of factors associated with dietary diversity among preschool children.

Variables	Univariate Analysis					Multivariate Analysis				
	β	95% CI		SE	*p*-value	β	95% CI		SE	*p*-value
		Lower	Upper				Lower	Upper		
Children's age (months)	0.004	-0.002	0.010	0.003	0.226					
Number of siblings	-0.037	-0.104	0.031	0.034	0.284					
Mother's age (years)	-0.019	-0.036	-0.002	0.009	0.027[a]	-0.019	-0.035	-0.002	0.008	0.029[*]
Household size	-0.004	-0.066	0.058	0.032	0.900					
Number of children under 5	0.019	-0.071	0.109	0.046	0.675					
Food security score	0.002	-0.038	0.042	0.020	0.926					
WAZ	-0.085	-0.171	0.001	0.044	0.051[a]	-0.010	-0.120	0.101	0.056	0.863
HAZ	-0.094	-0.176	-0.011	0.042	0.027[a]	-0.066	-0.159	0.027	0.047	0.162
BAZ	-0.002	-0.068	0.064	0.033	0.951					
Meal frequency	0.055	-0.064	0.175	0.061	0.363					
Energy intake	0.0000472	0.000	0.000	0.000	0.715					
Protein intake	0.005	-0.001	0.012	0.003	0.109[a]	0.023	0.012	0.033	0.005	<0.001[**]
Carbohydrate intake	0.001	0.000	0.003	0.001	0.162[a]	0.000	-0.002	0.002	0.001	0.921
Fat intake	-0.010	-0.017	-0.003	0.003	0.003[a]	-0.023	-0.032	-0.013	0.005	<0.001[**]

[a]*p*<0.200 in univariate analysis; [*]*p*<0.05, [**]*p*<0.001, both in multivariate analysis.

DISCUSSION

This study provides valuable insights into the dietary diversity of preschool children from low-income households in urban areas of Seremban, particularly in the context of the challenges posed by the Covid-19 pandemic. The mean DDS in this study of 6.34 ± 0.64 indicates a moderate level of dietary diversity, with 20.0% of children in the lowest DDS tertile and only 1.2% in the highest tertile. This finding indicates that

a significant proportion of children are not achieving optimal dietary diversity. This aligns with findings from several studies in China. Bi et al. (34) reported a mean DDS of 5.77 ± 1.22 among 3 to 5-year-old preschool children, while Meng et al. (35) found a mean DDS of 6.10 ± 1.67. In the Philippines, Leonard (36) reported a mean DDS of 5.15 out of 9 among preschool children. However, a study in Sri Lanka by Sirasa et al. (37) found a lower mean DDS of 4.56 (SD=0.85) out of 9 among preschool children. The variation in DDS across studies may be due to differences in sample populations and measurement methods (34).

Unlike previous studies that relied on a single-day dietary recall (38, 39), this study used a three-day 24-hour dietary recall, providing a more accurate reflection of children's dietary diversity. A single-day recall may not capture typical eating patterns over time (40). Jayawardena et al. (41) emphasized that multiple recalls across weekdays and weekends offer a clearer view of usual diets, which likely contributed to the higher DDS observed in the current study. Some studies set thresholds for food intake [e.g., 10g (42), 15g (43), 25g (44)], which can lower the DDS by excluding smaller portions, while the present study included all food intake, potentially increased the DDS. Additionally, variations in the number of food groups used to measure DDS, ranging from 6 (45) to 16 (46), complicate comparisons across studies due to the lack of standardized international methods (34). Moreover, children in this study spent more time in preschools where meals, prepared by the schools and prescribed by nutritionists from the relevant ministry, likely contributed to the high DDS observed. These findings highlight the critical role of school meal programs in ensuring dietary adequacy and diversity, and also demonstrate the importance of strengthening and expanding these programs to improve children's overall dietary quality.

Starchy staples, particularly rice, were highly consumed in this study as rice is the primary energy source in Malaysia and many other Asian countries including Indonesia (47), China (34), and the Philippines (46). High intake of fruits and vegetables ('other vitamin A rich fruits and vegetables' and 'other fruits and vegetables') likely reflects the preschool-provided meals in the present study, which included various fruits and vegetables daily. Milk consumption was also high, as preschools in the present study served milk for breakfast every day. The frequent consumption of meat and fish aligns with the local diet, where dishes such as fried chicken and fried fish are common. Conversely, organ meat was consumed by only one child in the present study, possibly due to parental concerns about its safety or healthiness for children (34).

The multiple linear regression model in this study found that mother's age, protein intake, and fat intake were significantly associated with dietary diversity among preschool children. Protein intake was positively associated with dietary diversity, indicating that children who consume higher amounts of protein tend to have a more varied diet. This finding aligns with previous studies that highlighted the role of protein-rich foods in contributing to overall dietary diversity (48). The positive association may be due to the inclusion of protein-rich foods such as meat, fish, eggs, legumes, and dairy products, which are often part of mixed meals that include vegetables, grains, and fruits, thereby diversifying the diet. As protein-rich foods tend to be nutrient-dense, their inclusion not only increases protein intake but also promotes a more balanced and varied nutrient profile. As a result, increased protein consumption among children from low-income households may improve their dietary diversity.

Conversely, results revealed that both higher maternal age and higher fat intake were associated with lower dietary diversity. The inverse relationship between maternal age and dietary diversity may reflect differences in dietary habits and knowledge, with older mothers potentially adhering to more traditional feeding practices (49), which may be less diverse. Older mothers may have limited knowledge of current dietary guidelines, highlighting the need for targeted education and support for mothers, particularly in understanding the importance of a varied diet for their children. Additionally, the negative association between fat intake and dietary diversity suggests that diets higher in fat may lack variety, potentially due to an over-reliance on energy-dense, nutrient-poor foods (50). This association highlights the need for balanced macronutrient distribution in children's diets to ensure a broad intake of different food groups.

This study found that 53.9% of households were food insecure, and the prevalence of underweight (23.3%), stunting (29.4%), and wasting (23.7%) highlighted significant nutritional challenges. However, these factors were not significantly associated with dietary diversity. This may be due to the multifaceted nature of food security and anthropometric outcomes, which reflect chronic, long-term nutritional and socioeconomic conditions, whereas dietary diversity captures short-term dietary quality. In addition, households facing food insecurity may adopt coping strategies to maintain dietary diversity, such as prioritizing diverse but less expensive foods. Interventions, including school meal programs, may also contribute to dietary diversity regardless of household food security status or child growth status. These findings suggest that addressing nutritional challenges requires a holistic approach that addresses both immediate and long-term factors that affect nutrition and health, especially in low-income settings.

The strengths of this study include the use of a three-

day 24-hour dietary recalls, offering a more accurate reflection of children's dietary diversity, and its focus on a vulnerable population who were preschool children from low-income urban families, providing valuable public health insights. However, the cross-sectional design limits causal inference, and self-reported dietary data may introduce recall bias. The findings' generalizability is limited to similar urban settings, and the lack of standardized dietary diversity measurement complicates comparisons with other studies.

CONCLUSION

In conclusion, the findings suggest that overall dietary diversity remains limited, although some food groups are regularly consumed by preschool children in this study. The findings of this study also showed that higher protein intake was positively associated with greater dietary diversity, while higher fat intake and older maternal age were associated with lower dietary diversity among children aged 2 to 6 years from low-income households. These findings highlight the need for targeted nutritional interventions that promote balanced diets as well as education for mothers to include diverse, nutrient-rich foods in their children's diets. Such interventions are particularly important in the aftermath of global crises such as the Covid-19 pandemic, which disrupted food systems, household incomes, and access to nutritious foods. Studying dietary intake and diversity during this period is essential to address nutritional gaps and inform targeted interventions for vulnerable communities. Addressing these issues is critical to improving the dietary diversity, nutritional status, and overall health of children in low-income households.

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REFERENCES

1. Kennedy GL, Pedro MR, Seghieri C, Nantel G, Brouwer ID. Dietary diversity score is a useful indicator of micronutrient intake in non-breast-feeding Filipino children. J Nutr. 2007;137(2):472–477. doi: 10.1093/jn/137.2.472.
2. Kennedy G, Ballard T, Dop M. Guidelines for measuring household and individual dietary diversity. Nutrition and Consumer Protection Division, Food and Agriculture Organization of the United Nations; 2010.
3. Arimond M, Ruel MT. Dietary diversity is associated with child nutritional status: Evidence from 11 Demographic and Health Surveys. J Nutr. 2004;134(10):2579–2585. doi: 10.1093/jn/134.10.2579.
4. Khamis AG, Mwanri AW, Ntwenya JE, Kreppel K. The influence of dietary diversity on the nutritional status of children between 6 and 23 months of age in Tanzania. BMC Pediatr. 2019;19(1):518. doi: 10.1186/s12887-019-1897-5.
5. Gassara G, Chen J. Household food insecurity, dietary diversity, and stunting in Sub-Saharan Africa: A systematic review. Nutrients. 2021;13(12):4401. doi: 10.3390/nu13124401.
6. Hasanah A, Kharisma B, Remi SS, Adam AM, Siregar AYM. Food diversity: Its relation to children's health and consequent economic burden. BMC Public Health. 2024;24(1):1155. doi: 10.1186/s12889-024-18530-w.
7. United Nations Children's Fund. Fed to Fail? The Crisis of Children's Diets in Early Life [Internet]. UNICEF; 2021.
8. Kumar R, Mahmood T, Naeem N, Khan SA, Hanif M, Pongpanich S. Minimum dietary diversity and associated determinants among children aged 6-23 months in Pakistan. Sci Rep. 2024;14(1):2639. doi: 10.1038/s41598-024-51705-4.
9. Moga Lencha F, Jebero Zaza Z, Ena Digesa L, Mulatu Ayana T. Minimum dietary diversity and associated factors among children under the age of five attending public health facilities in Wolaita Soddo town, Southern Ethiopia, 2021: A cross-sectional study. BMC Public Health. 2022;22(1):2368. doi.org/10.1186/s12889-022-14861-8.
10. Mrema JD, Nyaruhucha CN, Mwanri AW. Dietary intake and diversity among children of age 6-59 months in lowland and highland areas in Kilosa District in Morogoro, Tanzania. Nutr Metab. 2023;33:200205. doi: 10.1016/j.hnm.2023.200205.
11. Assefa D, Belachew T. Minimum dietary diversity and associated factors among children aged 6-23 months in Enebsie Sar Midir Woreda, East Gojjam, North West Ethiopia. BMC Nutrition. 2022;8(1):149. doi.org/10.1186/s40795-022-00644-2.
12. Endawkie A, Asmare L, Alemu HT, Geberu DM, Hagos A, Jejaw M, et al. Trend and determinants of minimum dietary diversity consumption change among children aged 6-23 months in Ethiopia from 2011 to 2019: A multivariate decomposition analysis. PLoS ONE. 2024;19(8):e0308349.
13. Saha J, Chouhan P, Malik NI, Ghosh T, Das P, Shahid M, et al. Effects of dietary diversity on growth outcomes of children aged 6 to 23 months in India: Evidence from National Family and Health Survey. Nutrients. 2022;15(1):159. doi:10.3390/nu15010159.
14. Rahman MA, Kundu S, Rashid HO, Tohan MM, Islam MA. Socio-economic inequalities in and factors associated with minimum dietary diversity among children aged 6-23 months

in South Asia: A decomposition analysis. BMJ Open. 2023;13(12):e072775. doi: 10.1136/bmjopen-2023-072775.
15. Vilar-Compte M, Burrola-Mйndez S, Lozano-Marrufo A, Ferrй-Eguiluz I, Flores D, Gaitбn-Rossi P, et al. Urban poverty and nutrition challenges associated with accessibility to a healthy diet: A global systematic literature review. Int J Equity Health. 2021;20(1):40. doi: 10.1186/s12939-020-01330-0.
16. Murtaza SF, Gan WY, Sulaiman N, Mohd Shariff Z, Ismail SIF. Sociodemographic, nutritional, and environmental factors are associated with cognitive performance among Orang Asli children in Malaysia. PLoS ONE. 2019;14(7):e0219841. doi: 10.1371/journal.pone.0219841.
17. Keno S, Bikila H, Shibiru T, Etafa W. Dietary diversity and associated factors among children aged 6 to 23 months in Chelia District, Ethiopia. BMC Pediatrics. 2021;21(1):565. doi: 10.1186/s12887-021-03040-0.
18. Rai RK, Kumar SS, Kumar C. Factors associated with minimum dietary diversity failure among Indian children. J Nutr Sci. 2022;11:e4. doi: 10.1017/jns.2022.2.
19. Antwi J, Quaidoo E, Ohemeng A, Bannerman B. Household food insecurity is associated with child's dietary diversity score among primary school children in two districts in Ghana. Food Nutr Res. 2022;66. doi: 10.29219/fnr.v66.7715.
20. Chua EY, Zalilah MS, Chin YS, Norhasmah S. Dietary diversity is associated with nutritional status of Orang Asli children in Krau Wildlife Reserve, Pahang. Malays J Nutr. 2012;18(1):1–13.
21. Devindran D, Ulaganathan V, Oeh ZY, Tan LX, Kuralneethi S, Eng ZYE, et al. Association between dietary diversity and weight status of aboriginal primary school children in Negeri Sembilan, Malaysia. Malays J Med Sci. 2022;29(1):101–112.
22. Tiew KF, Chan YM, Lye MS, Loke SC. Factors associated with dietary diversity score among individuals with Type 2 Diabetes Mellitus. J Health Popul Nutr. 2014;32(4):665–676.
23. Lemeshow S, Hosmer Jr DW, Klar J, Lwanga SK. Adequacy of sample size in health studies. John Wiley & Sons; 1990.
24. Gicevic, S. Dietary diversity, dietary quality and sustainable dietary surveillance. Harvard University; 2018.
25. Department of Statistics Malaysia. Household income and basic amenities survey report 2019. Department of Statistics, Malaysia; 2020.
26. Blumberg SJ, Bialostosky K, Hamilton WL, Briefel RR. The effectiveness of a short form of the Household Food Security Scale. Am J Public Health. 1999;89(8):1231–1234. doi: 10.2105/AJPH.89.8.1231.
27. Mesbah SF, Sulaiman N, Shariff ZM, Ibrahim Z. Does food insecurity contribute towards depression? A cross-sectional study among the urban elderly in Malaysia. International Int. J. Environ. Res. Public Health. 2020;17(9). doi: 10.3390/IJERPH17093118.
28. World Health Organization. WHO Child Growth Standards. World Health Organization; 2006.
29. World Health Organization. BMI-for-age (5-19 years). World Health Organization; 2007.
30. Ministry of Health Malaysia. Malaysian Food Composition Database [Internet]. Ministry of Health Malaysia; 2015 [cited 2024 October 23]. Available from: https://myfcd.moh.gov.my/
31. Tee ES, Mohd Ismail N, Mohd Nasir A, Khatijah I. Composition of Malaysian foods. Malaysian Food Composition Database Programme, Institute for Medical Research; 1997.
32. Health Promotion Board Singapore. Food Composition Guide Singapore. Health Promotion Board Singapore; 2003.
33. Ha K, Song Y. Associations of meal timing and frequency with obesity and metabolic syndrome among Korean adults. Nutrients. 2019;11(10):2437. doi: 10.3390/nu11102437.
34. Bi J, Liu C, Li S, He Z, Chen K, Luo R, et al. Dietary diversity among preschoolers: A cross-sectional study in poor, rural, and ethnic minority areas of Central South China. Nutrients. 2019;11(3):558. doi: 10.3390/nu11030558.
35. Meng L, Wang Y, Li T, Loo-Bouwman CA, Zhang Y, Man-Yau Szeto I. Dietary diversity and food variety in Chinese children aged 3-17 years: Are they negatively associated with dietary micronutrient inadequacy? Nutrients. 2018;10(11):1674. doi: 10.3390/nu10111674.
36. Leonard KGdL. Dietary Diversity Score (DDS) difference among preschool children (PSC) in rural and urban communities. Asia Pacific Journal of Multidisciplinary Research. 2019;7(2):49–55.
37. Sirasa F, Mitchell L, Harris N. Dietary diversity and food intake of urban preschool children in North-Western Sri Lanka. Matern Child Nutr. 2020;16(4). doi: 10.1111/mcn.13006.
38. Agrawal S, Kim R, Gausman J, Sharma S, Sankar R, Joe W, et al. Socio-economic patterning of food consumption and dietary diversity among Indian children: Evidence from NFHS-4. Eur J Clin Nutr. 2019;73(10):1361–1372. doi: 10.1038/s41430-019-0406-0.
39. Worku T, Gonete KA, Muhammad EA, Atnafu A. Sustainable under nutrition reduction program and dietary diversity among children's aged 6-23 months, Northwest Ethiopia: Comparative cross-sectional study. Int J Equity Health. 2020;19(1):14. doi: 10.1186/s12939-019-1120-1.
40. Frempong RB, Annim SK. Dietary diversity and child malnutrition in Ghana. Heliyon. 2017;3(5):e00298. doi: 10.1016/j.heliyon.2017.e00298.
41. Jayawardena R, Byrne NM, Soares MJ, Katulanda

P, Yadav B, Hills AP. High dietary diversity is associated with obesity in Sri Lankan adults: An evaluation of three dietary scores. BMC Public Health. 2013;13(1):314. doi: 10.1186/1471-2458-13-314.
42. Zhao W, Yu K, Tan S, Zheng Y, Zhao A, Wang P, et al. Dietary diversity scores: An indicator of micronutrient inadequacy instead of obesity for Chinese children. BMC Public Health. 2017;17(1):440. doi: 10.1186/s12889-017-4381-x.
43. Yang Q, Yuan T, Yang L, Zou J, Ji M, Zhang Y, et al. Household food insecurity, dietary diversity, stunting, and anaemia among left-behind children in poor rural areas of China. Int J Environ Res Public Health. 2019;16(23):4778. doi: 10.3390/ijerph16234778.
44. Li Y, Wedick NM, Lai J, He Y, Hu X, Liu A, et al. Lack of dietary diversity and dyslipidaemia among stunted overweight children: The 2002 China National Nutrition and Health Survey. Public Health Nutr. 2011;14(5):896–903. doi: 10.1017/S1368980010002971.
45. Sealey-Potts C. An assessment of dietary diversity and nutritional status of preschool children. Austin J Nutri Food Sci. 2014;2(7):5.
46. dela Luna KL, Bullecer E. Underweight among preschool children as an acute consequence of household food insecurity in Occidental Mindoro. Philippine Journal of Science. 2020;149(3). doi: 10.56899/149.03.19.
47. Mahmudiono T, Sumarmi S, Rosenkranz RR. Household dietary diversity and child stunting in East Java, Indonesia. Asia Pac J Clin Nutr. 2017;26(2):317–325.
48. Moughan PJ. Population protein intakes and food sustainability indices: The metrics matter. Global Food Security. 2021;29:100548. doi: 10.1016/j.gfs.2021.100548.
49. de Castro MBT, Freitas Vilela AA, Oliveira ASD, Cabral M, Souza RAG, Kac G, Sichieri R. Sociodemographic characteristics determine dietary pattern adherence during pregnancy. Public Health Nutr. 2016;19(7):1245–1251. doi: 10.1017/S1368980015002700.
50. Minaker LM, Mah CL, Cook BE. Population Health Intervention Research. London: Routledge; 2016.