Research Article

A Posteriori Dietary Patterns among Children in Sabah: A Cross-Sectional Study

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ABSTRACT

Introduction: A dietary pattern reflects the combination of foods of an individual's overall eating habits and there is accumulating evidence that dietary patterns are closely associated with health outcomes. Therefore, this study aimed to determine the *á posteriori* dietary patterns among children in Sabah. *Methods*: A cross-sectional study was conducted from December 2022 to February 2023 in Kota Kinabalu and Tawau. A total of 199 children aged 5 to 12 years were recruited. Body weight, height, and body mass index were determined using standard protocols. Dietary intakes were assessed using the 24-hour diet recall method and dietary patterns were derived using the principal component analysis based on 20 food groups. *Results*: Three dietary patterns emerged: "Fish Dietary Pattern", "Fruits Dietary Pattern", and "White Rice Dietary Pattern". There were significantly more children from households with monthly income less than RM 2500 (54.0%, P<0.001) and from Tawau (74.7%, P<0.001) adhered to the "Fish Dietary Pattern". Children adhered to the "Fish Dietary Pattern" were taller (P=0.016) and had greater intakes of energy (P<0.001), carbohydrate (P<0.001), and protein (P<0.001), while children adhered to the "White Rice Dietary Pattern" had greater weight (P<0.001), height (P=0.003), BMI (P=0.003), as well as higher intakes of energy (P=0.010), carbohydrate (P<0.001), and protein (P=0.032). *Conclusion*: There were three distinct dietary patterns among children in Sabah, which were associated with growth indicators and nutrient intakes.

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1. Introduction

Dietary pattern is defined by the quantity, variety, or combination of different foods and beverages in a diet and the frequency with which they are habitually consumed (Sànchez-Villegas & Sánchez-Tainta, 2018). The dietary pattern approach has gained prominence in nutrition epidemiology for exploring the relationship between diet and health outcomes. It offers a more holistic perspective compared to the single nutrient or food group approach, as it acknowledges the complex interactions among multiple nutrients in foods and reflects a typical diet in real life that is characterized by a mixture of foods with substitution effects (Zhao *et al.* 2021). There are three categories of dietary pattern analysis, namely *á priori*, *á posteriori*, and the hybrid method with a combination of both *á priori* and *á posteriori* approaches. The *á priori* dietary pattern analysis is also known as the hypothesis-driven approach, which is based on the current knowledge regarding defined dietary components and their impact on health outcomes. The *á priori* dietary pattern analysis uses a scoring system, also called dietary indices to reflect diet quality or adherence to national dietary guidelines or healthful dietary habits such as the Dietary Approaches to Stop

Hypertension or the Mediterranean diet. Contrarily, the *á posteriori* dietary pattern analysis is an exploratory approach, in which dietary patterns are derived solely from the underlying dietary data using extensive statistical analysis. The *á posteriori* dietary patterns describe the variation in dietary intake based on correlations between nutrients, food items, or food groups specific to the population (Schulz *et al.,* 2021).

Several studies have examined the relationship between *á posteriori* dietary patterns and nutritional status among children. Zhang *et al.* (2015) derived three dietary patterns among Chinese children aged 7-17 years: "Modern Dietary Pattern", "Traditional North Dietary Pattern", and "Traditional South Dietary Pattern". It was found that "Modern Dietary Pattern" and "Traditional North Dietary Pattern" were associated with an increased risk of obesity. Similarly, García-Chávez *et al.* (2020) identified four dietary patterns from 2751 Mexican children aged 5 to 11 years: "Traditional Dietary Pattern", "Industrial Dietary Pattern", "Varied Dietary Pattern", and "Modern Dietary Pattern". The "Modern Dietary Pattern" was significantly associated with obesity compared with the "Traditional Dietary Pattern". On the other hand, three dietary patterns were derived from 435 Korean children and adolescents: "Fast Food and Soda Dietary Pattern", "White Rice and Kimchi Dietary Pattern", and "Oil and Seasoned Vegetable Dietary Pattern". The "Fast Food and Soda Dietary Pattern" showed positive associations with body mass index (BMI) and waist circumference while the other two dietary patterns indicated negative associations. Given that *á posteriori* dietary patterns are tailored to reflect the unique dietary habits of a specific population, local studies are pivotal to gaining further insights into prevailing dietary behaviours. However, *á posteriori* dietary pattern among children in Malaysia, particularly in Sabah, remains unexplored. Therefore, this study aimed to determine the *á posteriori* dietary patterns among children in Sabah and examined the relationship between these dietary patterns and their nutritional status.

2. Materials and Methods

2.1 Study Design

This cross-sectional study was conducted in Kota Kinabalu and Tawau, Sabah, Malaysia from December 2022 to February 2023. The required sample size was 187 participants, which was calculated based on the reported prevalence of stunting of 12.7% among children aged 5 to 17 years by the NHMS 2019 using a single proportional formula (Daniel 1999) and additional 10% for missing data and implausible dietary data. Eligible participants were recruited via convenience sampling from three study sites, namely Pre-Sekolah SK Likas, SK Likas, and SK Batu 4 Jalan Apas. This study has received ethical approval from the Medical Ethical Committee of Universiti Malaysia Sabah [JKEtika 1/23(1)] and written informed consent was obtained from participants' parents or guardians.

2.2 Participants

The present study included children aged 5 to 12 years who resided in either Kota Kinabalu or Tawau. Children with self-reported mental disorders, physical disability, congenital problems, or chronic illnesses as well as those who were not able to communicate in Bahasa Malaysia or English were excluded.

2.3 Data Collection Procedures

Trained researchers performed the anthropometric measurements following the standard protocol. Body weight was measured using a calibrated digital weighing scale (Omron HBF-375, Omron, Japan) in kilograms to the nearest 0.1 kg while height was measured using a portable stadiometer (Seca 213, Seca GmbH, Germany) in cm to the nearest 0.1 cm. These measurements were carried out twice, and the mean of the two readings was used. BMI was derived by dividing body weight (kg) with height squared (m^2). Participants' nutritional status was determined by comparing these indices with the World Health Organization Growth Reference Data for 5 – 19 years (World Health Organization 2007) and z-scores were manually determined from the growth charts. Participants with a z-score for height-for-age below –2 standard deviations (SD) were categorized as stunted. Based on the BMI-for-age, participants with a z-score below –2 SD were defined as thinness while a z-score above +1 SD and +2 SD were defined as overweight and obese.

The 24-hour dietary recall method was used to assess dietary intake, as this approach has been used in a nationally representative survey to determine the diet quality among children (Hammer & Moore 2020). Face-to-face interviews were conducted with participants' parents or guardians as proxies for dietary assessment. Common household measurement tools such as bowls, spoons, and glasses were used to optimize the portion size estimation. Foods and beverages reported were transformed into absolute weight in grams before analysing for the nutrient composition using the Nutritionist Pro software (Axxya Systems LLC, USA), referencing to Malaysian Food Composition Database (Tee *et al.,* 1997) to derive total energy, carbohydrate, protein, and fat intakes. The Goldberg's cut-off was used to identify dietary misreporters. Basal metabolic rates were estimated using the predictive equations by Schofield (1985) and Poh *et al.* (1995) An energy intake to basal metabolic rate ratio within the range of 1.0 to 2.0 was considered acceptable, while ratios below 1.0 indicated under-reporting, and ratios above 2.0 indicated over-reporting (Lioret *et al.,* 2011).

2.4 Statistical Analyses

The normality of continuous variables was determined using the Kolmogorov-Smirnov test. Continuous variables with a normal distribution were presented as mean ± SD while skewed continuous variables were presented as median (interquartile range). Categorical variables were presented as frequency (percentage).

Dietary patterns were derived using the *á posteriori* approach as previously described (Khor *et al.,* 2020). The input variable for the factor analysis was the total weight for each food group. A total of 20 food groups were included in the Principal Component Analysis to derive dietary patterns. The derived dietary patterns were orthogonally rotated (varimax rotation) to enhance the difference between loadings to improve the interpretability of factors. The number of dietary patterns retained was determined based on eigenvalue > 1.0, examination of the scree plot, and interpretability of derived dietary patterns. The eigenvalue indicates the total variance explained by a given factor. Dietary patterns were labelled in accordance with the food group with the highest factor loading. Participants were assigned to factor scores computed for each dietary pattern identified, which indicated adherence to the dietary pattern. Based on the median of factor scores, participants were categorized into adherence or non-adherence for each dietary pattern.

An Independent *t*-test or Mann-Whitney test was used to compare anthropometric indices and nutrient intakes between adherence and non-adherence to *á posteriori* dietary patterns. Pearson Chi-Square test was used to determine the association between sociodemographic factors and adherence to *á posteriori* dietary patterns. All analyses were computed using SPSS version 29.0 (IBM, Chicago, IL, USA). Statistical significance was set as *P*-value < 0.05 for all evaluated parameters.

3. Results

The characteristics of 199 children included in the final analysis are presented in Table 1. The mean age of the children was 8.7 ± 1.9 years. Slightly more than half of the children were girls (52.3%) and Bajau ethnicity (50.3%). A vast majority of the children were from a household with a monthly income of less than RM 2500 (87.4%), while half of the children were from a household size of 3 to 4 members (50.7%). When assessed for their nutritional status, 15.6% of children were found to be stunted according to their height-for-age. Based on the BMI-for-age, 24.1% of children were classified as overweight or obese while 7.5% of children fell into the underweight category.

Table 1 Characteristics of children (*n* = 199).

Characteristics	*n* (%)	Mean ± SD
Age (years)		8.7 ± 1.9
Sex		
Male	95 (47.7)	
Female	104 (52.3)	
Ethnicity		
Bajau	100 (50.3)	
Malay	14 (17.0)	
Dusun	12 (6.0)	
Murut	9 (4.5)	
Kedayan	5 (2.5)	
Others	59 (29.7)*	
Monthly household income		
≤ RM 2500	174 (87.4)	
RM 2501 – RM 4500	8 (4.0)	
> RM4500	17 (8.5)	
Household size		
1 – 2	35 (17.6)	
3 – 4	101 (50.7)	
≥ 5	53 (22.1)	
Weight (kg)		27.7 ± 10.7
Height (cm)		126.3 ± 11.6
Normal height	168 (84.4)	
Stunted	31 (15.6)	
Body mass index (kg/m^2)		16.8 ± 4.0
Normal weight	136 (68.3)	
Overweight/obese	48 (24.1)	
Underweight	15 (7.5)	

*Other ethnic groups include: Bugis (*n* = 19), Suluk (*n* = 14), Jawa (*n* = 8), Brunei (*n* = 6), Bajau-Suluk (*n* = 3), Bisaya (*n* = 2), Ubian (*n* = 2), Banjar (*n* = 1), Bidayuh (*n* = 1), Dusun-Sungai (*n* = 1), Iban (*n* = 1), Iranun (*n* = 1).

Three *á posteriori* dietary patterns emerged from a total of 20 food groups using the principal component analysis (Table 2). The first dietary pattern that emerged was labelled as "Fish Dietary Pattern", which represented a high intake of fish and shellfish, *kuih*, and non-starchy vegetables, along with a low intake of chicken and duck as well as dairy products. The second dietary pattern that emerged was labelled as "Fruits Dietary Pattern", which reflected a high intake of fresh and dried fruits, rice dishes, and noodle dishes, along with a low intake of white rice. The third dietary pattern that emerged was labelled as the "White Rice Dietary Pattern", which was characterized by a high intake of white rice, fresh and dried fruits, chicken and duck, and chicken eggs, along with a low intake of refined bread and biscuits.

Table 2 Factor loadings for three *á posteriori* dietary patterns derived by principal component analysis.

Food groups	Fish DP	Fruits DP	White Rice DP
Candies	−0.117	-	−0.170
Chicken and duck	−0.477	-	0.228
Chicken eggs	-	-	0.216
Chips	-	−0.147	-
Dairy products	−0.404	-	-
Fish and shellfish	**0.794**	-	-
Fresh and dried fruit	0.148	**0.890**	0.418
Kuih	0.530	−0.140	−0.123
Instant noodles	−0.125	-	-
Noodle dishes	0.186	0.317	−0.132
Non-starchy vegetables	0.358	0.186	-
Processed chicken and meat products	−0.115	-	-
Processed fish and seafood products	-	0.130	−0.103
Refined bread and biscuits	0.115	-	−0.210
Rice dishes	−0.152	0.448	-
Sauce and condiments	-	-	0.156
Starchy vegetables	0.138	-	-
Sugar-sweetened beverages	−0.353	−0.131	-
Spread (sweet)	-	-	-
White rice	0.135	−0.455	**0.879**

Abbreviation: DP, dietary pattern.

The associations between adherence to *á posteriori* dietary patterns and sociodemographic factors are presented in Table 3. More children from households with monthly income less than RM 2500 (54.0%) and Tawau (74.7%) adhered to the "Fish Dietary Pattern". In contrast, monthly household income and location were not associated with adherence to the "Fruits Dietary Pattern" and "White Rice Dietary Pattern". Sex was not associated with all three *á posteriori* dietary patterns.

The comparisons of anthropometric indices and nutrient intakes by adherence to *á posteriori* dietary patterns are presented in Table 4. Children who adhered to the "Fish Dietary Pattern" were taller (P=0.016) and had greater intakes of energy (P<0.001), carbohydrate (P<0.001), and protein (P<0.001). Contrarily, anthropometric indices and nutrient intakes were not significantly different between children who adhered to and did not adhere to the "Fruit Dietary Pattern". Children who adhered to the "White Rice Dietary Pattern" had greater weight (P<0.001), height (P=0.003), BMI (P=0.003), as well as intakes of energy (P=0.010), carbohydrate (P<0.001), and protein (P=0.032).

Table 3 Associations between sociodemographic factors and adherence to *á posteriori* dietary patterns.

Characteristics	Fish Dietary Pattern		*P*-value[a]
	Adherence (*n* = 99)	Non-adherence (*n* = 100)	
Sex			
Male	46 (48.4)	49 (51.6)	0.720
Female	53 (51.0)	51 (49.0)	
Monthly household income			
≤ RM 2500	94 (54.0)	80 (46.0)	**< 0.001**
> RM 2500	5 (20.0)	20 (80.0)	
Location			
Kota Kinabalu	37 (31.9)	79 (68.1)	**< 0.001**
Tawau	62 (74.7)	21 (25.3)	
Characteristics	Fruits Dietary Pattern		*P*-value[a]
	Adherence (*n* = 99)	Non-adherence (*n* = 100)	
Sex			
Male	46 (48.4)	49 (51.6)	0.720
Female	53 (51.0)	51 (49.0)	
Monthly household income			
≤ RM 2500	85 (48.9)	89 (51.1)	0.504
> RM 2500	14 (56.0)	11 (44.0)	
Location			
Kota Kinabalu	58 (50.0)	58 (50.0)	0.938
Tawau	41 (49.4)	42 (50.6)	
Characteristics	White Rice Dietary Pattern		*P*-value[a]
	Adherence (*n* = 99)	Non-adherence (*n* = 100)	
Sex			
Male	49 (51.6)	46 (48.4)	0.622
Female	50 (48.1)	54 (51.9)	
Monthly household income			
≤ RM 2500	86 (49.4)	88 (50.6)	0.810
> RM 2500	13 (52.0)	12 (48.0)	
Location			
Kota Kinabalu	59 (50.9)	57 (49.1)	0.710
Tawau	40 (48.2)	43 (51.8)	

Data is presented as *n* (%). [a]Pearson Chi-square.

Table 4 Comparison of anthropometric indices and nutrient intakes by adherence to *á posteriori* dietary patterns.

Variable	Fish Dietary Pattern		*P*-value
	Adherence (*n* = 99)	Non-adherence (*n* = 100)	
Weight (kg)	24.7 (11.9)	23.2 (11.8)	0.211[b]
Height (cm)	127 (16)	124 (18)	**0.016**[b]
BMI (kg/m^2)	15.4 (3.6)	15.7 (4.1)	0.559[b]
Energy (kcal)	1720 ± 363	1445 ± 341	**<0.001**[a]
Carbohydrate (g)	235 (78)	195 (64)	**<0.001**[b]
Protein (g)	66.9 (29.2)	45.6 (20.2)	**<0.001**[b]
Fat (g)	54.2 (25.7)	48.6 (22.8)	0.088[b]
Characteristics	Fruits Dietary Pattern		*P*-value
	Adherence (*n* = 99)	Non-adherence (*n* = 100)	
Weight (kg)	24.1 (10.9)	24.8 (12.3)	0.892[b]
Height (cm)	126.4 ± 11.8	126.3 ± 11.5	0.966[a]
BMI (kg/m^2)	15.5 (4.1)	15.6 (3.5)	0.995[b]
Energy (kcal)	1608 ± 374	1555 ± 381	0.315[a]
Carbohydrate (g)	221 (71)	203 (79)	0.225[b]
Protein (g)	55.7 (28.2)	51.7 (30.1)	0.280[b]
Fat (g)	54.1 (23.2)	49.1 (24.1)	0.232[b]
Characteristics	White Rice Dietary Pattern		*P*-value
	Adherence (*n* = 99)	Non-adherence (*n* = 100)	
Weight (kg)	16.8 (13.5)	22.6 (11.3)	**<0.001**[b]
Height (cm)	130.2 (15.2)	123.2 (15.6)	**0.003**[b]
BMI (kg/m^2)	16.2 (4.8)	15.2 (2.6)	**0.003**[b]
Energy (kcal)	1614 (476)	1535 (505)	**0.010**[b]
Carbohydrate (g)	228 (72)	202 (72)	**<0.001**[b]
Protein (g)	56.1 (26.4)	50.8 (30.7)	**0.032**[b]
Fat (g)	50.0 (20.6)	52.5 (30.1)	0.731[b]

Data is presented as mean ± standard deviation or median (interquartile range).
[a]Independent *t*-test
[b]Mann-Whitney test

4. Discussion and Conclusion

To our knowledge, this is the first study that describes the *á posteriori* dietary patterns among children in Sabah. Three distinct *á posteriori* dietary patterns were identified from this population. Unlike previous studies that typically categorize *á posteriori* dietary patterns as "prudent" or "healthy", the present study did not designate any dietary pattern as inherently healthy. In addition, our analysis did not observe a dietary pattern that resembles the "Western Dietary Pattern", which is often characterized by high consumption of animal-based foods, sugar-sweetened beverages, and refined carbohydrates, alongside a low intake of fibres (Eng et al. 2020). These findings suggest that the dietary habits of children in Sabah are more aligned with local traditions rather than Western influences.

One of the *á posteriori* dietary patterns that emerged is the "White Rice Dietary Pattern", which highlights the preference for refined over wholegrain cereals among these children. This observation is in agreement with the MyBreakfast study, which found that merely one out of four Malaysian children consumed whole grain products. The limited taste acceptance of wholegrain, alongside its higher cost, is likely to contribute to its lower intake (Norimah *et al.*, 2015), particularly within the context of predominantly low-income households in our study population. On the other hand, it was observed that more children from Tawau adhered to the "Fish Dietary Pattern". The regional difference in dietary patterns suggests that the geographical location in Tawau has led to greater access to marine resources such as fish and seafood. Communities living around the coastal regions typically had greater consumption of seafood (Cisneros-Montemayor *et al.,* 2016). Interestingly, the "Fish Dietary Pattern" was also more prevalent among children from low-income households. This finding possibly reflects a cultural norm in Sabah, where foods are acquired through own production such as fishing and farming, along with in-kind transfers, and gifts are common particularly in rural areas of low-middle income countries (Turner *et al.* 2018).

When examining the anthropometric indices and nutrient intakes associated with the three identified dietary patterns, we found significant differences in children adhering to the "White Rice Dietary Pattern". These children had greater weight, height, and BMI, and increased intakes of energy, carbohydrate, and protein. A meta-analysis showed that the high consumptions of refined grains were associated with a higher risk of obesity in children and adolescents (Jakobsen *et al.* 2023). Interestingly, while children adhering to the "Fish Dietary Pattern" also consumed more energy, carbohydrates, and protein, only their height was significantly different compared to their counterparts not following this dietary pattern. The exact explanation for this observation remains unknown. However, it is hypothesized that the omega-3 polyunsaturated fatty acids prevalent in fish and seafood might have protective effects against obesity in children (Burrows et al. 2011). For the "Fruits Dietary Pattern," no significant differences were observed in terms of anthropometric indices and nutrient intakes such as energy and macronutrients. Significant variations might likely exist for micronutrient and fibre intakes, which were not evaluated in the present study.

Our study had several limitations. Firstly, the cross-sectional design of the present study only allows for the identification of associations instead of causality. Secondly, micronutrients were not included in the nutrient analysis. However, the primary outcomes of the present study are nutritional status assessed via weight, height, and BMI, which are predominantly influenced by energy and macronutrients. Furthermore, our study findings have limited External generalizability due to the *á posteriori* method being inherently data-driven and specific to the local population studied. In addition, this approach requires subjective judgement in categorizing foods into groups, selecting the number of components to retain, deciding on the rotation methods, and naming the dietary patterns, which could be influenced by researcher bias. Lastly, the 24-hour diet recall may not be able to accurately capture the variability in dietary intake and is subject to recall bias. To mitigate this, we used the Goldberg ratio to exclude misreporters to enhance the accuracy of the dietary data. Despite these limitations, the present study provides an overview of the dietary patterns among children in Sabah.

In conclusion, three *á posteriori* dietary patterns, namely the "Fish Dietary Pattern", "Fruits Dietary Pattern", and "White Rice Dietary Pattern" were identified among children in Sabah. Children who were from Tawau or households with a low income were more likely to adhere to the "Fish Dietary Pattern". Children who adhered to the "Fish Dietary Pattern" were taller and had greater intakes of energy, carbohydrate, and protein, while children who adhered to the "White Rice Dietary Pattern" had greater weight, height, and BMI, as well as intakes of energy, carbohydrate, and protein. Future studies investigating the relationship between these *á posteriori* dietary patterns and other health outcomes such as cognitive abilities and cardiometabolic markers are warranted to enhance the understanding of the broader impacts of these dietary patterns.

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