Household Food Security as a Mediating Pathway Linking Food Culture, Practices, and Values to Under-Five Nutritional Status among Rural Dayak Communities in Sarawak: A PLS-SEM Study

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ABSTRACT

Background: Child nutrition in remote Indigenous communities is shaped by food availability, household routines, cultural norms, and the ways families obtain, prepare, and share food. Evidence on how these socio-cultural factors operate through household food security remains limited in rural Sarawak. Objective: To examine direct and indirect associations linking food culture, food practices, and food values with under-five nutritional status among rural Dayak households, with household food security assessed as a mediating pathway and dietary diversity included in the structural model. Methods: This focused secondary analysis used data from a community-based cross-sectional survey of 808 parent/caregiver-child dyads from 50 Dayak villages in five divisions of Sarawak, Malaysia. Households were selected using multistage sampling followed by systematic household sampling. Food culture, practices, and values were measured using a study-specific Likert scale; household food security and 24-hour dietary diversity were assessed using established instruments; and child anthropometry followed World Health Organization procedures. The measurement model was assessed before partial least squares structural equation modelling and mediation analysis. Results: Food culture (β=0.254), food practices (β=0.307), and food values (β=0.196) were positively associated with household food security (all $p<0.001$). Household food security had the strongest association with child nutritional status (β=0.627, $p<0.001$). The socio-cultural constructs also showed smaller direct associations with nutritional status. Food security partially mediated the relationships of food culture, practices, and values with nutritional status, with variance accounted for of 68.61%, 62.86%, and 74.14%, respectively. Dietary diversity was not significantly associated with food security or nutritional status in the structural model. Conclusion: Socio-cultural food behaviours appear to relate to child nutrition chiefly through household food security. Rural nutrition programmes should combine culturally grounded food practices with interventions that strengthen reliable household access to nutritious food.

Keywords: Dayak, food culture, food security, child nutrition, PLS-SEM

INTRODUCTION

Child malnutrition remains a major public health concern despite substantial progress in child survival. The 2025 UNICEF/WHO/World Bank Joint Child Malnutrition Estimates reported that, in 2024, 150.2 million children under five were stunted, 42.8 million were wasted and 35.5 million were overweight globally (UNICEF, WHO, & World Bank Group, 2025). These outcomes are produced by interrelated biological, household and social conditions. In geographically remote settings, household access to adequate food can be constrained by income, transport, market access, seasonality and the availability of locally produced foods.

Food security captures whether households can reliably obtain sufficient and acceptable food, while household dietary diversity provides a short-term indication of the variety of food groups consumed (Coates *et al*., 2007; Kennedy *et al*., 2011). Both are useful, but they do not fully describe how families make food-related decisions. Food culture, food values and food practices include the norms, preferences, routines and skills

involved in choosing, preparing, sharing and consuming food. Family meals and cooking-related behaviours can shape children's eating environments, while food skills may also support household resilience when resources are limited (Hammons & Fiese, 2011; Ishikawa *et al*., 2019; Lavelle *et al*., 2016; Terragni *et al*., 2020).

This issue is particularly relevant to the Dayak communities of rural Sarawak, where longhouse and village settings, household food production, distance from markets and intergenerational food traditions may interact with socioeconomic constraints. The parent study from which this analysis was derived surveyed 808 households with children aged 6-59 months across 50 rural Dayak villages. Earlier publications from the same dataset described the prevalence and conventional predictors of undernutrition and the associations of household dietary diversity and food security with child anthropometric outcomes (Rahman, Kiyu, & Seling, 2021; Rahman, Seling, & Kiyu, 2021). Those reports did not foreground the socio-cultural food constructs and their indirect pathways in a structural model.

The present manuscript therefore addresses a distinct analytical question: whether food culture, food practices and food values are associated with under-five nutritional status directly and indirectly through household food security, with dietary diversity included in the structural model. Partial least squares structural equation modelling (PLS-SEM) was used because the parent analysis involved multiple latent constructs, non-normal data and an exploratory socio-cultural measurement model (Hair et al., 2017; Schamberger et al., 2020). The study hypothesised that favourable food culture, practices and values would relate to better household food security and child nutritional status, with household food security acting as an important intermediate pathway.

METHODOLOGY

Study design and setting

This was a focused secondary analysis of an analytical, quantitative, community-based cross-sectional study conducted in rural Sarawak, Malaysia. The field survey was undertaken in 2019 as part of a Doctor in Public Health research project (Seling, 2021). Five divisions, namely, Serian, Miri, Kapit, Betong and Bintulu were randomly selected. Two districts were selected from each division, followed by five Dayak villages per district, giving 50 villages in total.

Participants and sampling

Eligible households had at least one Dayak child aged 6-59 months and a parent or caregiver who had lived in the study area for at least one year and provided written consent. Where a household had more than one eligible child, one child was selected by ballot. Children with reported chronic illness, physical disability or mental disability, and households with major communication barriers or without consent, were excluded according to the parent protocol. Multistage random sampling was followed by systematic household sampling within villages. Of 979 households approached, 808 participated, giving an 82.5% response rate.

Analytical focus and prior dissemination

The parent dataset has previously supported two articles describing undernutrition prevalence and conventional predictors, and the relationships of household dietary diversity and food security with child anthropometric outcomes (Rahman, Kiyu, & Seling, 2021; Rahman, Seling, & Kiyu, 2021). The present manuscript reports a distinct analysis centred on the socio-cultural food constructs and their direct and indirect PLS-SEM pathways; it does not repeat the primary regression questions of those earlier reports.

Measures

Data were collected through face-to-face interviewer-administered questionnaires, observational checklists and anthropometric measurement. Household dietary diversity was assessed using a 24-hour recall across 12 food groups adapted from Food and Agriculture Organization guidance (Kennedy *et al*., 2011). Household food security was measured using items adapted from the Household Food Insecurity Access Scale and related

food-security questions covering recent and longer-term household experiences (Coates *et al*., 2007).

Food culture, food values and food practices were assessed using 21 Likert-type items developed from multiple published sources and adapted for the rural Sarawak context. Responses ranged from 1 (never) to 5 (always). The items covered intergenerational cooking knowledge, traditional food selection and preparation, shared meals, meal regularity, food preparation for children, ready-cooked and fast-food use, and the influence of modernisation on food behaviour (Seling, 2021). Exploratory factor analysis reduced the scale to 16 items. Subsequent measurement-model assessment retained four food-culture indicators, seven food-practice indicators and three food-value indicators.

Child nutritional status in the structural model was represented by standardised anthropometric indicators, including weight-for-height, height-for-age, weight-for-age, BMI-for-age and head-circumference z-scores. Measurements were performed using calibrated equipment following WHO procedures and processed using WHO Anthro software (WHO, 2006; WHO, 2007). Control variables included recent child morbidity, parental education, family size, household income, and household environment and sanitation.

Measurement model and statistical analysis

Data cleaning and descriptive analyses in the parent study were performed using Microsoft Excel and IBM SPSS Statistics version 22. The socio-cultural scale was screened for outliers before factor analysis; 741 observations remained for the psychometric analysis. Sampling adequacy was assessed using the Kaiser-Meyer-Olkin statistic and Bartlett's test of sphericity. Internal consistency, composite reliability, average variance extracted (AVE), cross-loadings, Fornell-Larcker criteria and heterotrait-monotrait (HTMT) ratios were examined. HTMT values below 0.90 were interpreted as supporting discriminant validity (Henseler *et al*., 2015).

PLS-SEM was used to estimate the structural paths reported in the parent thesis, with SmartPLS version 3.3.3 identified as the PLS software (Ringle *et al*., 2015; Seling, 2021). Statistical significance was set at $p<0.05$. Indirect and total effects were examined to evaluate mediation. Variance accounted for (VAF), calculated as the indirect effect divided by the total effect, was interpreted using the thresholds applied in the parent analysis: <20% no mediation, 20%-80% partial mediation, and >80% complete mediation (Hair *et al*., 2017). Because the data were cross-sectional, all paths are interpreted as statistical associations rather than proof of causality.

Ethical considerations

The parent study received ethical approval from the Ethics Committee of the Faculty of Medicine and Health Sciences, Universiti Malaysia Sarawak (UNIMAS/NC-21.02/03-02 Jld.3 (80)). Permission to enter the selected villages was obtained through the relevant village leadership. All participating parents or caregivers received study information and provided written informed consent, including consent for anthropometric measurement of the child.

RESULTS

Participant and household context

As previously reported from the parent dataset, the study included 808 parent/caregiver-child dyads. Most respondents were Iban, and the mean monthly household income was MYR 1,532. Household dietary diversity was generally moderate to high: 47.3% of households had medium dietary diversity and 45.3% had high dietary diversity, while 7.4% had low dietary diversity. Approximately 72% of households were food secure on average across the assessed periods; the remainder experienced food insecurity with or without hunger (Rahman, Seling, & Kiyu, 2021; Seling, 2021).

Measurement model

The socio-cultural food scale showed strong factorability. The Kaiser-Meyer-Olkin statistic was 0.906 and

Bartlett's test of sphericity was significant (chi-square(120)=4192.237, p<0.001). The three-factor solution explained 53.76% of the variance. The 16-item exploratory scale had an overall Cronbach's alpha of 0.868. In the final measurement model, composite reliability ranged from 0.765 to 0.886 and AVE from 0.525 to 0.556 (Table 1). The HTMT ratio was 0.887 between food culture and food practices, 0.666 between food culture and food values, and 0.558 between food practices and food values. Thus, discriminant validity met the <0.90 criterion, although the culture-practice pair was close to the conservative 0.85 threshold.

Table 1: Measurement properties of the final socio-cultural food constructs

Construct	Indicators	Cronbach's alpha	Composite reliability	AVE
Food culture	4	0.731	0.833	0.556
Food practices	7	0.849	0.886	0.528
Food values	3	0.555	0.765	0.525

Structural paths

Food culture, food practices and food values were each positively associated with the household food-security construct (beta=0.254, 0.307 and 0.196, respectively; all p<0.001). Food practices showed the largest socio-cultural association with food security. Each socio-cultural construct also had a smaller direct association with child nutritional status: food culture beta=0.070 (p<0.01), food practices beta=0.117 (p<0.001), and food values beta=0.045 (p<0.01). The strongest path in the model was between household food security and child nutritional status (beta=0.627, p<0.001). In contrast, household dietary diversity was not significantly associated with either food security (beta=-0.056, p=0.163) or nutritional status (beta=-0.045, p>0.05) in the structural model. Among the control variables, parental education (beta=0.060, p=0.018) and household income (beta=0.058, p=0.038) were positively associated with nutritional status, while family size showed a negative association (beta=-0.113, p<0.001). Recent morbidity and household environment and sanitation were not significant in the structural model.

Table 2: Selected direct paths in the PLS-SEM structural model

Pathway	beta	SD	Significance
Food culture -> food security	0.254	0.045	p<0.001
Food practices -> food security	0.307	0.044	p<0.001
Food values -> food security	0.196	0.033	p<0.001
Dietary diversity -> food security	-0.056	0.057	p=0.163
Food culture -> nutritional status	0.070	0.032	p<0.01
Food practices -> nutritional status	0.117	0.031	p<0.001
Food values -> nutritional status	0.045	0.024	p<0.01
Dietary diversity -> nutritional status	-0.045	0.042	p>0.05
Food security -> nutritional status	0.627	0.033	p<0.001
Parental education -> nutritional status	0.060	0.029	p=0.018
Family size -> nutritional status	-0.113	0.025	p<0.001
Family income -> nutritional status	0.058	0.032	p=0.038

Mediation through household food security

The indirect effects of all three socio-cultural food constructs on nutritional status were significant and

substantially larger than their direct paths. Food culture had an indirect effect of 0.153 and a total effect of 0.223, producing a VAF of 68.61%. Food practices had an indirect effect of 0.198 and a total effect of 0.315 (VAF 62.86%). Food values had an indirect effect of 0.129 and a total effect of 0.174 (VAF 74.14%). Under the thresholds used in the parent analysis, these results indicate partial mediation through household food security for all three constructs (Table 3). No complete mediation was observed.

Table 3: Indirect effects of socio-cultural food constructs on child nutritional status through household food security

Exposure	Indirect effect	Total effect	VAF (%)	Interpretation
Food culture	0.153***	0.223***	68.61	Partial mediation
Food practices	0.198***	0.315***	62.86	Partial mediation
Food values	0.129***	0.174***	74.14	Partial mediation

****p<0.001; VAF = variance accounted for.*

DISCUSSION

The principal finding is that household food security formed the dominant statistical pathway linking socio-cultural food factors with under-five nutritional status in rural Dayak households. Food culture, practices and values were all associated with food security and with child nutritional status, but their direct associations with nutritional status were modest. Their indirect effects through food security were considerably larger, and the VAF values of 62.86%-74.14% indicate that much of the observed socio-cultural association operated through the food-security pathway.

This finding adds a different perspective to the earlier analyses from the same parent dataset. Previous reports established that food insecurity was associated with wasting, stunting and underweight and that several socioeconomic characteristics were important predictors (Rahman, Kiyu, & Seling, 2021; Rahman, Seling, & Kiyu, 2021). The present structural analysis suggests a plausible household-level mechanism: food-related norms and routines may matter partly because they shape how available resources are translated into reliable food access, meal preparation and feeding practices. This does not imply that culture itself protects against malnutrition. Rather, specific practices embedded within household culture such as regular preparation of meals, food-planning skills, shared cooking knowledge and reduced dependence on prepared food may support a household's capacity to maintain food security.

Food practices showed the strongest socio-cultural path to food security and the largest total association with child nutritional status. This is consistent with evidence that cooking and food skills can influence food choice, meal preparation and dietary behaviour (Lavelle *et al*., 2016; Muzaffar *et al*., 2018). Parent-child meal preparation has also been associated with aspects of healthier feeding environments (Ishikawa *et al*., 2019). In resource-constrained households, practical food skills may be especially relevant because families must make decisions about purchasing, storage, preparation and the use of locally available foods. Terragni *et al*. (2020) similarly reported a relationship between food skills, food security and dietary diversity in a vulnerable population, supporting the broader idea that food skills can operate as a household resource.

Food values had the highest proportion of its total association with nutritional status mediated through food security (VAF 74.14%). This suggests that preferences and values concerning food selection and preparation may have limited direct influence on anthropometric outcomes unless they translate into consistent household access and feeding conditions. Food culture showed a similar pattern. These findings support culturally grounded nutrition programmes, but they also caution against focusing on cultural messaging alone. Interventions are more likely to be useful when culturally appropriate food education is combined with measures that improve affordability, access, income stability and the practical capacity to prepare nutritious meals.

An important result was the absence of a significant structural association between household dietary diversity and nutritional status. This should not be interpreted as evidence that dietary quality is unimportant. The dietary-diversity measure was based on a 24-hour count of food groups and does not quantify portion size, nutrient density, intra-household allocation or longer-term dietary consistency (Kennedy *et al*., 2011). In addition, more than 90% of households had medium or high dietary-diversity scores, which may have reduced contrast within the sample. Household food security, in comparison, reflects the reliability of access to food over a longer period and may therefore have captured the chronic household constraint more strongly in this structural model.

The associations of parental education, household income and family size reinforce the importance of structural determinants. Higher education and income were associated with better nutritional status, while larger family size was negatively associated. These findings imply that a culturally responsive nutrition strategy should be embedded within broader rural development and social protection measures. For remote Sarawak communities, practical priorities may include strengthening local food production and storage, improving reliable transport and market access, supporting household livelihoods, and delivering nutrition education through primary care and community outreach. Cooking demonstrations and intergenerational food-skills activities may be particularly useful when designed with community leaders and adapted to locally available foods rather than imposed as standardised urban dietary messages.

This analysis has several strengths. It drew on a large community sample from 50 villages across five divisions, used multistage sampling, incorporated direct anthropometric measurement and examined a socio-cultural construct rarely quantified in rural Sarawak. The PLS-SEM approach also permitted simultaneous evaluation of direct and indirect relationships rather than separate regression equations.

The limitations require careful interpretation. The cross-sectional design does not establish temporal sequence or causality. Dietary diversity relied on 24-hour recall, while longer-term food-security questions were vulnerable to recall error. Food availability in rural households may vary by agricultural season, and the parent study noted that seasonality could influence food-security responses. The food culture, practice and value scale was newly assembled from multiple sources and, although its overall reliability and convergent validity were acceptable, the food-value construct had weaker internal consistency and the culture-practice HTMT ratio was close to the conservative threshold. External validation in other Dayak subgroups and rural populations is therefore needed. Finally, the structural analysis was based on an existing dataset collected in 2019, so current household food environments may differ.

Future studies should validate the socio-cultural food scale prospectively, use repeated dietary and food-security measurements across seasons, and test longitudinal models. Mixed-method research would also help clarify which cultural practices are protective, neutral or potentially adverse, and how these practices interact with household income, market access and locally available foods.

CONCLUSION

Food culture, food practices and food values were associated with under-five nutritional status among rural Dayak households, but the strongest relationship in the structural model involved household food security. Food security partially mediated the associations of all three socio-cultural constructs with nutritional status, while household dietary diversity was not significant in the structural model. These findings indicate that food culture should not be considered separately from the material conditions that determine whether families can obtain and prepare sufficient food consistently. Public health programmes in rural Sarawak should combine culturally appropriate food and cooking practices with interventions that strengthen household food security, socioeconomic resilience and access to nutritious foods. Longitudinal research and further validation of the socio-cultural food scale are required before causal conclusions are made.

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Ethical Considerations

The parent study received ethical approval from the Ethics Committee of the Faculty of Medicine and Health Sciences, Universiti Malaysia Sarawak (UNIMAS/NC-21.02/03-02 Jld.3 (80)). Written informed consent was obtained from all participating parents or caregivers.

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Conflict Of Interest

The authors declare no potential conflicts of interest.

Data Availability

The participant-level dataset is not publicly available because it was collected under institutional ethics approvals and contains information requiring confidentiality protection. Requests for access may be directed to the corresponding author and will be considered subject to applicable ethical and institutional requirements.

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