

Sanitation and Sociocultural Correlates of Selected Dietary Behaviors in Rumah Lanting: Cross-Sectional Evidence

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ABSTRACT

Stunting reflects cumulative early-life exposures, whereas current dietary behavior is proximal and time-specific. Sanitation and sociocultural exposures may coexist within river-dependent rumah lanting communities. This study examined associations of sociocultural conditions and environmental sanitation with selected dietary behaviors and, secondarily, with quality-controlled height-for-age z-scores (HAZ). The cross-sectional analysis included 193 children aged 3–59 months from Pahandut and Pahandut Seberang, Palangka Raya. The selected dietary-behavior construct comprised AL2, AMS1, and AMS2. PLS-SEM evaluated sociocultural and sanitation associations with this construct using 5,000 bootstrap resamples. HAZ was independently recalculated using sex, completed age in months, and recorded length/height according to the 2006 WHO Child Growth Standards. Implausible HAZ values flagged by WHO criteria (<-6 or >6) were excluded from HAZ analyses, leaving 188 children. Sociocultural factors ($\beta=-0.210$, 95% CI -0.375 to -0.064 ; $p=0.008$) and environmental sanitation ($\beta=-0.171$, 95% CI -0.331 to -0.022 ; $p=0.032$) were associated with selected dietary behaviors, jointly explaining 9.1% of the variance ($Q^2=0.019$). In an age-adjusted composite-score sensitivity analysis, the sociocultural association remained statistically significant ($\beta=-0.200$, $p=0.027$), whereas the sanitation estimate was attenuated ($\beta=-0.124$, $p=0.095$). In the quality-controlled HAZ analysis, none of the three constructs was significantly associated with HAZ ($R^2=0.043$); associations remained non-significant after age adjustment ($R^2=0.048$). Sociocultural and sanitation conditions were associated with a narrow set of current dietary behaviors in the primary PLS model. However, the sanitation association was less robust after age adjustment, and the measured constructs explained little variation in concurrent HAZ. These cross-sectional findings should not be interpreted causally.

INTRODUCTION

Childhood stunting reflects cumulative impairment of linear growth resulting from interacting biological, nutritional, infectious, socioeconomic, and environmental exposures. Contemporary syntheses therefore caution against single-cause explanations of stunting and emphasize mechanisms operating across multiple stages of early life^{1,2}. In Indonesia, large-scale evidence likewise identifies social position, geography, water and sanitation, health service factors, and child characteristics as important correlates of stunting³.

Water, sanitation, and hygiene (WASH) form an important part of this upstream risk architecture. A recent systematic review and meta-analysis reported associations between improved water, sanitation, and hygiene conditions and lower odds of childhood stunting across low- and middle-income settings⁴. Biologically plausible pathways include repeated enteric exposure and environmental enteric dysfunction, which can compromise intestinal integrity, promote inflammation, and disrupt nutrient utilization and growth signaling^{5,6}. Food insecurity and limited dietary diversity also remain important correlates of stunting in Asia⁷.

Current feeding behavior, however, is conceptually distinct from established stunting. Feeding choices occur within the household and social context at a given point in time, whereas height-for-age reflects cumulative exposure from fetal life onward. Caregiver beliefs, family expectations, food preferences, time constraints, and local norms can influence what and how young children eat⁸⁻¹². Thus, current dietary behavior can reasonably be examined as a proximal outcome even when it does not explain substantial cross-sectional variation in a cumulative anthropometric outcome.

Rumah lanting are traditional floating dwellings situated directly on rivers. Along the Kahayan River corridor, floating and adjacent riverine households interact closely with the aquatic environment for residence, mobility, water use, and livelihoods. Existing stunting research in Indonesia has largely focused on national-level data and rural, urban-poor, or other land-based populations^{2,3}, while evidence integrating sanitation and sociocultural conditions with children's dietary behavior in floating and adjacent riverine settlements remains limited. The present study uses the term 'floating-settlement nutritional ecology' only as an interpretive lens to describe the co-location of environmental and social exposures; it is not treated as a formally tested theory.

Accordingly, this focused analysis addressed three questions: (1) Are sociocultural conditions associated with selected fat- and snack-related dietary behaviors? (2) Is environmental sanitation associated with these selected dietary behaviors? and (3) Are sociocultural conditions, sanitation, and selected dietary behaviors associated with height-for-age z-scores (HAZ), analyzed as a continuous outcome, following quality control of the anthropometric data? We expected the sociocultural and sanitation constructs to be associated with the selected dietary-behavior construct; associations with HAZ were evaluated without assuming a causal pathway.

MATERIALS AND METHODS

Study Design and Setting

This study is a focused quantitative analysis from a broader mixed-method ecological investigation. The quantitative component used an analytical cross-sectional design. Data were collected from January to December 2025 in Pahandut and Pahandut Seberang, Palangka Raya,

Central Kalimantan. For the parent study, rumah lanting households were floating dwellings physically located on the Kahayan River, while adjacent riverine households were land-based households situated along the same river corridor. Because all exposures and outcomes used here were observed within the same study period, structural coefficients are interpreted as associations rather than causal effects.

Participants and Sampling

The parent study targeted households with an under-five child living in a rumah lanting or the adjacent Kahayan riverbank community. Purposive sampling was used because the study specifically sought households embedded in this river-dependent ecological setting rather than a general city population. The parent protocol specified a minimum sample of 184 households; 193 children with complete data on all retained sociocultural, sanitation, and selected dietary-behavior indicators were available for the primary PLS analysis, and no imputation was required. Eligibility for the focused analysis required inclusion in the parent riverine under-five study and complete data on the retained questionnaire indicators. Field data collection was undertaken by trained enumerators following harmonization with local health personnel and community cadres. Source-record verification before resubmission corrected one implausible age entry from 65 to 45 months; the verified child-age range was 3-59 months.

Questionnaire and Anthropometry

The parent study used a structured interviewer-administered questionnaire covering dietary intake, infectious-disease-related factors, household food security, healthcare, sociocultural conditions, socioeconomic characteristics, and environmental sanitation. Instrument validity and reliability procedures were piloted in 30 respondents outside the study sample before field implementation. Retained questionnaire indicators used four ordered numeric response categories coded 1-4. Higher values reflected greater endorsement or frequency of the item as worded; because the retained items do not share a uniform favorable/adverse polarity, negative structural coefficients are reported as statistical direction and are not labeled globally as protective or harmful.

Length/height was measured according to age and the child's ability to stand. The parent protocol specified a microtoise with 0.1-cm precision for children aged 24 months or older/able to stand and a length board for younger children or those unable to stand, using equipment compliant with Indonesian national anthropometric standards¹³. For this revision, HAZ was independently recalculated from sex, completed age in months, and the recorded length/height using the monthly WHO 2006 Child Growth Standards¹³. Because measurement posture was not stored in the analysis spreadsheet, the WHO age-based convention was applied for recalculation: recumbent-length standards below 24 months and standing-height standards from 24 months onward. WHO

length/height-for-age plausibility flags (<-6 or >6 z) were applied. Five records exceeded these limits and were excluded only from HAZ-based analyses; all 193 records were retained for questionnaire-only PLS analyses. Stunting was descriptively defined as $HAZ < -2$ and severe stunting as $HAZ < -3$.

Construct Operationalization

Measurement-model refinement in the parent analysis retained eight sociocultural indicators, six environmental-sanitation indicators, and three dietary indicators. Because AL2, AMS1, and AMS2 capture a narrow subset of the broader dietary questionnaire, the construct is termed 'selected dietary behaviors' rather than 'food intake'. The retained indicator domains and loadings are shown in Table 1. HAZ was not modeled as a latent construct; it was treated as a continuous observed anthropometric outcome in a separate secondary analysis.

Table 1. Retained indicators and measurement properties of the focused constructs

Construct	Indicator(s)	Operational content in parent instrument	Coding note	Loading(s)
Sociocultural	KB1-KB3	Cultural-belief items relevant to child health and caregiving	4-point ordinal (1-4); direction follows item wording	0.733-0.857
Sociocultural	PENPT1-PENPT3	Traditional-treatment-practice items	4-point ordinal (1-4); no uniform favorable/adverse polarity	0.716-0.720
Sociocultural	PSK1-PSK2	Social and community influence items	4-point ordinal (1-4)	0.796-0.879
Environmental sanitation	FS1-FS3	Sanitation-facility items	4-point ordinal (1-4)	0.778-0.816
Environmental sanitation	PS1-PS3	Household waste-management items	4-point ordinal (1-4)	0.729-0.829
Selected dietary behaviors	AL2	Retained fat-related item; frequent fried-food consumption in the parent domain	4-point ordinal (1-4)	0.791
Selected dietary behaviors	AMS1-AMS2	Two retained items from the parent snack/sweet-drink/fast-food domain	4-point ordinal (1-4)	0.753-0.762

PLS-SEM and Sensitivity Analyses

PLS-SEM was selected for the primary analysis because the focused model involved multi-item latent constructs, an exploratory/predictive structural relationship, and a modest sample, while not requiring multivariate normality in the same way as covariance-based SEM^{14,15}. SmartPLS 3.2.9 was used for the primary measurement and structural model. Reliability and convergent validity were assessed using Cronbach's alpha, rho_A, composite reliability (CR), and average variance extracted (AVE); discriminant validity used the Fornell-Larcker criterion and HTMT¹⁴⁻¹⁶. The structural model

estimated two prespecified paths: sociocultural factors -> selected dietary behaviors and environmental sanitation -> selected dietary behaviors.

In the revised primary PLS analysis, 5,000 nonparametric bootstrap resamples were used with two-tailed testing and 95% percentile bootstrap confidence intervals. Effect size f^2 was calculated by comparing full and reduced structural models. Predictive relevance was assessed by blindfolding-based Q^2 (omission distance 7), while R^2 and adjusted R^2 were reported descriptively. To address the broad under-five age range, post hoc sensitivity analyses used standardized unit-weighted composite scores from the retained indicators and heteroskedasticity-robust (HC3) linear regression: first adjusted for child age and then additionally for child sex and maternal education. For the secondary anthropometric analysis, the same standardized composite predictors were regressed on standardized recalculated HAZ among records passing WHO plausibility checks ($n=188$), first without covariates and then with child age; a further model added sex and maternal education ($n=187$). These analyses were used to assess robustness rather than redefine the prespecified primary PLS model.

Ethical considerations

The study was approved by the Ethics Committee of the Palangka Raya Health Polytechnic, Ministry of Health (983/VII/KE.PE/2025). Parents or legal guardians received study information and provided informed consent. Data were handled confidentially.

RESULTS

Participant Characteristics

The analytical sample comprised 193 children and their households. Fathers and mothers were predominantly Banjar (80.3% and 83.9%, respectively). Most mothers were homemakers (83.9%). Primary school was the most frequent educational category among fathers (45.6%) and mothers (42.0%). Child sex was nearly balanced (49.2% boys, 50.8% girls). After source-record verification, child age ranged from 3 to 59 months; the largest age group was >28-40 months (26.9%). These characteristics are treated as contextual descriptors rather than adjusted determinants in the primary PLS model. For the secondary HAZ analysis, 188 records passed WHO plausibility checks. Mean recalculated HAZ was -1.16 (SD 1.71; median -1.28; range -5.41 to 4.55); 64/188 children (34.0%) had $HAZ < -2$, including 16/188 (8.5%) with $HAZ < -3$.

Table 2. Selected Sociodemographic Characteristics of Participants (n=193)

Characteristic	n	%
Father: private/other employment	123	63.7
Father: primary-school education	88	45.6
Father: Banjar ethnicity	155	80.3

Characteristic	n	%
Mother: homemaker	162	83.9
Mother: primary-school education	81	42.0
Mother: Banjar ethnicity	162	83.9
Child age 3-15 months	40	20.7
Child age >15-28 months	49	25.4
Child age >28-40 months	52	26.9
Child age >40-53 months	36	18.7
Child age >53-59 months	16	8.3
Male child	95	49.2
Female child	98	50.8

Measurement Model

All retained sociocultural indicators loaded above 0.70 (0.716-0.879), as did all environmental-sanitation indicators (0.729-0.829) and the selected dietary-behavior indicators (0.753-0.791). Sociocultural factors showed $\alpha=0.905$, $\rho_A=0.929$, $CR=0.923$, and $AVE=0.601$; environmental sanitation showed $\alpha=0.879$, $\rho_A=0.916$, $CR=0.907$, and $AVE=0.620$. The selected dietary-behavior construct had $\alpha=0.667$, $\rho_A=0.672$, $CR=0.813$, and $AVE=0.591$. Although α was below 0.70, CR and AVE were acceptable for this three-indicator exploratory construct. Fornell-Larcker and HTMT results supported empirical separation of the multi-item constructs; all reported HTMT values were below 0.31.

Table 3. Reliability and Convergent Validity of Retained Multi-Item Constructs

Construct	Indicators	Loading range	Alpha	CR	AVE
Sociocultural	8	0.716-0.879	0.905	0.923	0.601
Environmental sanitation	6	0.729-0.829	0.879	0.907	0.620
Selected dietary behaviors	3	0.753-0.791	0.667	0.813	0.591

Structural Model

Sociocultural factors were inversely associated with the selected dietary-behavior score ($\beta=-0.210$, $p=0.008$), as was environmental sanitation ($\beta=-0.171$, $p=0.032$). The 95% bootstrap confidence intervals were -0.375 to -0.064 and -0.331 to -0.022, respectively. Effect sizes were small ($f^2=0.045$ and 0.030). Together the two predictors explained 9.1% of variance in selected dietary behaviors ($R^2=0.091$; adjusted $R^2=0.082$), and $Q^2=0.019$ indicated only weak predictive relevance. Signed coefficients are reported consistently throughout; because retained item coding does not have a uniform favorable/adverse polarity, coefficients are interpreted as statistical direction rather than globally as protective or harmful.

Secondary continuous HAZ analysis showed no statistically significant association for sociocultural factors (standardized beta=0.163, 95% HC3 CI -0.013 to 0.339; p=0.070), environmental sanitation (beta=-0.061, 95% CI -0.246 to 0.124; p=0.519), or selected dietary behaviors (beta=-0.105, 95% CI -0.300 to 0.090; p=0.290). The model explained 4.3% of HAZ variance (R²=0.043; adjusted R²=0.027). Thus, the measured contemporary constructs had limited explanatory value for concurrent linear growth even when nutritional status was represented continuously rather than as a categorical single indicator.

Table 4. Structural Associations with Selected Dietary Behaviors

Path	β	SD	95% bootstrap CI	t	p	f ²	Inference
Sociocultural -> selected dietary behaviors	-0.210	0.080	-0.375 to -0.064	2.648	0.008	0.045	Associated
Sanitation -> selected dietary behaviors	-0.171	0.081	-0.331 to -0.022	2.143	0.032	0.030	Associated

Table 5. Explained Variance and Predictive Relevance for Selected Dietary Behaviors

Endogenous construct	R ²	Adjusted R ²	Q ²
Selected dietary behaviors	0.091	0.082	0.019

Sensitivity analysis

In the age-adjusted composite-score sensitivity model for selected dietary behaviors (n=193), the sociocultural association remained statistically supported (beta=-0.200, 95% HC3 CI -0.378 to -0.023; p=0.027), whereas the sanitation estimates attenuated and its interval crossed zero (beta=-0.124, 95% CI -0.269 to 0.022; p=0.095). Child age itself was associated with the selected dietary-behavior score (beta=-0.222, 95% CI -0.356 to -0.089; p=0.001), and model R² was 0.124. A further model including age, sex, and maternal education (n=192) produced the same pattern: sociocultural beta=-0.199 (p=0.029), sanitation beta=-0.126 (p=0.092), age beta=-0.217 (p=0.001), while sex and maternal education were not significant (R²=0.126). In the age-adjusted HAZ model (n=188), sociocultural factors (beta=0.160, p=0.088), sanitation (beta=-0.059, p=0.540), selected dietary behaviors (beta=-0.125, p=0.222), and child age (beta=-0.074, p=0.352) were all non-significant; R² was 0.048. Adding sex and maternal education (n=187) did not materially change the HAZ estimates (R²=0.048). These sensitivity results reinforce caution about age heterogeneity, residual confounding, and small effect sizes.

Table 6. Secondary Robust Regression of Recalculated Height-for-Age z-Score (HAZ), n=188

Model	Predictor	Standardized beta	95% HC3 CI	p
Unadjusted	Sociocultural factors	0.163	-0.013 to 0.339	0.070
Unadjusted	Environmental sanitation	-0.061	-0.246 to 0.124	0.519

Model	Predictor	Standardized beta	95% HC3 CI	p
Unadjusted	Selected dietary behaviors	-0.105	-0.300 to 0.090	0.290
Age-adjusted	Sociocultural factors	0.160	-0.024 to 0.343	0.088
Age-adjusted	Environmental sanitation	-0.059	-0.249 to 0.130	0.540
Age-adjusted	Selected dietary behaviors	-0.125	-0.325 to 0.075	0.222
Age-adjusted	Child age	-0.074	-0.230 to 0.082	0.352

Unadjusted model $R^2=0.043$ (adjusted $R^2=0.027$); age-adjusted model $R^2=0.048$ (adjusted $R^2=0.027$). Five records with WHO HAZ plausibility flags (<-6 or >6) were excluded. HC3, heteroskedasticity-robust standard errors.

DISCUSSION

Principal Findings

This revised analysis distinguishes a proximal behavioral outcome from an accumulated anthropometric outcome. In the prespecified PLS model, sociocultural and environmental-sanitation constructs were each associated with the selected dietary-behavior construct, but they explained only 9.1% of its variance and had small f^2 values. The age-adjusted composite-score sensitivity analysis retained the sociocultural association but attenuated the sanitation estimate. In the independently recalculated continuous HAZ analysis, none of the three measured constructs was significantly associated with HAZ, and only 4.3% of HAZ variance was explained (4.8% after age adjustment). The data therefore support a narrow conclusion about contemporary dietary behavior rather than a broad explanatory model of linear growth.

Age adjustment materially refines interpretation because the meaning of dietary behavior differs across infancy and preschool age. In the age-adjusted composite model, the sociocultural coefficient remained statistically supported, whereas the sanitation coefficient no longer met the conventional 0.05 threshold. This pattern suggests that the primary sanitation estimate should be regarded as less robust to age heterogeneity. The HAZ models remained non-significant before and after age adjustment, consistent with the cumulative nature of height-for-age.

Sociocultural and Sanitation Correlates of Selected Dietary Behaviors

Feeding is socially embedded. Qualitative and mixed-method evidence from Indonesia and Asia shows that caregiver perceptions, household norms, intergenerational expectations, and contextual constraints influence complementary-feeding decisions^{8–12}. The present study is consistent with that broader literature only at a general level: the sociocultural construct was associated with the retained fat/snack-related behavior score. Because the focused construct does not measure dietary diversity, protein adequacy, total energy, breastfeeding, or animal-source-food frequency, those mechanisms should not be inferred from the present quantitative result.

Environmental sanitation was also associated with the selected dietary-behavior score. A river-dependent household environment can plausibly connect sanitation with food preparation, illness-related appetite, or daily routines, but these mechanisms were not directly measured in the final focused model. The result is therefore best described as a contextual association requiring mechanistic testing rather than evidence that sanitation 'shapes' diet. This cautious interpretation is consistent with evidence linking WASH and child growth while recognizing substantial heterogeneity and multiple pathways^{4,17}.

Interpretive Framework and Implications

The phrase 'floating-settlement nutritional ecology' is retained only as an interpretive description of co-located environmental and social exposures in river-dependent settlements. The present focused analysis does not formally validate this framework. Broader interventions involving maternal nutrition, infection prevention, social protection, and healthcare access remain relevant in the wider stunting literature, but they were not directly tested here and are not presented as effects demonstrated by this study.

Within the evidence actually measured, two practical implications are cautiously suggested. First, culturally responsive counseling may need to address everyday food practices rather than assuming that information alone determines behavior. Second, sanitation remains an important contextual consideration in river-dependent settings based on the broader WASH literature; however, the attenuation of the sanitation-dietary association after age adjustment means this study alone does not establish an intervention effect. Intervention effectiveness requires prospective or experimental evaluation.

Strengths and Limitations

Strengths include analysis of an underrepresented riverine population, explicit evaluation of measurement properties, reconciliation of coefficient signs, reporting of bootstrap confidence intervals and effect sizes, Q2 assessment, age-adjusted sensitivity analysis, and independent recalculation of continuous HAZ using WHO 2006 standards with prespecified plausibility checks. Separating the latent dietary-behavior model from the observed continuous HAZ analysis also avoids treating a categorical nutritional-status variable as a PLS latent construct.

Limitations are substantial. The cross-sectional design precludes temporal or causal inference, and purposive sampling limits generalizability. The selected dietary-behavior construct contains only three fat/snack-related indicators and is not a comprehensive assessment of energy, nutrient adequacy, dietary diversity, or feeding quality. Item wording and response coding do not support a single favorable/adverse interpretation across all retained sociocultural and sanitation indicators. Several potentially important confounders and life-course determinants were not included

in the focused model. Anthropometric data were available only as completed age in months plus recorded length/height; exact age in days and measurement posture were not stored in the analysis spreadsheet. Five observations had WHO-flagged implausible HAZ and were excluded from HAZ analyses, reducing the HAZ sample to 188. Although the age-adjusted analyses reduce one important source of heterogeneity, residual confounding remains likely.

CONCLUSION

In rumah lanting and adjacent Kahayan River communities, sociocultural conditions and environmental sanitation were associated with a narrow set of fat- and snack-related dietary behaviors in the primary PLS model, with small effect sizes and limited explained variance. After age adjustment, the sociocultural association remained statistically supported, whereas the sanitation estimate was attenuated. In the secondary analysis, which used independently recalculated and quality-controlled HAZ as a continuous outcome, sociocultural factors, sanitation, and selected dietary behaviors were not significantly associated with HAZ. The HAZ models explained only approximately 4–5% of the variance.

These findings should therefore be interpreted as cross-sectional evidence concerning proximal dietary behavior rather than as a causal model of stunting or linear growth. Future longitudinal studies should use exact age in days, duplicate standardized anthropometric measurements with documented measurement posture, repeated and more comprehensive dietary assessments, and measurement of prespecified confounders to examine how riverine environmental and sociocultural exposures relate to growth trajectories over time.

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