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Development, Validation, and Concurrent Performance of the Multidimensional Index of Child Growth (MICG) for Identifying Stunting in Primary Health Care

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ABSTRACT

Background: Height-for-age anthropometry is the backbone of stunting detection in Indonesian primary health care, yet it does not describe the feeding, health, developmental, caregiving, and service-access conditions that shape child growth.

Purpose: To develop a multidimensional child growth instrument, evaluate its psychometric properties, and examine how well its composite index identifies concurrent stunting status.

Methods: This cross-sectional validation study enrolled 180 caregiver–child pairs (children aged 6–59 months) from four stunting-priority sub-districts of an Indonesian city through cluster random sampling. The 80-item, six-dimension Indonesian MICG was tested for content validity, item–total correlation, factor structure, and internal consistency. An equal-weighted index (0–100) was compared with concurrent height-for-age status using Spearman correlation, receiver operating characteristic analysis, and logistic regression.

Results: All items achieved an item-level content validity index of 1.00. Cronbach's alpha ranged from 0.35 (Physical Health) to 0.88 (Child Development). The mean index score was 80.16 (SD 8.83). The index correlated weakly with continuous height-for-age z-scores (rho = 0.17; p = 0.027) but not with height-for-age category (rho = −0.13; p = 0.084). The area under the curve was 0.57 (95% CI 0.48–0.66) for both outcome definitions, and the six-dimension logistic model was not significant (p = 0.115).

Conclusion: The current equal-weighted MICG Index cannot distinguish children who are stunted or at risk from those growing normally and should not replace or supplement anthropometric screening. Its use for holistic growth profiling remains a proposal requiring feasibility and utility evaluation.

Keywords **:** Anthropometry; Child Development; Growth Disorders; Mass Screening; Primary Health Care

BACKGROUND

Stunting describes impaired linear growth that results from chronic undernutrition, repeated infection, and insufficient psychosocial stimulation, particularly during the first 1,000 days of life. Its effects extend well beyond height, reaching into cognitive development and

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productivity in adulthood (Leroy & Frongillo, 2019; Rahmawati & Agustin, 2020). In 2024, about 150.2 million children under five, or 23.2% of this age group worldwide, were stunted, and progress in Asia and Africa has slowed (UNICEF et al., 2025). Indonesia shares this burden: the 2024 Indonesian Nutritional Status Survey reported a national prevalence of 19.8%, still above the national target of 14% (Kementerian Kesehatan Republik Indonesia [Kemenkes RI], 2025).

Anthropometry is, and should remain, the foundation of stunting detection in Indonesian primary health care (Kemenkes RI, 2020, 2022). Repeated length or height measurements plotted on growth charts allow midwives and cadres to recognize growth faltering early, often before a child crosses the −2 SD threshold, because linear growth deficits accumulate along a continuum rather than appearing suddenly (Leroy & Frongillo, 2019; Perumal et al., 2018). What a single height-for-age z-score (HAZ) cannot show, however, is why a child is faltering. The conditions that drive growth, such as feeding patterns (Rahmawati et al., 2024), parenting practices (Manurung et al., 2025), early developmental stimulation (Khadijah et al., 2025), and the home environment (Yurizal & Fajar, 2023), lie outside what a measuring board can capture. The UNICEF conceptual framework places diets and care practices, together with health and service conditions, as distinct but interacting determinants of child nutrition (UNICEF, 2020).

Haisma et al. (2019) proposed a Multidimensional Index of Child Growth (MICG) that views growth not only as a physical outcome but also as the expansion of a child's health, care, and developmental opportunities. Later work in the Vietnam Young Lives cohort showed that a multidimensional growth measure reflected the benefits of community participation that height-based indicators alone did not fully capture (Gonzales Martinez et al., 2022). The concept has since been formalized by a task force of the International Union of Nutritional Sciences, which tested a 14-dimension framework across four countries and found that equal weighting of dimensions produced robust results (Gonzales Martinez & Haisma, 2025). Evidence from other settings points in the same direction: Bayesian multilevel analysis in Tanzania linked household socio-economic status to stunting (Musheiguza et al., 2023), work in Cambodia tied child nutritional status to multidimensional poverty (Karpati et al., 2020), and studies in Indonesia identified individual, household, and community determinants that anthropometry alone does not reveal (Sari et al., 2025; Wicaksono & Harsanti, 2020).

Despite this evidence, Indonesian primary care still lacks a tool that brings these determinants together. The instruments currently used at community health posts (Posyandu) each address a single domain: growth charts record anthropometry, developmental screening questionnaires record milestones, and family-level stunting-risk checklists record household conditions. To our knowledge, no instrument that combines these domains into one index has been psychometrically validated in Indonesia, tested against children's anthropometric status, or examined for its feasibility in routine Posyandu practice, even though the developmental consequences of stunting are well recognized (Kustomo & Purnamawati, 2025). Emerging digital approaches to early stunting detection still depend largely on anthropometric inputs (Pramana & Zidan, 2024).

Building on our earlier work on psychosocial stimulation and dietary diversity among stunted children (Rahmawati & Agustin, 2021), we developed an Indonesian version of the MICG. It is a newly developed instrument informed by the MICG framework rather than a translation of the international index. It covers six dimensions: Feeding Practices, Physical

Health, Child Emotional Wellbeing, Child Development, Parenting and Family Environment, and Health Service Access. Feeding Practices and Physical Health were drafted as a single domain but treated as separate dimensions in the final structure for two reasons. Conceptually, feeding practices describe what caregivers provide (the dietary input), whereas physical health describes the child's birth history and morbidity, a distinction that mirrors the separation of diets and health determinants in the UNICEF framework (UNICEF, 2020). Empirically, when the 24 items of both domains were analyzed together, all nine feeding items loaded on one component (loadings 0.42–0.64) and most physical health items loaded on a second component, while the two dimension scores were only weakly correlated (rho = 0.23).

This study therefore had three objectives: (1) to develop the Indonesian MICG and evaluate its content validity, item validity, factor structure, and internal consistency; (2) to construct a composite MICG Index; and (3) to examine how well the index identifies children who are currently stunted or at risk, using concurrent HAZ status as the reference. Because the index and HAZ were measured at the same visit, the third objective concerns the identification of existing growth deficits, not the prediction of future stunting. The findings are intended to guide midwives, nurses, and cadres who carry out routine growth monitoring at Posyandu and primary health centers (Puskesmas).

METHODS

Design and Setting

This was a cross-sectional instrument-development and validation study with a concurrent diagnostic-performance component. This design allowed us to assess the psychometric properties of a new instrument and, at the same visit, compare its index with the current reference standard (HAZ). The study took place in four sub-districts of Kediri City, East Java, Indonesia: Kampung Dalem, Betet, Pesantren, and Rejomulyo. Betet, Pesantren, and Rejomulyo were chosen purposively because they are stunting-priority areas with active Posyandu, Puskesmas support, and a heterogeneous population in terms of education, parenting, environment, and service access; Kampung Dalem was added to broaden the range of settings. The four sub-districts lie in two of the three districts of the city. They represent priority areas rather than the whole city, a point we return to in the limitations. Data were collected in all four sub-districts from 9 to 16 July 2026, after ethical approval had been obtained.

Participants and Sampling

The population consisted of children aged 6 to 59 months and their mothers or primary caregivers. Children were eligible if they lived in the study area, their mother or primary caregiver lived in the same household, the family held a Maternal and Child Health Handbook (Buku KIA) or other growth records, and the caregiver gave written informed consent. Children with a severe congenital anomaly or physical condition that could affect anthropometric measurement, children who were seriously ill on the day of data collection, and caregivers who declined or were absent were excluded. Participants were selected through cluster random sampling, with the study areas serving as clusters, and were recruited at Posyandu sessions with the help of village midwives and cadres.

The study protocol planned 150 caregiver–child pairs, in line with the common recommendation that at least 100 respondents are adequate for instrument validation and

exploratory factor analysis. With the addition of Kampung Dalem, 180 pairs were enrolled (49–51 in each of the three original sub-districts and 30 in Kampung Dalem), all with complete questionnaire and anthropometric data. This number provides 10 respondents per item for the largest dimension (18 items), the minimum ratio commonly recommended for factor analysis (Boateng et al., 2018). All 180 pairs were used for every analysis, so that psychometric testing, index construction, and performance testing refer to the same children.

Instruments and Data Collection

Item generation and content validation. Items were drafted in Indonesian on the basis of the MICG framework (Gonzales Martinez & Haisma, 2025; Haisma et al., 2019), the UNICEF conceptual framework (UNICEF, 2020), and national stunting guidelines (Kemenkes RI, 2022). Feeding items followed the WHO food-group approach to dietary diversity; Child Emotional Wellbeing items were adapted from the Ages and Stages Questionnaires: Social-Emotional (ASQ:SE-2); and Child Development items were adapted from the national developmental pre-screening questionnaire (Kuesioner Pra Skrining Perkembangan, KPSP). The final instrument contained 80 items across six dimensions: Feeding Practices (9 items), Physical Health (15 items: birth history, acute respiratory infection, diarrhea, and chronic illness), Child Emotional Wellbeing (14 items), Child Development (12 items), Parenting and Family Environment (18 items: maternal self-efficacy, decision-making, home stimulation, and a safe home environment), and Health Service Access (12 items: Posyandu attendance, access to Puskesmas, and immunization). Each item was scored 0 (poor/high risk), 1 (moderate risk), or 2 (good/no risk). Three experts, a midwifery expert, a pediatrician, and the head of a family health program, rated each item for relevance on a four-point scale (1 = not relevant to 4 = highly relevant). Ratings of 3 or 4 were coded as relevant. The item-level content validity index (I-CVI) was the proportion of experts rating an item relevant, the scale-level index S-CVI/Ave was the mean of all I-CVIs, and S-CVI/UA was the proportion of items rated relevant by all experts. With three experts, an item is acceptable only when all agree (I-CVI = 1.00) (Polit et al., 2007; Yusoff, 2019). No item received a rating of 1 or 2, so no disagreement had to be resolved and no item was removed. We recognize that a high CVI shows that experts judged the items relevant; it does not by itself establish the overall validity of the instrument.

Administration. Data were collected face to face at Posyandu or other agreed locations. Mothers or primary caregivers completed the MICG on a structured electronic form with the help of the researchers or trained enumerators, who clarified items when needed and completed the items that required interviewer judgment (for example, the number of food groups consumed and congenital or chronic conditions). Completion took about 20–30 minutes per caregiver.

Item validity, construct validity, and reliability. Item validity was examined with Pearson correlations between each item and its dimension total; with n = 180, coefficients above 0.146 are significant at $p < 0.05$. Corrected item–total correlations (CITC), which exclude the item from the total, are also reported, with 0.30 used as the usual benchmark (Streiner et al., 2015). Construct validity was assessed separately for each dimension through exploratory factor analysis (principal component extraction with Varimax rotation). Sampling adequacy was judged with the Kaiser–Meyer–Olkin (KMO) measure, with values of 0.50 or above considered acceptable (Kaiser, 1974), and with Bartlett's test of sphericity; components with eigenvalues above 1 were retained. Internal consistency was assessed with Cronbach's alpha for each

dimension, with 0.70 used as the conventional threshold (Taber, 2018). Items were retained for content coverage even when their statistics were weak, and these items are flagged for revision.

Index construction. For each dimension, the raw score (sum of item scores) was converted to a 0–100 scale by dividing it by the maximum possible score and multiplying by 100. The MICG Index was the unweighted mean of the six dimension scores, so that higher scores indicate better growth conditions and lower risk. Equal weighting was specified in the protocol because there was no prior empirical basis for assigning different weights, because it keeps the index transparent for primary care staff, and because equal weights have proved robust in the international MICG work (Gonzales Martinez & Haisma, 2025). For descriptive purposes only, the index was grouped a priori into conventional percentage bands: Good (≥80), Fair (60–79), Poor (40–59), and Very Poor (<40). These bands were not derived from the outcome and are not proposed as screening cut-offs.

Anthropometric measurement. Recumbent length (children younger than 24 months) was measured with a length board and standing height (older children) with a microtoise, to the nearest 0.1 cm, by the researchers or trained enumerators following WHO and UNICEF recommendations (WHO & UNICEF, 2019). Each child was measured once. Age in months was calculated from the date of birth recorded in the Buku KIA. HAZ was calculated from the WHO Child Growth Standards using the LMS method; an independent recalculation against the official WHO LMS tables reproduced every child's category. For three children, the height recorded at entry was illegible or implausible; the values were re-estimated in line with the growth status recorded at the Posyandu and confirmed by the enumerators, and these children were examined in a sensitivity analysis.

Outcome categories. For analysis, HAZ was grouped into three categories: Normal ($z \geq -1$ SD), At Risk of Stunting (-2 SD $\leq z < -1$ SD), and Stunted ($z < -2$ SD). The Stunted category corresponds to the WHO and national definition of stunting (Kemenkes RI, 2020). The At Risk category is an analytic grouping, not a clinical diagnosis; it was added because linear growth deficits lie on a continuum and children between −2 and −1 SD are a natural target for prevention (Leroy & Frongillo, 2019; Perumal et al., 2018). These categories were not intended to replace the WHO classification. Two binary outcomes were used in the ROC analysis: Definition A (Normal vs. At Risk/Stunted), an exploratory definition that captures any growth deficit, and Definition B (Normal/At Risk vs. Stunted), which follows the WHO stunting cut-off and is therefore the primary definition for interpretation.

Data Analysis

Sample characteristics were summarized with frequencies, percentages, means, and standard deviations. The association between the continuous MICG Index score and the ordinal HAZ category (0 = Normal, 1 = At Risk, 2 = Stunted) was tested with Spearman correlation; correlations with the continuous HAZ z-score were also computed. The association between MICG category and HAZ category was tested with the chi-square test, supplemented by a Monte Carlo exact test (100,000 permutations) because some expected cell counts were below five. Screening performance was assessed with receiver operating characteristic (ROC) analysis. Because lower MICG scores indicate greater risk, the analysis was specified so that a smaller test result indicated a positive outcome. The area under the curve (AUC) is reported with its standard

error and 95% confidence interval and interpreted as follows: 0.50–0.59 very weak, 0.60–0.69 weak, 0.70–0.79 acceptable, 0.80–0.89 good, and ≥0.90 excellent (Mandrekar, 2010; Nahm, 2022). The Youden index was used to locate the cut-off that maximized sensitivity plus specificity; these values are reported to describe performance, not to propose a screening threshold. An ordinal concordance index (C-index) was computed across all three HAZ categories without dichotomization.

Multivariable logistic regression (Enter method) was used to assess the joint contribution of the six dimension scores to HAZ status under Definition A (121 at-risk or stunted vs. 59 normal children). Model fit was examined with the omnibus chi-square test, Nagelkerke R^2, the Hosmer–Lemeshow test, and the classification table; collinearity was examined with variance inflation factors (VIF) and Spearman inter-dimension correlations (Kim, 2019). As a sensitivity analysis, the equal-weighting scheme was compared with expert-based weighting schemes derived through the Analytic Hierarchy Process (AHP) (Saaty, 2008). The research team made pairwise comparisons of the six dimensions on Saaty's 1–9 scale without reference to the study data; weights were derived with the eigenvector method and accepted when the consistency ratio (CR) was below 0.10 (Schmidt et al., 2015). Two versions were produced (Table 3), and each was applied to the same dimension scores to compute an alternative index whose correlation and AUC were compared with those of the equal-weighted index. A further sensitivity analysis repeated the main analyses after excluding the three children with re-estimated heights.

The analytic dataset contained no missing values. All tests were two-sided with a significance level of 0.05. Analyses were performed in IBM SPSS Statistics version 27 and independently cross-checked in Python (SciPy, scikit-learn, and statsmodels), with full agreement on all reported statistics.

Ethical Considerations

Ethical approval was granted by the Health Research Ethics Committee of Universitas STRADA Indonesia (Approval No. 0923400/EC/KEPK/I/07/2026, issued in 2026). Mothers or primary caregivers received a verbal and written explanation of the study and gave written informed consent on behalf of their children before data collection. Each participant was identified only by a code, identity data were stored separately from study data in protected files accessible only to the research team, and no identifiable images were collected. Data collection was paused or stopped if a child or caregiver felt uncomfortable. Caregivers of children identified as stunted or at risk were advised to seek follow-up at the Posyandu or the nearest health facility.

RESULTS

All 180 enrolled caregiver–child pairs had complete data and were included in every analysis. The children were aged 6 to 59 months (mean 32.32 months, SD 14.25); 52.8% were boys and 47.2% girls. Most (76.7%) had been exclusively breastfed, and 8.9% had been born preterm. Their mothers had a mean age of 32.24 years (SD 6.91); 63.3% had completed senior high school, 75.6% were not working outside the home, 65.6% reported a monthly family income of IDR 1–3 million, and 94.4% were enrolled in the national health insurance scheme (JKN/BPJS). The mean HAZ was −1.46 (SD 1.34). By HAZ status, the sample was split almost evenly between Normal (32.8%), At Risk of Stunting (31.7%), and Stunted (35.6%) (Table 1). The mean MICG Index score was 80.16 (SD 8.83; range 48.71–94.22). More than half of the

children (57.8%) fell into the Good category, and no child scored in the Very Poor band. Mean index scores declined slightly from Normal (81.65) through At Risk (80.13) to Stunted children (78.81).

Table 1. Characteristics of children and caregivers, HAZ status, and MICG Index (n = 180)

Variable	Category	n (%) / Mean ± SD
Child age (months)	Mean ± SD	32.32 ± 14.25
Age group	6–11 months	12 (6.7)
	12–23 months	40 (22.2)
	24–35 months	57 (31.7)
	36–47 months	40 (22.2)
	48–59 months	31 (17.2)
Sex	Boys	95 (52.8)
	Girls	85 (47.2)
Exclusive breastfeeding	Yes	138 (76.7)
Preterm birth	Yes	16 (8.9)
Maternal age (years)	Mean ± SD	32.24 ± 6.91
Maternal education	None/primary	18 (10.0)
	Junior high school	29 (16.1)
	Senior high school	114 (63.3)
	Higher education	19 (10.6)
Mother working	Yes	44 (24.4)
Monthly family income	< IDR 1 million	46 (25.6)
	IDR 1–3 million	118 (65.6)
	> IDR 3 million	16 (8.9)
JKN/BPJS membership	Yes	170 (94.4)
HAZ (z-score)	Mean ± SD	−1.46 ± 1.34
HAZ status	Normal (≥ −1 SD)	59 (32.8)
	At Risk (−2 to < −1 SD)	57 (31.7)
	Stunted (< −2 SD)	64 (35.6)
MICG Index score	Mean ± SD	80.16 ± 8.83
MICG category	Good (≥ 80)	104 (57.8)
	Fair (60–79)	69 (38.3)
	Poor (40–59)	7 (3.9)
	Very Poor (< 40)	0 (0.0)

Note. HAZ = height-for-age z-score; JKN/BPJS = national health insurance; MICG = Multidimensional Index of Child Growth; SD = standard deviation. HAZ categories are analytic groupings; only the Stunted category corresponds to the WHO definition of stunting. MICG categories are descriptive percentage bands set a priori and are not screening cut-offs. Percentages may not total 100% because of rounding.

All 80 items were rated relevant by all three experts (I-CVI = 1.00 for every item; S-CVI/Ave = 1.00; S-CVI/UA = 1.00). Item–total correlations ranged from 0.01 to 0.80, and 77 of 80 items were significant. The three exceptions were two care-seeking items in the Physical Health dimension (taking the child to a health worker for respiratory infection or diarrhea; r = 0.01 and 0.03) and one item on age-appropriate toys in the Parenting and Family Environment dimension (r = 0.07). Psychometric performance differed across dimensions (Table 2). KMO values ranged from 0.59 to 0.87, all above the minimum of 0.50, and Bartlett's test was significant for every dimension ($p < 0.001$). Child Development ($\alpha = 0.88$), Child Emotional

Wellbeing (α = 0.83), and Feeding Practices (α = 0.72) reached the conventional reliability threshold. Health Service Access (α = 0.69) and Parenting and Family Environment (α = 0.67) were slightly below it, whereas Physical Health showed clearly inadequate internal consistency (α = 0.35), with 14 of its 15 items below the CITC benchmark of 0.30 and two items correlating negatively with the rest of the scale. Dimensions that combined several distinct sub-indicators (Physical Health, Parenting and Family Environment, and Health Service Access) produced five or six components each, whereas the more homogeneous dimensions produced three.

Table 2. Item validity, construct validity, and reliability of the six MICG dimensions (n = 180)

Dimension	Items	Item–total r	CITC	KMO	Components (% var.)	α
Feeding Practices	9	0.43–0.63	0.29–0.47	0.71	3 (58.9)	0.72
Physical Health	15	0.01–0.52	−0.24–0.30	0.59	6 (69.2)	0.35
Child Emotional Wellbeing	14	0.41–0.68	0.28–0.60	0.84	3 (52.8)	0.83
Child Development	12	0.56–0.80	0.47–0.75	0.87	3 (63.8)	0.88
Parenting and Family Environment	18	0.07–0.57	−0.05–0.45	0.64	6 (61.5)	0.67
Health Service Access	12	0.22–0.62	0.08–0.52	0.62	5 (74.9)	0.69

Note. Item–total r = Pearson correlation of each item with its dimension total (critical value 0.146 at $p < 0.05$); CITC = corrected item–total correlation; KMO = Kaiser–Meyer–Olkin measure of sampling adequacy (acceptable ≥ 0.50); components = principal components with eigenvalue > 1 and cumulative variance explained; α = Cronbach's alpha (acceptable ≥ 0.70). Bartlett's test of sphericity was significant for all dimensions ($p < 0.001$). Content validity: I-CVI = 1.00 for all 80 items; S-CVI/Ave = 1.00; S-CVI/UA = 1.00.

The MICG Index score was not significantly correlated with HAZ category (rho = −0.13; p = 0.084). It did, however, show a weak positive correlation with the continuous HAZ z-score (rho = 0.17; p = 0.027), indicating that higher MICG scores tended to accompany better linear growth. Cross-tabulation of MICG category and HAZ category showed no significant association ($\chi^2 = 4.77$; df = 4; p = 0.311; Monte Carlo p = 0.319). The AUC was 0.57 under both outcome definitions (Definition A: 0.568, 95% CI 0.481–0.655, p = 0.141; Definition B: 0.569, 95% CI 0.481–0.658, p = 0.124), and the upper limits of both confidence intervals fell below the acceptable level of 0.70 (Table 3). At the Youden-optimal cut-off (≤82.21 for Definition A; ≤81.93 for Definition B), sensitivity was 57.9% and 62.5% and specificity 57.6% and 53.4%, respectively. The ordinal C-index across the three HAZ categories was 0.561. At the bivariate level, three dimensions showed weak but significant correlations with HAZ category: Physical Health (rho = −0.16; p = 0.031), Child Emotional Wellbeing (rho = −0.17; p = 0.027), and Health Service Access (rho = −0.16; p = 0.036). No single dimension reached an AUC of 0.70; the highest values were for Health Service Access (0.600) and Physical Health (0.593).

Table 3. Association and screening performance of the MICG Index against HAZ status (n = 180)

Analysis	Value	Interpretation
Spearman, MICG Index vs. HAZ category	rho = −0.13; p = 0.084	Not significant
Spearman, MICG Index vs. continuous HAZ	rho = 0.17; p = 0.027	Weak, significant
Chi-square, MICG category vs. HAZ category	χ^2 = 4.77; df = 4; p = 0.311	Not significant
AUC, Definition A (Normal vs. At Risk/Stunted)	0.568 (SE 0.044; 95% CI 0.481–0.655); p = 0.141	Very weak
AUC, Definition B (Normal/At Risk vs. Stunted)	0.569 (SE 0.045; 95% CI 0.481–0.658); p = 0.124	Very weak
Youden cut-off, Definition A	≤ 82.21; Se 57.9%; Sp 57.6%	Descriptive only
Youden cut-off, Definition B	≤ 81.93; Se 62.5%; Sp 53.4%	Descriptive only
Ordinal C-index (three HAZ categories)	0.561	Very weak
Physical Health vs. HAZ category	rho = −0.16; p = 0.031; AUC 0.593	Weak
Child Emotional Wellbeing vs. HAZ category	rho = −0.17; p = 0.027; AUC 0.553	Weak
Health Service Access vs. HAZ category	rho = −0.16; p = 0.036; AUC 0.600	Weak
AHP weighting v1 (CR = 0.032; weights 18.2/25.6/14.3/16.2/14.3/11.5%)	rho = −0.12; p = 0.096; AUC 0.562	Very weak
AHP weighting v2 (CR = 0.017; weights 10.0/28.1/15.7/17.8/15.7/12.6%)	rho = −0.15; p = 0.045; AUC 0.581	Very weak
Sensitivity analysis excluding three re-estimated heights (n = 177)	rho (continuous HAZ) = 0.15; p = 0.050; AUC A 0.553; AUC B 0.559	Unchanged conclusion

Note. AHP = Analytic Hierarchy Process (weights listed in the order Feeding Practices, Physical Health, Child Emotional Wellbeing, Child Development, Parenting and Family Environment, Health Service Access); AUC = area under the receiver operating characteristic curve (dimension AUCs for Definition A); CI = confidence interval; CR = consistency ratio; HAZ = height-for-age z-score; MICG = Multidimensional Index of Child Growth; Se = sensitivity; Sp = specificity. HAZ category was coded 0 = Normal, 1 = At Risk, 2 = Stunted. ROC analysis was specified so that lower MICG scores indicate a positive outcome.

The multivariable logistic regression model was not statistically significant (χ2 = 10.23; df = 6; p = 0.115; Nagelkerke R2 = 0.08), and none of the dimensions remained significant once all six were entered together (Table 4). Calibration was adequate (Hosmer–Lemeshow χ2 = 3.23; df = 8; p = 0.919), but discrimination was not: the model classified 95.9% of at-risk or stunted children correctly but only 5.1% of normal children, largely by predicting the majority class. VIFs ranged from 1.18 to 2.23, and the strongest inter-dimension correlation was between Child Emotional Wellbeing and Child Development (rho = 0.65). The two AHP weighting schemes (CR = 0.032 and 0.017) gave AUCs of 0.562 and 0.581, almost identical to the equal-weighted

index. Excluding the three children with re-estimated heights weakened the associations slightly (MICG with continuous HAZ: rho = 0.15, p = 0.050; AUC 0.553 for Definition A and 0.559 for Definition B) and did not change any conclusion.

Table 4. Multivariable logistic regression of the six MICG dimensions on at-risk or stunted status (Definition A; n = 180)

Dimension	B	SE	p	OR	95% CI for OR
Feeding Practices	0.014	0.010	0.159	1.014	0.994–1.034
Physical Health	−0.033	0.023	0.146	0.968	0.926–1.012
Child Emotional Wellbeing	0.001	0.017	0.955	1.001	0.968–1.035
Child Development	−0.005	0.012	0.700	0.995	0.971–1.020
Parenting and Family Environment	−0.026	0.023	0.262	0.974	0.931–1.020
Health Service Access	−0.022	0.017	0.189	0.978	0.947–1.011
Constant	6.598	2.528	0.009	—	—

Note. Outcome coded 1 = At Risk or Stunted (n = 121), 0 = Normal (n = 59); predictors are dimension scores on a 0–100 scale. Omnibus $\chi^2 = 10.23$, df = 6, p = 0.115; −2 log likelihood = 217.51; Nagelkerke $R^2 = 0.077$; Hosmer–Lemeshow $\chi^2 = 3.23$, df = 8, p = 0.919; overall classification accuracy 66.1%; VIF 1.18–2.23. B = regression coefficient; OR = odds ratio; SE = standard error; VIF = variance inflation factor.

DISCUSSION

Correlation, cross-tabulation, ROC, and regression analyses all pointed in the same direction: in its current form, the MICG Index cannot separate children who are currently stunted or at risk from children who are growing normally. An AUC of 0.57 is far below what is usually expected of a screening tool and means that the index ranks children only slightly better than chance (Mandrekar, 2010; Nahm, 2022). The confidence intervals are also informative: their upper limit of about 0.66 suggests that, even allowing for sampling error, acceptable performance is unlikely with this version of the index. At its best cut-off, the index would miss roughly four in ten stunted children while referring almost half of those growing normally.

The weak but significant correlation with continuous HAZ deserves attention. It suggests that the index carries some information about linear growth, but that this information is too diffuse to sort children into categories reliably. Several explanations, which are not mutually exclusive, may account for this pattern. First, the MICG and HAZ measure different things. The MICG describes the conditions in which a child is growing now, whereas HAZ reflects the cumulative effect of past exposures; a currently stunted child may live in a household whose feeding and care practices have already improved, and the reverse is also possible. The international MICG was designed to describe wellbeing and opportunity rather than to screen for stunting (Gonzales Martinez & Haisma, 2025; Haisma et al., 2019), so weak agreement with HAZ does not necessarily mean that the concept is flawed. Second, measurement error dilutes associations. The low reliability of the Physical Health dimension ($\alpha = 0.35$) and the borderline reliability of two others would weaken any correlation with HAZ. Third, the index showed limited spread at the lower end: more than half of the children were classified as Good and none as Very Poor, so dimensions with high average scores, such as Child Development and Health Service Access, pulled the composite upward even when linear growth was poor.

The psychometric findings help explain the second point. Physical Health, Parenting and Family Environment, and Health Service Access combine sub-indicators that need not move together; a child may have had a normal birth weight yet frequent diarrhea, or a family may attend Posyandu regularly yet lack transport to the Puskesmas. Such dimensions behave more like formative indices than reflective scales, and Cronbach's alpha, which assumes a single underlying trait, will underestimate their quality (Taber, 2018). The two care-seeking items that correlated negatively with the rest of the Physical Health scale illustrate a scoring problem rather than a content problem: a child who is never ill is never taken to a health worker, so the score for these items depends on illness occurrence as well as on caregiver behavior. These items need to be rescored or reworded.

These findings should not be taken as evidence against the multidimensional idea behind the MICG. Three dimensions, Physical Health, Child Emotional Wellbeing, and Health Service Access, were associated with HAZ status at the bivariate level. Although these correlations were weak, the signal is broadly in line with earlier evidence that non-physical conditions carry information about child growth that anthropometry alone does not provide (Gonzales Martinez et al., 2022; Haisma et al., 2019). The loss of significance in the multivariable model cannot be attributed to severe collinearity, because all VIFs were well below conventional thresholds (Kim, 2019). It more plausibly reflects the small unique contribution of each dimension once the others are taken into account, together with limited statistical power: with 59 normal children and six predictors, the model had few events per predictor in the smaller outcome group. Shared variance between the conceptually close Child Emotional Wellbeing and Child Development dimensions (rho = 0.65) may have contributed, but only modestly.

The equal-weighting scheme gives all six dimensions the same influence, even though their associations with HAZ differed. Replacing equal weights with expert-based AHP weights did not improve performance, which suggests that the problem lies less in how the dimensions are combined than in what they measure and how reliably they measure it. Empirically derived weights may help, but they would need to be estimated in one sample and cross-validated in another, so that any gain in AUC is not simply the result of fitting the index to the data.

Limitations

This study has several limitations. First, its cross-sectional design means that the MICG Index was compared with concurrent HAZ status; we could not assess whether the index predicts future growth faltering, which is arguably the more relevant question for prevention. Second, the same 180 children were used for psychometric testing, index construction, and performance testing, and no independent validation sample was available; the sample also meets only the minimum ratio of respondents per item for factor analysis, so the component structures should be regarded as exploratory and confirmed with confirmatory factor analysis in a larger sample. Third, the four sub-districts were selected purposively as priority areas, so the findings may not apply to areas with lower stunting prevalence or to rural settings. Fourth, several dimensions, especially Physical Health, showed inadequate internal consistency. Fifth, each child was measured only once, and three heights had to be re-estimated; although the sensitivity analysis did not change the conclusions, repeated measurement would have reduced measurement error. Sixth, most items relied on caregiver reports, which may be affected by recall and social

desirability bias. Finally, the At Risk category is an analytic grouping rather than a recognized clinical category, which limits comparison with studies that use only the WHO cut-off.

Implications for Nursing Practice

For midwives, nurses, and cadres working at Posyandu and Puskesmas, the main message is clear: the MICG Index should not replace or supplement routine HAZ-based screening, and a MICG cut-off should not be used as the sole basis for referral, because it would classify children little better than chance. We also propose, as a hypothesis to be tested rather than a demonstrated benefit, that dimension-level scores might help health workers build a holistic growth profile. Low scores on Physical Health or Health Service Access, for instance, could prompt a structured conversation with caregivers alongside routine anthropometric monitoring. Whether this adds value in practice has not been evaluated. Feasibility is a real concern: the 80-item instrument takes about 20–30 minutes per caregiver, requires training for cadres and enumerators, and adds to the burden on caregivers during busy Posyandu sessions. Future research should (1) revise or rescore weak items, particularly the care-seeking items in the Physical Health dimension, and develop a shorter version; (2) derive empirical weights and cross-validate them in an independent sample; (3) follow children prospectively to test whether the index predicts future growth faltering; and (4) evaluate the feasibility, acceptability, and usefulness of the instrument in routine primary care. This agenda is consistent with our research roadmap toward parenting- and caregiver-empowerment interventions for stunting prevention in nursing and midwifery practice.

CONCLUSION

The Indonesian MICG was developed with strong expert-rated content validity, but its psychometric performance varied across dimensions, and the Physical Health dimension requires revision. In its current equal-weighted form, the composite index showed only a weak correlation with continuous HAZ and did not identify children who were concurrently stunted or at risk (AUC = 0.57); it is therefore not suitable as a screening tool, either alone or alongside anthropometry. Its possible role in holistic growth monitoring is a proposal that requires evaluation, and further work should focus on item refinement, cross-validated weighting, and prospective testing.

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AUTHOR CONTRIBUTIONS

Dian Rahmawati: Conceptualization, Methodology, Investigation, Funding acquisition, Supervision, Writing – original draft. Lia Agustin: Formal analysis, Data curation, Validation. Lely Khulafa'ur Rosidah: Project administration (financial management), Writing – review and editing. All authors approved the final manuscript and agree to be accountable for all aspects of the work.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DECLARATION OF AI USE

During data verification and manuscript revision, the authors used Claude (Anthropic) to cross-check statistical calculations in Python, paraphrase text, improve English language and structure, and organize responses to reviewers. The authors reviewed and edited all output and remain fully responsible for the content and integrity of the article.

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