A Predictive Model for Stunting Risk in Infants Aged 6-12 Months: Integrating Health Belief Model Constructs and Complementary Feeding Indicators

Abstract

Stunting in children under five remains a critical public health problem in Indonesia, particularly in rural areas where access to optimal complementary feeding practices and health literacy are limited. The study was conducted in Bone Regency, Indonesia.

Aims: This study aimed to develop and validate a predictive model to identify infants aged 6-12 months at risk of stunting (LAZ<-2) using maternal behavioral determinants and feeding indicators.

Instrument & Methods: A cross-sectional design was used to combine online questionnaire responses from 401 mothers with anthropometric data. The model incorporated constructs from the Health Belief Model (HBM)—including perceived severity, benefits, barriers, self-efficacy, and cues to action—in feeding based on WHO/UNICEF criteria (MDD, MMF, MAD). Structural equation modeling (PLS-SEM) was applied to test direct and indirect pathways to risk classification.

Findings: The study showed that feeding practices were the strongest direct predictor of stunting risk (β=0.537; p<0.001). Mediation analysis confirmed that barriers indirectly increased risk through their negative impact on feeding behavior. The model demonstrated acceptable fit (SRMR=0.061) and explained substantial variance in the primary outcomes (R^2=0.825 for Intention, 0.526 for Feeding Practices, and 0.542 for Risk).

Conclusion: These findings suggest that targeting maternal beliefs and behavioral intentions can increase complementary feeding and reduce the risk of stunting. The intervention focused on reducing perceived barriers, strengthening self-efficacy, and ensuring timely cues to action. Community health centers can play a critical role in operationalizing this strategy at scale.

Keywords

Health Belief Model [https://www.ncbi.nlm.nih.gov/mesh/2052026];
Growth Disorders [https://www.ncbi.nlm.nih.gov/mesh/68006130];
Weaning [https://www.ncbi.nlm.nih.gov/mesh/68014886];
Infant Nutritional Physiological Phenomena [https://www.ncbi.nlm.nih.gov/mesh/68007227];
Risk Assessment [https://www.ncbi.nlm.nih.gov/mesh/68018570]

Introduction

Stunting, defined as length-for-age more than two standard deviations below the WHO growth standard (LAZ<-2), remains a widespread public health challenge. Globally in 2021 [1], an estimated 149 million children under 5 years (over one in five) were stunted. This chronic malnutrition in early life has irreversible consequences, impeding children's physical growth and cognitive development [2]. In Indonesia, despite recent improvements, stunting rates are still high–about 27.7% of under-5 children were stunted in 2019, dropping to 24.4% in 2021 [3]. The burden is particularly pronounced in disadvantaged and rural communities, where children have significantly higher odds of being stunted compared to their urban peers [4]. These figures underscore the urgency of early identification and intervention for at-risk infants, especially in rural settings where access to nutrition and health education may be limited [5].

The first *1000 days* of life (from conception through 2 years) is a critical window for growth. In particular, the period of 6-24 months–when infants transition to complementary feeding–is when most growth faltering occurs [6]. Many infants begin to fall behind between 6 and 12 months of age as they start consuming foods other than breast milk [7]. Inappropriate complementary feeding practices have been identified as a direct risk factor for stunting globally [6]. The World Health Organization's infant and young child feeding (IYCF) indicators highlight the importance of diet diversity and feeding frequency during this stage [8]. Meeting the minimum dietary diversity (MDD) promotes healthy linear growth and helps prevent micronutrient deficiencies in infants [9], while achieving the minimum meal frequency (MMF) ensures adequate energy intake for proper nutrition [9]. A composite of these, the minimum acceptable diet (MAD), reflects overall feeding adequacy. However, in Indonesia, the prevalence of adequate complementary feeding remains alarmingly low–for instance, only around 37.6% of infants 6-23 months receive a minimum acceptable diet [9]. Poor complementary feeding–insufficient quality or quantity of foods–has been directly linked to stunting, with most growth failure happening during the complementary feeding period [6]. These findings point to the need for improving infant feeding practices to combat stunting [10].

Maternal knowledge, beliefs, and behaviors are fundamental determinants of infant feeding practices [11]. According to the Health Belief Model (HBM), a mother's perceptions of her child's susceptibility to health problems and the perceived severity of those outcomes will shape her likelihood of taking preventive action [12]. In the context of stunting, enhancing mothers' understanding of stunting risk and consequences is critical to establish a sense of threat that can motivate behavior change [12]. Yet evidence suggests a significant gap in awareness among caregivers. A survey in rural Indonesia found that only 2.1% of mothers had even heard of the term "stunting", and roughly two-thirds attributed child short stature to purely hereditary factors [12]. Such low awareness and misperceptions mean that many mothers may not perceive the *susceptibility* of their infant to stunting or the *severity* of its long-term impacts. Other HBM constructs are equally important: If mothers do not recognize the *benefits* of recommended feeding (e.g., providing diverse foods), or if they perceive high *barriers* (such as food costs or cultural practices), they may not adopt optimal feeding behaviors [13]. Self-efficacy (confidence in their ability to feed the child adequately) and cues to action (reminders or advice from health workers, family, etc.) also influence whether proper feeding practices are followed. In line with HBM principles, interventions that target these belief factors have shown promise [14]. For example, an educational program in Iran that taught mothers using HBM constructs led to significantly improved complementary feeding behavior and better growth outcomes in infants [7]. This demonstrates that addressing maternal perceptions and skills can translate into tangible nutritional benefits for children, reinforcing the importance of maternal behavior in stunting prevention [13].

Despite the clear relevance of maternal behavioral factors, most stunting risk assessments and prediction tools to date have focused on biomedical and socioeconomic variables (such as child illness, birthweight, parental height, or income) [15]. Far less attention has been given to mothers' cognitive and behavioral determinants. In fact, prior studies in Indonesia have noted limitations in that they *"were not able to investigate all potential risk factors, such as ... health knowledge, due to insufficient data"* [4]. This represents a critical *research gap*: We lack predictive models that integrate maternal psychological factors–like health beliefs and feeding intentions–alongside feeding practice indicators to identify infants at risk of stunted growth. Early identification is key, as it would enable targeted nutritional counseling or interventions before severe stunting manifests [16]. By incorporating modifiable behavioral factors, such a model could also highlight intervention points (for example, improving a mother's risk perception or self-efficacy) to prevent stunting [17].

Study aims and objectives: In light of the above, the present research was undertaken to develop and evaluate a predictive model for identifying infants aged 6-12 months at risk of stunting (LAZ<–2) using maternal behavioral variables. The model leverages mothers' HBM construct scores (including perceived susceptibility, severity, benefits, barriers, self-efficacy, and cues to action), their complementary feeding intention levels, and their actual complementary feeding practices (MDD, MMF, and MAD) [18]. The specific objectives of the study were:

1. To characterize the current maternal beliefs and feeding practices in the target population, describing the distribution of HBM construct scores and complementary feeding practice indicators among mothers of 6-12 month-old infants.
2. To assess the reliability and validity of the HBM-based measurement tool used for evaluating maternal perceptions and intentions, ensuring that these psychosocial variables are measured consistently.
3. To develop evidence-based recommendations for community-level interventions, suggesting how health providers at local clinics (community health centers) can operationalize findings–for example, by addressing identified perception gaps or reinforcing beneficial feeding practices–in order to reduce stunting risk among infants [19].

Through achieving these objectives, this study addresses the narrative gap by linking maternal behavioral factors with infant nutritional outcomes. Ultimately, the goal is to inform more holistic stunting prevention strategies that empower mothers in rural community settings to take effective actions during the critical early months of their children's lives [20].

Instrument and Methods

Study design and overview

This study was an analytical cross-sectional investigation using a hybrid data-collection strategy: An online questionnaire to capture behavioral and sociodemographic variables, and secondary extraction of anthropometric records from primary-health facility (puskesmas) databases to obtain objective measures of child growth. The primary aim was to develop and internally validate a predictive model for stunting-related risk among infants aged 6.0-12.0 months based on Health Belief Model (HBM) constructs and complementary-feeding practices (MP-ASI) consistent with WHO/UNICEF/IDAI guidance.

Study setting and population

Data collection targeted all public primary health centers (puskesmas) in Kabupaten Bone. The analytic unit was the mother–infant dyad. Eligible infants were aged between 6.0 and 12.0 months at the time of the mother's questionnaire response. Mothers (or legal guardians) had to be able to provide informed consent and to authorize matching to puskesmas anthropometry using a unique respondent code. Infants with chronic medical conditions documented in puskesmas medical records that affect growth (for example, congenital malformations, chronic infections or endocrine disorders) were excluded.

Sample size and justification

A target sample size of N=401 mother-infant dyads was prespecified. This sample was chosen to provide sufficient outcome events (expected combined prevalence of moderate+severe stunting=23-25% based on pilot data) to permit stable estimation of multivariable predictive models and internal validation by bootstrapping and cross-validation procedures. The size also supports structural equation modeling (PLS-SEM) for testing the HBM → Intention → Feeding Practice → Risk pathway while maintaining adequate indicator-to-sample ratios after pruning low-loading items.

Sampling strategy and recruitment

A quota sampling approach was applied to achieve broad geographic coverage and to distribute recruitment proportionally across puskesmas. Each puskesmas/posyandu was allocated a target number of respondents proportional to the estimated number of 6-12-month infants in its catchment. Recruitment proceeded in two coordinated steps: The research team briefed district midwife coordinators and obtained their cooperation to disseminate study information and the online survey link via WhatsApp groups of posyandu mothers in each puskesmas area. Mothers who opened the Google Form completed the online informed-consent process and the behavioral/demographic instrument. Each consenting respondent received a unique alphanumeric code generated by the form. Mothers who agreed to anthropometry matching were asked to provide that code to their puskesmas midwife (or upload a photo of the code screen) so puskesmas staff could map the code to medical records and extract the required de-identified anthropometry.

This procedure prioritized respondent confidentiality while enabling secure matching to facility records.

Inclusion criteria was infant age 6.0-12.0 months at the time of survey response; Mother/legal guardian provided informed consent and agreed to record matching; Availability of a puskesmas anthropometric measurement within 4 weeks of the survey response (or the nearest routine visit). We excluded infants with documented chronic medical conditions likely to alter growth trajectories; Missing or non-matchable unique code; Mother/guardian refusal to allow access to puskesmas data.

Instruments and measures

The Google Form included four modules; Sociodemographics (maternal age, education, household income, parity, and other covariates. Covariates: Maternal age (years), education (ordinal categories), household income category, parity, child sex, and breastfeeding status (Never/Exclusive/Prolonged) were included as control variables. HBM constructs (multi-item scales for perceived barriers, perceived benefits, perceived severity, self-efficacy, and cues to action). Each construct comprised six items Likert scale that underwent content validation prior to deployment. Intentions consist of a 3-item reflective scale measuring the mothers stated intention to adopt recommended complementary-feeding behaviours. HBM constructs: Computed as mean scores of retained items for each construct (after confirming internal consistency). Higher scores indicate a greater degree of the construct. Complementary Feeding module consists of a 24-hour dietary recall and feeding frequency module operationalized to compute standard indicators: Minimum Dietary Diversity (MDD), Minimum Meal Frequency (MMF), and Minimum Acceptable Diet (MAD) according to WHO/UNICEF/IDAI criteria. Feeding practice indicators: MDD, MMF, and MAD computed per WHO/UNICEF/IDAI algorithms; A composite Feeding Practice latent score/higher-order formative variable was constructed for SEM, and component indicators used for predictive modeling. All questionnaire items were presented in Indonesian and implemented with forced-response (required) and input validation (format checks) where appropriate to reduce missingness and input errors.

Anthropometry (secondary data)

Anthropometric variables were extracted from puskesmas medical records: Date of measurement, infant age (date of birth), sex, recumbent length (cm), and weight (kg). The research team requested the measurement recorded closest in time to the mother's questionnaire response, ideally within a 4-week window preceding the response. Where multiple recent measurements existed, the most proximate date was selected. The research team required puskesmas to follow standard measurement protocols (recumbent length for <24 months using an infantometer, calibrated scales) and to document measurement dates. Anthropometry was converted to WHO length-for-age z-scores (LAZ) using the LMS method (L, M, S parameters) and WHO growth references. Standard WHO plausibility flags were applied and implausible z-scores were queried with the originating puskesmas; Suspect measurements could be excluded following verification. Outcome (Risk): Derived from LAZ and classified into categories (Healthy, Moderate stunting: LAZ <-2 to ≥-3, Severe stunting: LAZ <-3) consistent with WHO thresholds. For predictive modeling, a binary risk variable (at-risk vs healthy) and a multinomial specification were considered.

Statistical analysis

All analyses were performed using standard statistical software (e.g., Stata/R for descriptive and regression analyses; SmartPLS or similar for PLS-SEM). Statistical significance was assessed at $\alpha=0.05$ (two-sided). All model coefficients (standardized where appropriate), bootstrap standard errors and 95% confidence intervals, R^2, f^2, SRMR, and predictive metrics (AUC, calibration) will be reported. Supplemental materials include indicator-level loadings, deleted items, and full bootstrap tables.

Ethical approval for this study was obtained from the Health Research Ethics Committee, Institute Nani Hasanuddin (Recommendation No. 285/STIKES-NH/KEPK/X/2025). All participating mothers provided informed consent (including permission to match facility anthropometry via a unique code), and access to puskesmas records was governed by a Data-Use Agreement with de-identification procedures in place to protect participant privacy.

Findings

The study sample consisted of 401 mother-infant dyads from Kabupaten Bone. Descriptive statistics for key sociodemographic and child-health variables are summarized in Table X, including child sex, stunting-risk classification (based on LAZ), maternal education, household income category, parity, and breastfeeding status. Participant recruitment combined an online questionnaire distributed via local midwife networks (IKATAN BIDAN INDONESIA) and secondary anthropometric records obtained from puskesmas visits; Anthropometric classification followed WHO criteria for length-for-age z-scores. The table below therefore provides the baseline context for subsequent multivariable and SEM analyses.

Table 1. Subject characteristics (n=401)

Variable	Category	Frequency (%)
Sex	F	200 (49.9)
	M	201 (50.1)
Risk classification	Severe	54 (13.5)
	Moderate	41 (10.2)
	Healthy	306 (76.3)
Education	Basic	53 (13.2)
	Middle	70 (17.5)
	Higer	119 (29.7)
	Academy	80 (20.0)
	Bachelor	79 (19.7)
Income cat	>2-5 million	253 (63.1)
	>5-8 million	84 (20.9)
	>8 million	64 (16.0)
Parity	1	140 (34.9)
	2	149 (37.2)
	3	71 (17.7)
	4	31 (7.7)
	5	10 (2.5)
Breastfeeding status	Never breastfeed	77 (19.2)
	Exclusive breastfeed	27 (6.7)
	Prolonged breastfeed	297 (74.1)

The analytic sample includes 401 infants aged 6.0-12.0 months (mean 9.05±1.75 months). Average recumbent length was 69.29±4.27 cm (range 57.2-79.5), and average weight was 8.32±0.72 kg (range 6.36-10.12). Mothers' ages ranged from 18 to 40 years (mean 27.41±4.54). Relative variability is modest for anthropometry (length CV≈6.2%; Weight CV≈8.6%) and larger for age variables, reflecting the restricted infant age window and a fairly homogeneous anthropometric distribution.

Table 2. Descriptive statistics for key continuous variables (n=401)

Variable	N	Minimum	Maximum	Mean±Std. Deviation	Coefficient of variation (%)
Age (months)	401	6.0	12.0	9.05±1.75	19.3
Length (cm)	401	57.2	79.5	69.29±4.27	6.2
Weight (kg)	401	6.36	10.12	8.32±0.72	8.6
Maternal age (years)	401	18	40	27.41±4.54	16.6

The analytic sample comprised 401 observations with complete data on age, anthropometry, and maternal age. Infants were between 6.0 and 12.0 months old (mean 9.05±1.75 months). Mean recumbent length was 69.29±4.27 cm (range 57.2-79.5 cm) and mean weight was 8.32±0.72 kg (range 6.36-10.12 kg). Maternal ages ranged from 18 to 40 years (mean 27.41±4.54 years). Relative variability was modest for anthropometric measures (CV≈6-9%), while infant age and maternal age showed greater relative spread (CV≈16-19%). These summary statistics provide the baseline distribution for subsequent z-score computation and multivariable analyses; Anthropometric values will be standardized to WHO growth references (length/height-for-age z-scores) for stunting classification and used as the outcome in structural models.

Measurement model

All reflective indicators with outer loading <0.70 were removed prior to final estimation. After item pruning, retained reflective constructs showed acceptable internal consistency and convergent validity. The summary below lists construct reliability statistics and AVE; Detailed indicator-level loadings are provided in supplementary Table S1 (or in Table1_MeasurementModel.xlsx).

Table 3. Measurement model—construct reliability and convergent validity (summary)

Construct	Cronbach's α	Composite reliability (CR)	AVE
Barriers	0.873	0.904	0.612
Benefits	0.784	0.853	0.537
Cues to action	0.871	0.903	0.608

Self-efficacy	0.882	0.911	0.629
Intentions	0.853	0.911	0.773
Severity	0.691	0.829	0.618
Breastfeeding state (single item)	—	1.000	1.000
Family income (single item)	—	1.000	1.000
Feeding practice (formative/higher-order)	—	1.000	1.000
Mother's age (single item)	—	1.000	1.000
Mother's education (single item)	—	1.000	1.000
Parity (single item)	—	1.000	1.000
Risk (outcome; single item/classification)	—	1.000	1.000

Notes: Single-item constructs appear with CR=1.00/AVE=1.00 because they are represented by a single indicator. Full indicator-level outer loadings and deleted items (pre-pruning) are available in Supplementary Table S1.

Structural model (direct effects)

Model inference uses bootstrap-based standard errors from your bootstrap output. Endogenous construct explained variances are: R^2(Intention)=0.825, R^2(Feeding Practice)=0.526, R^2(Risk)=0.542. SRMR (estimated model)=0.061.

Table 4. Selected direct effects (standardized coefficients, bootstrap SE, t, p, 95% CI)

Path	β (standardized)	SE	t	p	95% CI
Barriers → Intentions	−0.342	0.054	6.281	<0.001	−0.448 to −0.236
Barriers → Feeding practice	−0.194	0.083	2.320	0.020	−0.357 to −0.031
Self-efficacy → Intentions	0.241	0.053	4.577	<0.001	0.137 to 0.345
Cues to action → Intentions	0.232	0.054	4.270	<0.001	0.126 to 0.338
Benefits → Intentions	0.099	0.041	2.407	0.016	0.019 to 0.179
Intentions → Feeding practice	0.134	0.081	1.652	0.099	−0.025 to 0.293
Severity → Feeding practice	0.093	0.059	1.577	0.115	−0.023 to 0.209
Self-efficacy → Feeding practice	0.128	0.087	1.471	0.141	−0.043 to 0.299
Feeding practice → Risk	0.537	0.036	14.981	<0.001	0.466 to 0.608
Mother's education → Risk	0.128	0.035	3.654	<0.001	0.059 to 0.197
Parity → Risk	−0.150	0.035	4.298	<0.001	−0.219 to −0.081
Mother's age → Risk	0.137	0.033	4.081	<0.001	0.072 to 0.202

Notes: The path coefficients are standardized estimates from the PLS algorithm and their inference is based on bootstrap SE and bootstrap-derived t statistics (see Methods for bootstrap procedure). Bolded rows denote highly significant and substantively large effects.

Mediation/indirect effects

We evaluated indirect effects that represent the theoretical chain HBM → Intentions → Feeding Practice → Risk.

Table 5. Selected indirect effects (bootstrap estimates)

Indirect path	Indirect β	SE	t	p	95% CI
Barriers → Feeding practice → Risk	−0.104	0.046	2.254	0.024	−0.194 to −0.014

Notes: Additional indirect paths (e.g., Intentions → Feeding practice → Risk; Self-efficacy → Feeding practice → Risk) are reported in Supplementary Table S2. The Barriers → Feeding practice → Risk indirect effect indicates that perceived barriers reduce appropriate feeding practices and, through that mechanism, worsen the stunting-related risk outcome.

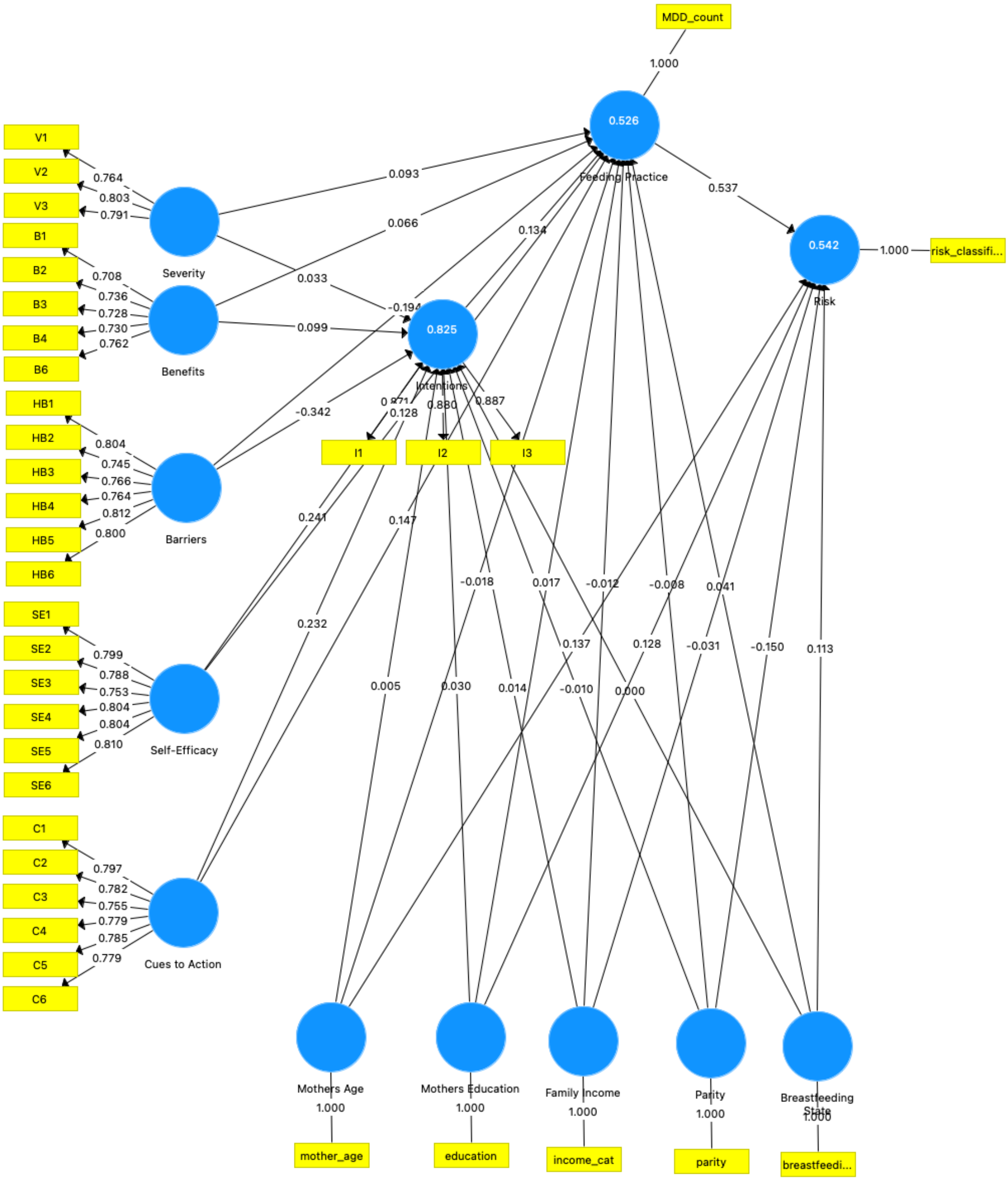

Figure 1. Fit model

After removal of indicators with outer loadings below 0.70, all retained reflective indicators exhibited adequate reliability and convergent validity. Composite reliability values ranged from 0.829 to 0.911, and most constructs had AVE>0.50, supporting convergent validity (Table 3). The final structural model (Figure 1) explained substantial proportions of variance in the endogenous constructs: R^2 for Intention=0.825, Feeding practice=0.526, and Risk=0.542. Perceived barriers had a large and statistically significant negative effect on mothers' intentions to implement recommended feeding practices (β=−0.342; SE=0.054; t=6.281; p<0.001) and directly reduced appropriate feeding practice (β=−0.194; p=0.020). Conversely, self-efficacy (ß=0.241; SE=0.053; t=4.577; p<0.001), cues to action (β=0.232; SE=0.054; t=4.270; p<0.001), and perceived benefits (β=0.099; p=0.016) were significant positive predictors of mothers' intention. Intention was positively associated with feeding practice, though this effect was marginal (β=0.134; p≈0.10). Most importantly, Feeding Practice—operationalized based on dietary diversity (MDD), meal frequency

(MMF), and MAD criteria—was a strong predictor of the risk outcome (β=0.537; SE=0.036; t=14.981; p<0.001), indicating a substantive relationship between feeding behaviors and stunting-related risk.
Mediation. The mediation analysis indicates that perceived barriers influence Risk indirectly through their adverse effects on feeding practices. Specifically, the indirect effect Barriers → Feeding Practice → Risk was statistically significant (indirect β=−0.104; SE=0.046; t=2.254; p=0.024), consistent with a pathway where structural/practical constraints reduce appropriate complementary-feeding behaviors that are directly linked to stunting risk.
Model fit and predictive relevance. The model's SRMR (estimated) was 0.061, indicating acceptable overall fit for the PLS model. Blindfolding-based predictive relevance (Q^2) and additional predictive checks are reported in Supplementary materials; In-sample explanatory power is substantial as indicated by R^2 values above.
Sociodemographic controls explained additional variance in Risk: Higher maternal education and older maternal age were associated with lower risk (education β=0.128; p<0.001; mothers' age β=0.137; p<0.001), while parity was inversely associated with risk (β=−0.150; p<0.001; See Table 2 for coefficients and bootstrap statistics).

Discussion

Our findings highlight that perceived barriers have a significant negative impact on maternal intention to practice optimal complementary feeding, and they directly diminish the quality of feeding practices. In rural Indonesian contexts, mothers often face substantial obstacles–from time constraints due to heavy workloads to economic hardship–that hinder their ability to feed young children appropriately [21]. These barriers can erode a mother's confidence or willingness to plan for diverse, frequent complementary feeding, explaining the lower intentions observed. Consistent with our results, qualitative studies in low-resource settings report that excessive household chores, farm work, and poverty frequently limit mothers' capacity to provide recommended meals [21]. In Ethiopia, for example, many rural mothers cited *lack of time* and *financial constraints* as key barriers to preparing nutritious complementary foods [21]. Similarly, an analysis of suboptimal feeding in South Asia found that poverty and food insecurity were primary causes of inadequate complementary feeding practices [22]. Taken together, these findings underscore that perceived barriers–whether due to economic limitations, cultural misconceptions, or practical constraints–can substantially deter mothers from intending and executing optimal feeding. Interventions should therefore prioritize barrier reduction: For instance, improving food affordability and availability, offering time-saving food preparation strategies, and enlisting family support to alleviate the childcare burden. By addressing these barriers, programs can empower mothers to act on their feeding intentions.
Beyond perceived barriers, maternal self-efficacy and cues to action also emerged as important enablers of positive feeding intentions in our SEM model. Mothers with higher self-efficacy–i.e., confidence in their ability to overcome challenges and feed their child well–showed significantly stronger intentions to practice optimal complementary feeding. This result aligns with health behavior theory and prior research. A study in Bali, Indonesia found that mothers with high self-efficacy were far more likely to engage in stunting prevention behaviors and meet nutritional recommendations for their toddlers [23]. Indeed, across diverse LMIC contexts, low maternal self-efficacy has been implicated as a cause of suboptimal infant feeding, whereas empowering mothers with knowledge and skills can improve feeding practices [22]. Our findings reinforce that building mothers' confidence–through nutrition education, skill-building, and supportive counseling–is crucial for motivating intentional behavior change.
Cues to action also played a significant role in increasing mothers' intention. In the Health Belief Model framework, "cues to action" are triggers or reminders that prompt individuals to adopt a healthy behavior. In our context, mothers who reported more frequent cues (such as reminders from healthcare workers, family encouragement, or exposure to stunting prevention messages) were more inclined to intend optimal feeding. This observation is supported by behavior change studies in Indonesia: For example, hearing nutrition and stunting information via local media (radio or TV) has been noted to serve as an effective cue that spurs mothers to improve their child feeding practices [17]. A community-based HBM intervention in eastern Indonesia similarly reported that caregivers with high exposure to cues took more preventive actions against stunting (77 out of 80 such mothers engaged in prevention efforts) [24]. These cues to action likely work by keeping child nutrition salient and resolving uncertainties–effectively bridging the gap between knowledge and practice. Therefore, strengthening cues to action should be part of stunting prevention strategies. This could include

regular community nutrition messaging, growth monitoring sessions that actively engage mothers, and family or peer support groups, all of which can continually nudge mothers toward the intended feeding behaviors. Importantly, our results suggest that even when underlying knowledge is present, timely cues and bolstered self-efficacy are critical for translating that knowledge into committed intention.

Nevertheless, our findings further revealed a discrepancy between maternal intention and actual feeding behavior, as intention to practice optimal complementary feeding demonstrated only a marginal influence on actual feeding practices. In other words, even mothers who intended to follow recommended feeding guidelines did not always translate that intention into consistent action. This finding points to the well-known "intention–behavior gap" in public health [25]. As noted in recent behavioral research, having the intention to perform a health behavior is a necessary first step but often not sufficient; Many individuals with high intentions still fail to carry out the behavior due to intervening obstacles or lack of support [25]. In the context of infant feeding, our study suggests that mothers' good intentions can be easily derailed by day-to-day challenges–such as a sick child, competing household demands, or unavailability of diverse foods–which may explain the weak direct pathway from intention to practice. Other studies have similarly reported that positive infant feeding intentions do not guarantee proper feeding in practice when mothers face resource constraints or strong cultural pressures against certain foods [21]. Bridging this intention-behavior gap will require that programs not only foster intention (through knowledge and motivation) but also create enabling environments for action. This means reducing practical barriers (as discussed above) and providing follow-up support. For instance, hands-on cooking demonstrations, home visits, or mobile health reminders could help mothers translate feeding plans into daily routines. Additionally, involving other family members (husbands, grandparents) may reinforce the mother's intention and help sustain the behavior when her resolve falters. Our finding of a marginal intention-to-behavior link underscores that intention, while important, must be bolstered by supportive conditions and skills to yield actual behavior change [25].

This behavioral gap may have broader implications, as our results further suggest that the quality of complementary feeding practices is a strong predictor of stunting-related risk. Mothers who provided more optimal complementary feeding–likely meaning timely introduction of solids, adequate meal frequency, and diverse, nutrient-rich diets–had children with markedly lower risk of stunting or growth faltering. This finding corroborates a large body of evidence across LMICs linking poor complementary feeding to chronic undernutrition [21, 26]. Undernutrition and stunting prevalence tend to spike in infancy around 6-24 months of age, a period when breast milk alone no longer meets nutritional needs, and deficiencies emerge if complementary feeding is inadequate [21]. A study in Malawi, for example, demonstrated that children who received appropriate complementary feeding (meeting minimum diet diversity and frequency) had significantly lower odds of being stunted, even after controlling for confounders [26]. In our region of rural Indonesia, where stunting rates remain troublingly high, suboptimal feeding practices are a recognized contributor to this problem [26, 27]. Recent meta-analyses have quantified this impact: Infrequent or insufficient complementary feeding can increase a child's risk of stunting by nearly two-fold [28]. Thus, the strong feeding-to-stunting pathway in our SEM aligns with both biological plausibility and epidemiologic data–inadequate dietary intake in early life leads to cumulative growth deficits and higher stunting risk. This underscores that improving complementary feeding practices is one of the most direct leverage points for stunting prevention [29]. Public health efforts should intensify focus on promoting timely, diverse, and frequent feeding for infants and toddlers. Culturally tailored nutrition counseling and community programs (e.g., cooking classes using local foods) can help caregivers provide an adequate diet even in resource-poor settings. Moreover, policy measures addressing poverty and food security will complement behavior change efforts, ensuring families have the means to put feeding recommendations into practice. Our findings give empirical weight to the idea that preventing stunting in rural Indonesia will require closing the gap between what children should eat and what they do eat on a daily basis [26].

Study limitations

This study was cross-sectional, which limits causal interpretation of the associations. We measured predictors (e.g., barriers, self-efficacy) and outcomes (feeding practices, stunting risk) at the same time. Thus, while the SEM is theoretically grounded, we cannot definitively establish temporal order or causality. Longitudinal studies would strengthen confidence that, for example, higher self-efficacy leads to better feeding (and not vice versa). The data on maternal psychosocial factors and feeding practices relied on self-reported responses, which are subject to recall bias and social desirability bias. Mothers may have over-reported "optimal" feeding behaviors or intentions due to awareness of health recommendations. Such biases could attenuate or inflate certain relationships in the model. Future research could incorporate more objective measures of feeding. Our assessment of stunting-related risk likely used child anthropometric measurements that may have been drawn from secondary sources or routine health records. The accuracy and consistency of these measurements (e.g., timing, equipment, technique) could not be fully controlled. Any measurement error in child height/length could affect the precision of the stunting outcome. Additionally, we used a derived "stunting risk" variable; If this was a proxy (like a risk score or probability), its construction may carry its own assumptions and limitations. The study was conducted in a specific rural Indonesian setting, which may limit generalizability. Cultural practices, food availability, and health services vary across regions. Our participants also had a high rate of certain characteristics (e.g., a certain education or socioeconomic profile), which might not represent all rural Indonesian mothers. Caution is needed in extending conclusions to vastly different contexts without further validation.

Conclusion

This study underscores the importance of maternal behavioral factors in stunting prevention. Perceived barriers significantly reduced mothers' intention and ability to practice optimal complementary feeding, while self-efficacy and cues to action strengthened feeding intentions. However, intention alone was not always translated into practice, highlighting the need for supportive environments. Feeding practice was a strong predictor of stunting risk, reinforcing the value of improving infant diets during the 6-12-month window. To reduce stunting in rural settings, interventions should focus on empowering mothers through practical nutrition education, strengthening self-efficacy, reducing feeding barriers, and providing regular cues to action. Community health centers can play a key role by integrating these strategies into maternal-child health services, alongside broader efforts to improve food access and family support.