

Strategic Management for Stunting Prevention and Reduction

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ABSTRACT

Stunting remains a major public health challenge in Central Sulawesi, where the prevalence reaches 27.2%, exceeding the national average of 24.2%. Sigi District is among the highest-burdened areas, with a prevalence of 24.6%, and Dolo Subdistrict reported 22.34% stunting among 976 children under five in 2024. Priority loci include Wisolo, Poi, and Waturalele Villages, where inadequate maternal knowledge, inappropriate parenting practices, and poor sanitation continue to hinder progress toward the regional target of reducing stunting to 14.2% by 2029. The objective of this study was to analyze the underlying determinants of stunting and formulate improvement strategies using a SWOT-based strategic management approach. A qualitative design was applied through environmental scanning, strategy formulation, implementation, and evaluation using IFE, EFE, IE, and SWOT matrices. Informants included the head of the community health center, stunting program managers, village midwives, and the Stunting Reduction Acceleration Team. Data analysis followed the four stages of strategic management supported by the aforementioned matrices. The results showed that the primary contributing factors were limited nutritional knowledge, suboptimal caregiving practices, and inadequate sanitation access. Existing strategies such as the “Sejuta Telur” program, “Tangguh Bersinar,” and specific and sensitive nutrition interventions were identified as ongoing efforts. SWOT analysis positioned the organization to strengthen data-driven planning, optimize resource allocation, and enhance convergence across 14 local government agencies. Improved coordination and real-time data utilization were found essential to overcoming field-level barriers. In conclusion, optimizing strategic management through cross-sector program integration and strengthened community education is critical for accelerating stunting reduction and achieving regional targets.

Keywords: strategic management; stunting; SWOT analysis

INTRODUCTION

Stunting represents one of the most critical global threats to human resource quality, long-term economic productivity, and national competitiveness. As a chronic condition resulting from prolonged undernutrition, recurrent infections, and inadequate caregiving practices, stunting has far-reaching consequences for cognitive development, school performance, and adult earning potential. The World Health Organization (WHO) reported that in 2024, approximately 150 million children under five worldwide were affected by stunting, reflecting the persistent burden of malnutrition across low- and middle-income countries [1]. This global figure underscores the urgency of strengthening multisectoral interventions, as stunting is not merely a health issue but a developmental challenge that shapes the future trajectory of nations.

In Indonesia, stunting remains a major public health concern. National data in 2023 showed a prevalence of 21.5%, positioning Indonesia as the country with the second-highest stunting burden in the ASEAN region after Timor Leste [2]. Recognizing the severity of this issue, the Government of Indonesia has established an ambitious target to reduce stunting prevalence to 14.2% by 2029, as mandated in Presidential Regulation No. 72 of 2021 on the Acceleration of Stunting Reduction [3]. This target reflects a national commitment to improving child health outcomes through integrated interventions involving nutrition, sanitation, education, and social protection. However, achieving this target requires substantial improvements in program implementation, coordination, and monitoring at the regional and local levels.

The situation in Central Sulawesi illustrates the complexity of regional disparities in stunting reduction efforts. In 2023, the province recorded a stunting prevalence of 27.2%, significantly higher than the national average of 24.2% [3]. Sigi District is one of the major contributors to this burden, with a prevalence of 24.6% [3]. More specifically, data from the Dolo Community Health Center (Puskesmas Dolo) in 2024 revealed that Dolo Subdistrict is among the highest-burdened areas in Sigi, with a prevalence of 22.34%—equivalent to 218 stunted children out of 976 measured under-five children [4]. Villages such as Wisolo, Poi, and Waturalele have been identified as priority loci due to their disproportionately high number of stunting cases, indicating persistent structural and behavioral challenges that require targeted interventions.

Although stunting reduction has been designated as a priority program in Sigi District, preliminary observations indicate that the effectiveness of ongoing interventions remains suboptimal. Since 2022, the district government has launched several innovative initiatives, including the “Sejuta Telur” program mandated by District Regulation No. 56/2022 [5], the “Tangguh Bersinar” nutritious food assistance program, family mentoring through the Stunting Reduction Acceleration Team (TPPS), and the provision of locally sourced supplementary feeding (PMT). Despite these efforts, the expected decline in stunting prevalence has not been achieved. The limited impact of these interventions suggests underlying issues related to program management, coordination across sectors, resource allocation, and monitoring mechanisms. These challenges highlight the need for a structured evaluation to identify gaps and formulate more effective strategies.

The urgency of this study is driven by the widening gap between policy targets and actual achievements. While the national target aims for a reduction to 14.2% by 2029, Dolo Subdistrict continues to struggle with a prevalence of 22.34%, with priority villages showing persistent high case numbers [3]. Without a comprehensive evaluation of existing programs and coordination mechanisms, this gap is unlikely to be closed within the remaining timeframe. The challenge is further compounded by the complexity of multisectoral coordination involving 14 local government agencies (Organisasi Perangkat Daerah, OPD) under the TPPS framework. Stunting reduction requires integrated efforts across health, sanitation, food security, education, social welfare, and community empowerment sectors. Cultural perceptions that normalize short stature, limited maternal knowledge, inadequate caregiving practices, and poor sanitation further complicate intervention efforts. Therefore, a strategic management approach using SWOT analysis is essential to integrate fragmented efforts into a coherent, evidence-based strategy capable of producing measurable outcomes for the Dolo community.

Previous studies provide important insights into the determinants of stunting. Nirmalasari identified inadequate dietary intake, infectious diseases, poor caregiving practices, and suboptimal sanitation as direct contributors to stunting [6]. Essa further highlighted high poverty levels, poor environmental sanitation, and weak adaptive capacity as structural drivers of stunting prevalence [7]. However, these studies primarily focus on clinical or nutritional determinants. The present study differs by examining stunting through the lens of strategic management, employing

analytical tools such as the Internal Factor Evaluation (IFE), External Factor Evaluation (EFE), Internal-External (IE) matrix, and SWOT analysis. Guided by the strategic management framework of Hunger and Wheelen [8], this study systematically evaluates environmental scanning, strategy formulation, implementation, and evaluation to map strengths, weaknesses, opportunities, and threats across multisectoral coordination involving 14 OPDs in Dolo Subdistrict. This approach enables the formulation of more practical, context-specific, and data-driven strategies for improving stunting reduction efforts. The objective of this study is to analyze the underlying factors contributing to stunting and to formulate improved stunting reduction strategies using SWOT analysis within a strategic management framework.

METHODS

This study employed a qualitative research design using a strategic management approach, selected to allow an in-depth exploration of managerial processes underlying stunting prevention and reduction efforts. Unlike clinical or epidemiological studies that focus primarily on anthropometric indicators, this research emphasized the managerial dimensions of program implementation, coordination, and evaluation. The strategic management framework used in this study consisted of four core stages; environmental scanning, strategy formulation, strategy implementation, and evaluation and control which served as the primary analytical variables and observational focus throughout the research process.

The study was conducted in Dolo Subdistrict, Sigi Regency, Central Sulawesi Province, an area identified as having one of the highest stunting burdens in the region. Data collection took place from January to April 2024, coinciding with the annual reporting cycle of local stunting programs. The selection of Dolo Subdistrict was based on its high stunting prevalence of 22.34%, with priority loci concentrated in Wisolo, Poi, and Waturalele Villages. These villages were chosen due to their persistent stunting cases and the strategic importance of understanding managerial challenges in high-burden settings.

The subjects of this study consisted of key stakeholders involved in stunting reduction efforts. Informants were selected using purposive sampling to ensure that only individuals with direct roles, responsibilities, and knowledge relevant to stunting management were included. The informants comprised the Head of Dolo Community Health Center (*Puskesmas*), program managers responsible for nutrition and stunting interventions, village midwives assigned to priority loci, and representatives of the Stunting Reduction Acceleration Team (TPPS) at the subdistrict level. These informants were considered essential sources of information because they are directly involved in planning, coordinating, and evaluating stunting reduction activities across sectors.

Data collection was conducted using triangulation techniques to enhance validity and reliability. First, in-depth interviews were carried out to obtain detailed insights into managerial processes, coordination mechanisms, perceived challenges, and program implementation experiences. Second, direct observations were conducted at posyandu and Puskesmas service points to document real-time practices related to nutrition services, maternal and child health counseling, and community engagement. Third, document analysis was performed using secondary data sources, including e-PPGBM nutritional records, TPPS meeting minutes, local regulations such as Sigi District Regulation No. 56/2022, and program monitoring reports. This triangulated approach ensured that the data captured reflected both managerial perspectives and operational realities.

The variables in this study were derived from the strategic management framework. Environmental scanning included identification of internal and external factors influencing stunting reduction efforts. Strategy formulation involved mapping strengths, weaknesses, opportunities, and threats. Strategy implementation focused on assessing how planned interventions were executed across sectors. Evaluation and control examined monitoring mechanisms, feedback loops, and program adjustments. These variables were operationalized using structured analytical instruments. Internal factors were measured using the Internal Factor Evaluation (IFE) matrix, which assigns weights and ratings to organizational strengths and weaknesses. External factors were assessed using the External Factor Evaluation (EFE) matrix, which evaluates opportunities and threats arising from the broader environment. The results of the IFE and EFE matrices were then plotted into the Internal-External (IE) matrix to determine the strategic position of the organization. Finally, the SWOT matrix was used to generate alternative strategies by integrating internal and external assessments.

Data analysis followed a systematic qualitative procedure. The first stage involved data reduction, where interview transcripts, observation notes, and documents were organized and coded according to thematic categories aligned with the strategic management variables. The second stage involved data display, where coded data were arranged into matrices and narrative summaries to facilitate interpretation. The third stage involved conclusion drawing and verification, where emerging patterns were compared with theoretical constructs and validated through cross-checking among data sources. The integration of qualitative thematic analysis with strategic management matrices allowed for a comprehensive evaluation of managerial performance and strategic alignment in stunting reduction efforts.

Ethical considerations were strictly observed throughout the study. Prior to data collection, permission was obtained from the Dolo Community Health Center and the Sigi District Health Office. All informants were provided with clear explanations regarding the purpose, procedures, and voluntary nature of participation. Written informed consent was obtained from each informant before interviews were conducted. Confidentiality was ensured by anonymizing informant identities and restricting access to raw data. No personal or sensitive information was disclosed in any part of the research report. The study adhered to ethical principles of autonomy, beneficence, non-maleficence, and justice, ensuring that the research process respected the rights and well-being of all participants.

RESULTS

Factors contributing to stunting

The analysis of stunting determinants in this study is grounded in the UNICEF Conceptual Framework, which categorizes the causes of stunting into three major domains: immediate causes, underlying causes, and basic (root) causes [9]. This framework provides a comprehensive lens for understanding how biological, behavioral, environmental, and structural factors interact to shape child growth outcomes. Findings from Dolo Subdistrict align closely with this model, revealing a complex interplay of nutritional behaviors, caregiving practices, environmental exposures, socio-economic constraints, and governance challenges.

Immediate causes

Immediate causes refer to factors that directly affect a child's nutritional status, primarily inadequate dietary intake and infectious diseases [9]. In Dolo Subdistrict, several behavioral patterns were identified as significant contributors.

One prominent issue is food neophobia, where children exhibit strong preferences for certain foods; such as eggs and fish while rejecting others, particularly nutrient-dense items like meat, beans, carrots, or leafy vegetables. This phenomenon has been documented as a direct contributor to stunting because it limits dietary diversity and micronutrient intake [10]. Informants reported that many children in Dolo habitually refuse vegetables and protein sources, leading parents to rely on foods that are more readily accepted but nutritionally insufficient.

Another immediate cause is the widespread consumption of snack foods among toddlers. Excessive intake of processed snacks creates a false sense of satiety, reducing appetite for nutritious meals. Parents often provide snacks to prevent children from becoming fussy, inadvertently reinforcing unhealthy eating patterns. This shift from nutrient-dense foods to calorie-dense, low-nutrient snacks reflects a broader transition in dietary habits, where traditional balanced meals are increasingly replaced by commercially processed foods.

Although supplementary feeding programs such as *Pemberian Makanan Tambahan* (PMT) and the “Sejuta Telur” initiative have been implemented, their effectiveness is undermined by sharing feeding practices. Eggs or other nutritious foods intended for stunted children are frequently consumed by all household members, including adults. As a result, the target child does not receive the required protein dosage for nutritional recovery. This dilution of nutritional interventions prevents the achievement of therapeutic thresholds necessary for catch-up growth.

Underlying causes

Underlying causes encompass household and community factors that influence food security, caregiving practices, health services, and environmental conditions [9]. Findings from Dolo Subdistrict highlight several critical issues.

A major underlying factor is low maternal health literacy. Mothers with limited knowledge about nutrition and stunting are less able to make informed decisions about feeding practices, hygiene, and healthcare utilization. Health literacy serves as a foundational determinant of caregiving behavior; without adequate knowledge, mothers are more susceptible to misinformation and local myths. One informant reported a prevalent myth claiming that dragon fruit seeds are harmful to children's digestion, leading mothers to avoid nutrient-rich fruits. Such misconceptions illustrate how misinformation can directly undermine dietary diversity and micronutrient intake.

Low health literacy also weakens mothers' ability to critically evaluate hoaxes, making them more likely to adopt harmful feeding practices. The relationship between knowledge, myth rejection, and child nutrition forms a linear continuum: inadequate knowledge increases susceptibility to myths, which in turn compromises nutritional intake and elevates stunting risk.

Environmental factors further exacerbate underlying causes. Although access to clean water in Dolo is generally adequate, many households live in close proximity to livestock pens. This increases exposure to fecal contamination and elevates the risk of Environmental Enteric Dysfunction (EED)—a chronic inflammatory condition of the small intestine caused by repeated ingestion of pathogenic bacteria. EED impairs nutrient absorption even when dietary intake is sufficient, making it a major contributor to growth failure [11]. Chronic exposure to bacteria such as *E. coli* from animal or human feces creates a cycle of infection and malnutrition, often referred to as the “nutrition-infection cycle.”

Additionally, the aftermath of the liquefaction disaster in Sigi has had long-term effects on agricultural productivity and food availability. Informants noted that the disaster damaged farmland, disrupted irrigation systems, and temporarily limited access to clean water. Extreme weather events and climate variability further destabilize local food systems, reducing the availability of nutrient-rich foods such as vegetables, fish, and legumes. These environmental disruptions contribute to household food insecurity, a key underlying determinant of stunting.

Basic (root) causes

Basic causes refer to structural and systemic factors that shape the broader environment in which households operate, including economic constraints, governance quality, and institutional capacity [9].

Economic limitations remain a central root cause of stunting in Dolo. According to Engel's Law, households with low income allocate most of their expenditure to staple foods, leaving little room for purchasing nutrient-dense items such as animal protein. This economic reality forces families to prioritize caloric sufficiency over nutritional quality, perpetuating protein deficiency and increasing stunting risk.

Governance challenges also play a significant role. Weak coordination among the 14 local government agencies (OPD) involved in the Stunting Reduction Acceleration Team (TPPS) leads to fragmented program implementation. Poor data synchronization results in delays in updating the e-PPGBM system, causing children experiencing early weight faltering to miss timely interventions. In public management theory, such siloed data systems create inefficiencies, duplication of efforts, and misaligned resource allocation. Without accurate and timely data, sensitive interventions (e.g., sanitation improvements) and specific interventions (e.g., supplementary feeding) fail to converge on the same target population [12].

Another structural barrier is the capacity gap among Posyandu cadres, who serve as frontline workers in stunting prevention. Although the number of cadres is adequate, their technical skills in anthropometric measurement, counseling, and data entry require strengthening. Errors in height measurement or delays in data input can lead to misclassification of nutritional status, resulting in late or inappropriate interventions. Heavy workloads; such as home visits, data entry, and community mobilization combined with limited incentives further reduce cadre performance and motivation.

UNICEF's report in *Maternal & Child Nutrition* emphasizes that nutrition education alone is insufficient without parallel investments in strengthening frontline worker capacity [9]. This aligns with findings from Dolo, where cadres face multiple operational challenges that hinder effective program delivery.

Strategic analysis of SWOT (Strengths, Weaknesses, Opportunities, and Threats) in the stunting program

A comprehensive strategic analysis was conducted to evaluate the internal and external conditions influencing the performance of stunting-reduction programs in Dolo Subdistrict, Sigi Regency. This analysis integrates the Internal Factor Evaluation (IFE) matrix, External Factor Evaluation (EFE) matrix, Internal–External (IE) matrix, and SWOT matrix to generate a holistic understanding of organizational readiness, environmental dynamics, and strategic leverage points. The findings reflect not only the managerial realities of program implementation but also the sociogeographical characteristics of Dolo, which shape the feasibility and effectiveness of stunting interventions.

Internal factor evaluation (IFE) matrix

The IFE matrix assesses internal strengths and weaknesses that directly influence program performance (Table 1). In Dolo Subdistrict, several internal strengths were identified, including the presence of a complete TPPS organizational structure extending to the village level, adequate numbers of midwives and Posyandu cadres, and the existence of local innovations such as the “Sejuta Telur” program and the *siBunda* digital application. These strengths indicate that the foundational elements for program implementation; organizational structure, human resources, and innovation are present and functional.

However, the analysis also revealed significant internal weaknesses. The most critical weakness is the lack of coordination among OPDs, which often operate in silos rather than through integrated convergence. This silo mentality results in fragmented interventions, duplication of efforts, and inefficient use of resources. Another weakness is the delay in data entry and inconsistencies across institutions, particularly in the

e-PPGBM system. These data issues hinder early detection of weight faltering and delay timely interventions. Additionally, budget reductions at the district level have constrained program activities, limiting the ability to scale interventions or sustain high-impact initiatives.

The total IFE score of 2.25 indicates a weak internal position, suggesting that despite having structural and human resource strengths, internal weaknesses; particularly coordination and budget constraints significantly undermine program effectiveness.

External factor evaluation (EFE) matrix

The EFE matrix evaluates external opportunities and threats that shape the program's operating environment (Table 2). Dolo Subdistrict possesses substantial external opportunities, including abundant local natural resources (agriculture and fisheries), strong political support through national priority programs, and active involvement of religious and community leaders in health education. These opportunities provide a favorable external environment for strengthening stunting-reduction efforts, particularly through community-based economic empowerment and culturally grounded health promotion.

Nevertheless, several external threats pose challenges. The post-liquefaction disaster continues to affect food security, agricultural productivity, and water access. Behavioral threats such as excessive snack consumption, food myths, and nutrition hoaxes (e.g., misconceptions about dragon fruit seeds) undermine dietary quality. Economic constraints, including high food prices for low-income households, further limit access to nutrient-dense foods.

The total EFE score of 2.70 indicates a moderate external response capacity. While external opportunities are substantial, they are not yet fully leveraged to support program goals.

SWOT matrix: strategic formulation

The SWOT matrix integrates internal and external assessments to generate strategic alternatives. The analysis produced four categories of strategies is presented in Table 3.

Table 3. SWOT matrix: strategic formulation

IFE / EFE	Strengths	Weaknesses
Opportunities	S–O Strategies	W–O Strategies
1. Agricultural potential in Dolo	Optimizing the “Sejuta Telur” program by leveraging local fisheries and agricultural resources through village-based MSMEs	Strengthening inter-agency (OPD) coordination to integrate village fund allocations with Puskesmas nutrition programs
2. Influence of religious leaders	Formally involving religious leaders within the TPPS organizational structure to reinforce community-based nutrition education	Utilizing the authority of community leaders to validate child-growth data collection in the field
Threats	S–T Strategies	W–T Strategies
1. Liquefaction disaster impacts	Utilizing the <i>siBunda</i> application for real-time monitoring of child nutritional status in disaster-affected areas	Implementing collective livestock-pen relocation policies through village regulations to reduce Environmental Enteric Dysfunction (EED) risk
2. Unhealthy eating behaviors and nutrition hoaxes	Mobilizing cadres to conduct local PMT cooking demonstrations to counter nutrition myths and reduce snack dependency	Securing alternative funding sources (CSR/NGO) to compensate for budget reductions and provide food subsidies for low-income households

SWOT matrix positioning (IE matrix interpretation)

The combined IFE and EFE scores place the stunting program in Quadrant III (Turnaround Strategy) of the IE matrix. This quadrant indicates that the organization must prioritize internal improvements; particularly coordination, budgeting, and data management before it can fully capitalize on external opportunities. The strategic focus should therefore shift from creating new programs to strengthening existing systems, improving governance, and enhancing cross-sectoral convergence.

Table 1. Internal factor evaluation (IFE) matrix

Internal strategic factors	Weight	Rating	Score
Strengths			
1. Existence of a fully established TPPS organizational structure extending to the village level	0.15	4	0.60
2. Adequate number of health personnel (midwives and community cadres)	0.10	3	0.30
3. Local program innovations such as the “Sejuta Telur” initiative and the <i>siBunda</i> digital application	0.15	4	0.60
Weaknesses			
1. Weak inter-agency coordination among OPDs, characterized by sectoral or silo-based working patterns	0.20	1	0.20
2. Delays in data entry and inconsistencies in data reporting across institutions	0.15	2	0.30
3. Reduction of district-level budget allocation for stunting-related programs	0.25	1	0.25
Total IFE score	1.00		2.25

Table 2. External factor evaluation (IFE) matrix

External strategic factors	Weight	Rating	Score
Opportunities			
1. Significant local natural resource potential (agriculture and fisheries) in Dolo	0.20	4	0.80
2. Strong political support through national priority programs (Presidential Priority/Astacita)	0.15	3	0.45
3. Active involvement of religious leaders and community figures in health and nutrition education	0.15	3	0.45
Threats			
1. Post-liquefaction disaster impacts on food security and water availability	0.20	2	0.40
2. High consumption of snack foods and widespread nutrition myths/hoaxes (e.g., dragon fruit seed misconceptions)	0.15	2	0.30
3. Economic constraints, including high food prices for low-income households	0.15	2	0.30
Total EFE Score	1.00		2.70

Program improvement strategies

Based on the SWOT analytical framework described above, three major strategic directions were formulated to strengthen stunting-reduction efforts in Dolo Subdistrict. These strategies address structural weaknesses, leverage existing opportunities, and mitigate environmental threats. Each strategy is grounded in evidence-based public management principles and aligned with national stunting-reduction policies.

Strategy 1: Strengthening governance and cross-sector coordination

The first strategic priority focuses on improving governance quality and enhancing coordination across sectors. Weak inter-agency collaboration was identified as the most critical internal barrier to effective stunting reduction. Therefore, governance reform is essential to ensure that interventions are synchronized, data flows are efficient, and resources are allocated strategically.

1) Overcoming silo mentality through collaborative governance

The primary weakness in Dolo's stunting program is the silo-based working pattern among OPDs, where each agency operates independently rather than collaboratively. To address this, the program must adopt the principles of Collaborative Governance, which emphasize face-to-face dialogue, trust building, shared decision-making, and collective accountability [13]. Collaborative governance provides a structured mechanism for aligning goals, harmonizing budgets, and integrating interventions across health, sanitation, agriculture, education, and social protection sectors.

Operationalizing collaborative governance requires activating cross-OPD Standard Operating Procedures (SOPs) and empowering the Subdistrict Head (Camat) as the TPPS Chair with formal authority to synchronize village fund allocations with Puskesmas nutrition programs. This alignment ensures that village-level resources directly support stunting-reduction priorities rather than being dispersed across unrelated activities. Evidence from UNICEF's *Maternal & Child Nutrition* report shows that Indonesian regions with high program convergence; where clean water access, social assistance, and nutrition services are synchronized achieve stunting reduction 2.5 times faster than regions implementing fragmented interventions [9]. This underscores the importance of governance reform as a foundational strategy.

2) Transforming data into precision intervention

Another critical governance challenge is the delay and inconsistency in e-PPGBM data entry. Data gaps hinder early detection of weight faltering and delay targeted interventions. To address this, data management must shift from passive reporting to precision intervention, where real-time data guides weekly operational decisions. Optimizing the *siBunda* application enables digitalization of monitoring processes, allowing frontline workers to track child growth in real time. Data becomes a navigational tool, identifying which households require immediate visits, which children need urgent follow-up, and which villages require intensified cross-sectoral support. Precision intervention transforms data from a bureaucratic requirement into a strategic asset for decision-making.

Strategy 2: Reforming specific nutrition interventions and strengthening local food systems

The second strategic direction focuses on improving the quality and effectiveness of specific nutrition interventions while leveraging Dolo's local food resources to enhance household food security.

1) Optimizing local supplementary feeding (PMT) and mitigating sharing feeding

The "Sejuta Telur" program frequently experiences benefit leakage due to sharing feeding, where eggs intended for stunted children are consumed by other household members. This prevents children from receiving the therapeutic protein dosage required for catch-up growth. To address this, the distribution model must shift from home-based raw food provision to centralized feeding sessions at Posyandu or Puskesmas. Centralized PMT ensures that the intended child consumes the full portion of nutrient-dense foods. Menus should be based on Dolo's local food resources, such as freshwater fish and moringa leaves, which are abundant, culturally acceptable, and nutritionally rich. This approach aligns with global recommendations emphasizing community-based feeding models to ensure dosage fidelity and reduce leakage in supplementary feeding programs [9].

2) Utilizing Dolo's natural resource potential as a nutritional safety net

Dolo Subdistrict has strong agricultural and fisheries potential. To strengthen household food security, the Pekarangan Pangan Lestari (P2L) program must be integrated with stunting data. Families with stunted children should be prioritized as recipients of agricultural inputs, including vegetable seeds, livestock, and fish fingerlings from the Agriculture Office.

This targeted approach ensures that vulnerable households have sustainable access to animal protein and micronutrient-rich foods. Integrating P2L with stunting data transforms agricultural programs into a nutritional safety net, reducing dependency on external food assistance and enhancing resilience against economic shocks.

Strategy 3: Environmental interventions and behavior change communication

The third strategic direction addresses environmental determinants and behavioral factors that significantly contribute to stunting in Dolo.

1) Mitigating Environmental Enteric Dysfunction (EED)

Environmental weaknesses—particularly the close proximity of homes to livestock pens—expose children to fecal contamination and increase the risk of Environmental Enteric Dysfunction (EED). EED causes chronic intestinal inflammation, reducing nutrient absorption even when dietary intake is adequate [11]. To mitigate EED, livestock pens must be relocated through village-level regulations (Perdes). This structural intervention reduces bacterial exposure and improves environmental hygiene. Additionally, accelerating access to healthy latrines is essential to break the cycle of fecal-oral contamination. Environmental interventions are critical because EED can undermine the effectiveness of nutrition programs, making dietary improvements insufficient without parallel sanitation reforms.

2) Integrated Behavior Change Communication (BCC)

Behavioral barriers such as snack dependency and nutrition myths (e.g., misconceptions about dragon fruit seeds) require culturally grounded communication strategies. Behavior Change Communication (BCC) must be integrated with religious and community structures to enhance message acceptance. Religious leaders in Dolo are highly influential and actively engaged in community affairs. Their involvement in delivering nutrition messages through Friday sermons, village religious gatherings, and community events can significantly strengthen the credibility of health information. Religious leaders serve as cultural validators, helping to counter hoaxes and reinforce evidence-based nutrition practices. UNICEF emphasizes that nutrition education without frontline capacity strengthening often fails to change household behavior [9]. Therefore, BCC must be accompanied by cadre training, community mobilization, and culturally resonant messaging.

DISCUSSION

Factors contributing to stunting

Stunting is the biological manifestation of chronic growth failure resulting from prolonged nutritional inadequacy, repeated infections, and suboptimal caregiving practices. In Dolo Subdistrict, despite the presence of a complete organizational structure such as the Stunting Reduction Acceleration Team (TPPS) extending to the village level, the prevalence of stunting remains high and persistent. To understand the multidimensional drivers of stunting in this context, this study adopts the UNICEF Conceptual Framework, which categorizes stunting determinants into immediate, underlying, and basic (root) causes [9]. This framework allows for a holistic interpretation of how biological, behavioral, environmental, and structural factors interact to shape child growth outcomes.

Immediate causes

Immediate causes refer to factors that directly influence a child's nutritional status, particularly dietary intake and disease exposure [9]. In Dolo, several behavioral and dietary patterns were identified as significant contributors.

The first is food neophobia. Children in Dolo frequently exhibit food neophobia, a psychological tendency to fear or reject unfamiliar foods. Many toddlers prefer eggs and fish but consistently refuse meat and vegetables such as carrots and beans. Food neophobia is defined as a developmental stage characterized by reluctance to try new foods, typically peaking between ages 2 and 6 [14]. It is considered an evolutionary protective mechanism; known as the "omnivore's paradox" designed to prevent ingestion of potentially harmful substances when children begin exploring their environment independently [15].

A key characteristic of food neophobia is that rejection is based on novelty rather than taste, as the child often refuses the food before tasting it. This distinguishes food neophobia from picky eating, which involves rejection of both familiar and unfamiliar foods due to sensory preferences [10]. If unmanaged, food neophobia can significantly reduce dietary diversity, limiting intake of essential micronutrients such as fiber, vitamins, and minerals, and may persist into adolescence or adulthood [16].

The second is Excessive Consumption of Ultra-Processed Foods (UPF). Another immediate cause is the widespread consumption of industrial snack foods, which creates a false sense of satiety and reduces appetite for nutritious meals. These snacks fall under the category of Ultra-Processed Foods (UPF)—products that undergo extensive industrial processing and contain additives not commonly used in home cooking [12]. UPFs typically contain emulsifiers, preservatives, artificial sweeteners, colorants, and flavor enhancers to increase palatability and shelf life [17]. They are high in added sugars, saturated fats, and sodium, but extremely low in fiber, protein, and micronutrients.

The relationship between UPF consumption and stunting is multidimensional and significant. UPFs contribute to "fullness without nutrition," where children consume sufficient calories but lack essential nutrients required for bone growth, tissue development, and immune function [12]. Pries et al. found that UPF consumption among toddlers is negatively correlated with linear growth due to low micronutrient density [18].

According to the NOVA classification system, UPFs such as sweetened cereals, commercial baby biscuits, flavored drinks, and instant noodles contain little or no whole foods [19]. Their high sugar and sodium content, combined with low protein and micronutrient levels (iron, zinc, vitamin B12), makes them nutritionally inadequate for growing children. Moreover, additives in UPFs can disrupt gut microbiota, impairing nutrient absorption during critical growth periods [20].

UNICEF reports that increasing UPF consumption globally has degraded children's diet quality and is directly associated with rising malnutrition, including micronutrient deficiencies that contribute to stunting [12]. Beyond physical growth, high UPF intake in preschool years is linked to behavioral and emotional development issues.

Recent longitudinal studies (2022–2023) show that high UPF consumption among children aged 2–4 years correlates with declining height-for-age Z-scores (HAZ), the primary indicator of stunting [17]. Children who feel full from UPFs tend to reduce intake of animal-source proteins; such as eggs, fish, and meat which are protective against stunting. UPF consumption also creates a paradox where children may become stunted yet overweight later in life due to metabolic dysregulation and chronic inflammation [18].

The third is leakage in supplementary feeding programs (sharing feeding). A critical failure in specific nutrition interventions in Dolo is sharing feeding, where supplementary foods intended for stunted children are consumed by other household members. For example, eggs distributed through the "Sejuta Telur" program are often shared among adults and siblings, preventing the target child from receiving the required protein dosage.

This phenomenon is known as leakage in food assistance programs. Leroy et al. demonstrated that home-based supplementary feeding interventions often fail to improve linear growth without strict supervision because food portions are redistributed within the household [21]. In Dolo, sharing feeding significantly reduces the effectiveness of PMT programs, contributing to persistent stunting despite ongoing interventions.

Underlying causes

The findings from Dolo Subdistrict reveal that the interplay between maternal health literacy, local cultural myths, and environmental exposures forms a critical chain of underlying causes that significantly contributes to stunting. These factors do not directly impair growth but create conditions that predispose children to chronic malnutrition and repeated infections, ultimately leading to linear growth failure. In the UNICEF Conceptual Framework, underlying causes operate at the household and community levels, shaping caregiving practices, food choices, hygiene behaviors, and exposure to pathogens [9].

The first is maternal health literacy as a foundational determinant. Maternal knowledge is not merely the possession of information; it functions as a protective barrier that shields children from nutritional risks. Health literacy is defined as the ability to access, understand, evaluate, and apply health information in daily life [21]. It encompasses cognitive, social, and functional skills that enable mothers to make informed decisions about feeding, hygiene, and healthcare utilization.

Educational disparities create significant gaps in health literacy. Mothers with lower educational attainment are more likely to have limited health literacy, making them vulnerable to misinformation and unable to critically appraise the validity of circulating narratives. The analysis shows that low literacy reduces a mother's ability to appraise health information, causing her to adopt myths or hoaxes without verification from health workers. Ideally, maternal knowledge should serve as a linear guide that directs mothers toward correct nutritional practices, even when confronted with cultural pressures or misinformation.

The second is cognitive overload and the dominance of local myths. Beyond literacy, cognitive barriers also play a role. Many mothers in Dolo carry heavy domestic workloads, leading to cognitive overload, where mental fatigue reduces the ability to retain or apply nutrition messages

delivered by cadres. In such contexts, local myths; which are frequently repeated within social networks become more salient and memorable than formal health education.

Local myths function as nutritional taboos, shaping food avoidance behaviors that can harm child nutrition. A specific example in Dolo is the myth that dragon fruit seeds are dangerous for children's intestines. Scientifically, dragon fruit is rich in fiber, antioxidants, and micronutrients, yet this myth prevents children from consuming a nutrient-dense food source.

Meyer-Rochow's theory on cultural food taboos explains that such prohibitions often disproportionately target vulnerable groups—pregnant women, lactating mothers, and young children—who paradoxically require the highest nutrient intake [10]. UNICEF reports that in Indonesia, maternal nutrition knowledge has a stronger correlation with stunting than food availability itself; many families can afford nutritious foods but choose inappropriate items due to cultural perceptions [12].

The third is environmental factors and exposure to pathogens. Environmental conditions in Dolo further exacerbate underlying causes. Although access to clean water is generally adequate, many households are located too close to livestock pens, creating a high-risk environment for fecal contamination. Field observations identified significant exposure pathways where animal waste contaminates soil and water sources frequently accessed by toddlers.

This environmental setup increases the risk of Environmental Enteric Dysfunction (EED), a chronic subclinical inflammatory condition of the small intestine caused by repeated ingestion of pathogenic bacteria. EED is characterized by villous blunting, increased intestinal permeability ("leaky gut"), and impaired nutrient absorption [21]. Chronic exposure to bacteria such as *E. coli*—common in environments where livestock pens are adjacent to homes—causes structural damage to intestinal villi, reducing the surface area available for nutrient uptake.

In children with EED, the body diverts essential nutrients such as protein and iron toward immune responses rather than growth processes. Thus, even when dietary intake is adequate, nutrients cannot be absorbed effectively due to chronic intestinal inflammation. This explains why some children in Dolo exhibit stunting despite consuming sufficient calories.

Leroy et al. describe EED as a key mediator linking poor environmental hygiene to linear growth failure in low-income settings [21]. Rogawski and Guerrant further emphasize that nutrition interventions alone have limited impact on stunting reduction when environmental bacterial exposure remains high; without improvements in sanitation and hygiene (WASH), the burden of EED continues to undermine growth outcomes [22].

Taken together, the underlying causes of stunting in Dolo form a multilayered chain of vulnerability:

- 1) Low maternal health literacy → inability to evaluate information → adoption of harmful myths
- 2) Cognitive overload → reduced retention of nutrition messages → dominance of cultural narratives
- 3) Environmental contamination → chronic bacterial exposure → EED → impaired nutrient absorption

These factors interact synergistically, creating conditions where even well-designed nutrition programs fail to achieve optimal outcomes. Addressing underlying causes therefore requires integrated interventions that combine education, cultural engagement, and environmental sanitation improvements.

Basic causes

Based on the SWOT diagram analysis, which positions the stunting-reduction program in Quadrant III (Turnaround Strategy), and in alignment with the UNICEF Conceptual Framework, the fundamental or basic causes of stunting in Dolo Subdistrict are rooted not in environmental or political limitations—since external opportunities scored relatively high (2.70)—but in structural weaknesses and systemic governance failures. These basic causes represent deep-seated constraints that shape the effectiveness of all upstream and downstream interventions.

Structural governance failures and silo mentality

The most critical basic cause identified is the weakness of collaborative governance, manifested as silo mentality among local government agencies (OPDs). Stunting is inherently a multisectoral problem that cannot be addressed by the health sector alone. Effective reduction requires synchronized actions across health, agriculture, sanitation, education, and social protection sectors. However, in Dolo, OPDs often work independently, resulting in fragmented interventions that fail to converge on the same target households.

This siloed approach prevents specific nutrition interventions (e.g., supplementary feeding, growth monitoring) from aligning with sensitive interventions (e.g., sanitation improvements, agricultural support). Beal et al. emphasize that without accurate and synchronized data, sensitive and specific interventions will never reach the same beneficiaries, leading to inefficiency and poor outcomes [22]. Rogawski & Guerrant further argue that successful public programs depend on synergy, two-way communication, and shared commitment—core principles of collaborative governance [22]. Thus, governance failure is not merely an administrative issue; it is a root cause that undermines the entire stunting-reduction ecosystem.

Capacity gaps among posyandu cadres

another fundamental cause is the limited technical capacity of posyandu cadres, who serve as frontline workers interacting directly with mothers and children. cadres are responsible for anthropometric measurements, nutrition counseling, home visits, and data entry into the e-pggbm system. their performance directly influences the accuracy of growth monitoring and the timeliness of interventions.

accurate anthropometric measurement is the foundation of early detection. when cadres lack adequate skills, measurement errors occur, leading to under-diagnosis (children at risk not detected) or over-diagnosis (misclassification). both scenarios distort program targeting and budget allocation. evidence from *the lancet regional health* shows that intensive cadre training can reduce measurement errors by up to 80%, significantly accelerating response time for children experiencing growth faltering [23].

cadres also play a crucial role in behavior change communication. their ability to deliver persuasive counseling; not merely informational lectures determines whether mothers adopt healthier feeding practices, reject harmful myths, and prioritize animal-source protein over ultra-processed foods. cadres are the bridge between formal health systems and household behavior; thus, their capacity is a basic determinant of program success.

Inefficiencies in budget allocation and financial governance

Financial governance represents another basic cause. The SWOT analysis highlights budget optimization as a major internal weakness. The issue is not simply insufficient funding, but inefficient allocation and management. In many cases, stunting budgets are spent on ceremonial activities, administrative meetings, or non-essential coordination events rather than on high-impact interventions such as protein provision, sanitation improvements, or cadre training.

Nutrition spending at the village level in Indonesia is often constrained by rigid bureaucratic procedures, limiting flexibility and responsiveness to local needs [24]. Inefficient budgeting reduces the ability of programs to deliver meaningful nutritional support, especially in low-income households.

Data integration failures and delayed digitalization

Technical governance issues also contribute to basic causes, particularly data integration failures in the e-PPGBM system. Delayed anthropometric data entry creates intervention gaps. When data are uploaded late, children may have already passed critical windows of growth faltering and progressed to irreversible stunting.

Studies on health information systems in Southeast Asia show that the success of digital health platforms depends on data quality and timeliness [25]. In Dolo, delayed data entry prevents real-time monitoring, weakens cross-sectoral coordination, and reduces the effectiveness of precision interventions.

Economic vulnerability and Engel's law

for Sigi regency, a major basic cause is economic vulnerability, particularly in the aftermath of the liquefaction disaster. reduced household income affects purchasing power, limiting access to nutrient-dense foods. Engel's law explains that low-income households spend a disproportionately large share of their budget; often more than 60% on cheap staple foods (carbohydrates) to achieve satiety. as a result, they cannot afford more expensive animal-source proteins such as eggs, fish, or meat, which are essential for preventing stunting.

even though Dolo has strong agricultural and fisheries potential, households cannot fully benefit from these opportunities without improved purchasing power or targeted subsidies. Engel's law thus provides a critical lens for understanding why nutrition interventions often fail in poor households despite the availability of local food resources.

Synthesis of basic causes

The basic causes of stunting in Dolo form a systemic chain of structural constraints:

- 1) Weak collaborative governance → fragmented interventions → poor convergence
- 2) Limited cadre capacity → inaccurate data → mistargeted interventions
- 3) Inefficient budgeting → low impact of nutrition programs
- 4) Delayed digitalization → late detection of growth faltering
- 5) Economic vulnerability → inability to access animal-source protein

These root causes operate at institutional and structural levels, shaping the effectiveness of all upstream and downstream interventions. Addressing basic causes requires systemic reform, not merely program expansion.

Analysis of SWOT (Strengths, Weaknesses, Opportunities, and Threats)

Based on the SWOT matrix analysis, the stunting-reduction program in Dolo Subdistrict is positioned in Quadrant III (Turnaround Strategy). This quadrant indicates a strategic imbalance: the program benefits from substantial external opportunities (EFE score: 2.70), yet its performance is constrained by significant internal weaknesses (IFE score: 2.25). In strategic management theory, this position reflects an organization that must prioritize internal restructuring before it can fully capitalize on external advantages.

Strengths

The strengths of the stunting program in Dolo lie primarily in its structural support and resource potential. The presence of national regulations; particularly the Presidential Priority Agenda (*Asta Cita*) provides strong policy legitimacy and mandates coordinated action across sectors. This regulatory foundation strengthens the authority of the Stunting Reduction Acceleration Team (TPPS) at the village level, enabling structured planning and community mobilization.

Another major strength is the availability of local food resources, particularly animal-source protein such as eggs and freshwater fish. These resources are critical because animal-source protein is one of the strongest protective factors against stunting. According to the Resource-Based View (RBV), organizations achieve strategic advantage by leveraging unique internal assets and capabilities [RBV Theory]. In the context of Dolo, the abundance of local protein sources represents a strategic asset that, if optimized through effective program design, can significantly improve child nutrition outcomes.

The combination of strong policy support and rich local food resources provides a solid foundation for program improvement—provided that internal weaknesses can be addressed.

Weaknesses

Internal weaknesses constitute the primary barrier that places the program in the Turnaround quadrant. The most critical weakness is the silo mentality among OPDs, where agencies operate independently rather than collaboratively. This ego-sectoral behavior prevents convergence between specific nutrition interventions (health sector) and sensitive interventions (agriculture, sanitation, social protection). As a result, interventions fail to reach the same households, reducing program effectiveness.

Weak coordination also affects data literacy and data flow, particularly in the e-PPGBM system. Delays in data entry hinder early detection of growth faltering, causing children to miss critical windows for intervention. Data fragmentation across institutions further complicates decision-making and resource allocation.

Another internal weakness is the limited technical capacity of Posyandu cadres, especially in anthropometric measurement. Inaccurate height or weight measurements create data bias, leading to misclassification of nutritional status. This results in under-diagnosis of at-risk children or misallocation of resources. UNICEF's *Maternal & Child Nutrition* report emphasizes that without synchronized cross-sectoral coordination and accurate data, nutrition interventions cannot achieve optimal effectiveness—even when adequate funding is available [9].

These weaknesses collectively undermine program performance and must be addressed before external opportunities can be leveraged.

Opportunities

External opportunities represent powerful drivers that can accelerate stunting reduction if internal weaknesses are resolved. One major opportunity is the availability of integrated information systems, which enable real-time monitoring of child growth and facilitate precision targeting. Digital tools such as *SiBunda* can support rapid decision-making and improve coordination across sectors.

Another opportunity lies in partnership potential with NGOs, private companies, and community organizations. These actors can provide funding for sensitive interventions such as sanitation improvements, clean water access, and food security programs. External partnerships also bring technical expertise, innovation, and community engagement strategies that complement government efforts.

Ansell & Gash highlight that external opportunities can only be fully utilized when there is strong synergy between government and non-government actors, achieved through collaborative governance and shared responsibility [13]. Thus, opportunities in Dolo are abundant—but their realization depends on internal reform.

Threats

External threats represent factors that can worsen stunting conditions if not addressed promptly. The most significant threat is the risk of Environmental Enteric Dysfunction (EED), caused by poor environmental hygiene. In Dolo, many households are located close to livestock pens, increasing exposure to fecal contamination. Chronic ingestion of pathogenic bacteria leads to subclinical intestinal inflammation, villous blunting, and impaired nutrient absorption. *The Lancet* identifies EED as a major cause of growth failure even when dietary intake is adequate [23].

Another threat is the prevalence of nutrition hoaxes and cultural myths, such as misconceptions about dragon fruit seeds or prohibitions against eating fish. These myths reduce dietary diversity and prevent children from consuming nutrient-dense foods. Cultural beliefs can override scientific knowledge, especially in communities with low maternal health literacy.

Post-disaster conditions also pose significant threats. The liquefaction disaster in Sigi damaged agricultural land, disrupted water systems, and weakened household economic resilience. Infrastructure recovery remains incomplete, affecting food availability and clean water access—both essential for preventing stunting. These threats highlight the need for environmental sanitation improvements, behavior change communication, and disaster-responsive nutrition strategies.

Synthesis

The SWOT analysis reveals a clear strategic direction:

- 1) Strengths and opportunities are substantial, indicating strong potential for program success.
- 2) Weaknesses and threats are severe, indicating structural barriers that must be addressed urgently.

The Turnaround position (Quadrant III) therefore requires internal restructuring, including governance reform, data integration, cadre capacity strengthening, and budget optimization. Only after these internal weaknesses are resolved can Dolo fully leverage its external opportunities to accelerate stunting reduction.

Program improvement strategies

Based on the SWOT diagram positioning the stunting-reduction program in Quadrant III (Turnaround), the central priority is to strengthen internal systems so that the substantial external opportunities can be fully leveraged. In alignment with the Social Ecological Model (SEM), the improvement strategies in Dolo Subdistrict must operate across multiple layers—individual, interpersonal, organizational, community, and policy—because stunting is not merely a biological condition but a systemic failure shaped by interactions across these levels. Therefore, the strategies formulated below emphasize structural reform, governance strengthening, data integration, and community-level empowerment.

Strategy for strengthening governance and cross-sector coordination

This strategy focuses on improving coordination among OPDs and integrating the e-PPGBM data system—two core weaknesses identified in Quadrant III. The goal is to eliminate silo mentality through collaborative governance, enhance inter-sectoral convergence, reform budget allocation mechanisms, and strengthen the role of frontline workers as data intermediaries.

Eliminating silo mentality through collaborative governance

Collaborative governance is essential because stunting cannot be solved by a single sector. Health interventions must converge with sanitation, agriculture, education, and social protection. The strategy is grounded in the theory of Ansell & Gash, which emphasizes the importance of face-to-face dialogue, trust building, shared understanding, and joint decision-making in achieving effective cross-sector collaboration [13]. In Dolo, this requires shifting coordination from administrative compliance to functional integration, where OPDs understand that their interventions must reach the same households simultaneously. To operationalize this, a shared command center at the subdistrict level should be established to synchronize data weekly rather than monthly. Weekly synchronization ensures rapid detection of growth faltering and timely deployment of cross-sector interventions. This approach aligns with SEM's organizational and policy levels, ensuring that institutional structures support coordinated action.

Transforming data into precision intervention

One of the most critical weaknesses is delayed data entry in e-PPGBM. To address this, data management must shift from passive reporting to real-time digital monitoring. Optimizing the *siBunda* application enables frontline workers to track child growth continuously and identify households requiring urgent intervention. In this model, data becomes a navigational tool, not merely a bureaucratic requirement. Real-time data allows cross-sector teams to determine which households need home visits, which children require urgent nutritional support, and which villages need intensified sanitation interventions. This transformation aligns with global best practices in precision public health, where data guides targeted, high-impact interventions.

Implementing Inter-Sectoral Convergence

Inter-sectoral convergence is essential because non-convergent interventions are a major cause of stunting program failure. A study in *The Lancet Regional Health* found that regions with One Data Convergence Systems; integrating health, sanitation, and economic data reduced stunting 30% faster than regions with fragmented data systems [26].

In Dolo, convergence requires integrating e-PPGBM with infrastructure data (sanitation, clean water) to map bacterial infection risks (EED) with precision. This allows targeted sanitation improvements in households where children show early signs of growth faltering.

Reforming cross-sector budget allocation (result-based budgeting)

Budget optimization is a core weakness in Quadrant III. The strategy requires shifting from activity-based budgeting to result-based budgeting, consistent with the Theory of Change in public finance. Funds should be allocated based on measurable nutrition outcomes; such as the

percentage of children consuming eggs regularly rather than the number of meetings or administrative activities. This includes providing village-level incentive funds for communities that successfully eliminate coordination barriers between Posyandu cadres and agricultural/sanitation extension workers. Ansell & Gash emphasize that timely data integration is crucial for budget optimization and precision targeting [13].

Strengthening frontline workers (cadres) as data bridges

Frontline workers are the backbone of stunting reduction. Cross-sector coordination is most effective at the micro level; village and Posyandu where cadres operate [27]. Therefore, cadre capacity must be strengthened through bottom-up approaches.

Cadres should serve as cross-sector monitors, ensuring that health interventions (egg distribution) are not undermined by environmental risks (poor sanitation) or behavioral barriers (snack dependency). Strengthening cadres enhances SEM's interpersonal and community levels by improving direct interactions with mothers and households.

Summary of strategy 1

This strategy addresses the structural roots of stunting by reforming governance, integrating data systems, aligning budgets with outcomes, and empowering frontline workers. It transforms the program from fragmented and reactive to coordinated, data-driven, and results-oriented.

Strategy for reforming specific nutrition interventions and local food systems

Reforming specific nutrition interventions and strengthening the local food system constitute the second major strategic pillar for accelerating stunting reduction in Dolo Subdistrict. In alignment with the Social Ecological Model (SEM), this strategy operates across individual, household, community, and institutional levels. The goal is to transform nutrition interventions from administrative, routine, and generalized approaches into data-driven, precision-based, and locally anchored systems capable of delivering measurable improvements in child growth outcomes.

Reforming specific nutrition interventions through precision nutrition

The reform of specific nutrition interventions must begin with correcting the structural weaknesses identified in the SWOT analysis—particularly delayed data entry, leakage in supplementary feeding, and low dosage fidelity. Traditional supplementary feeding programs in rural Indonesia often rely on monthly schedules and generalized menus, which fail to address the dynamic nature of child growth. Findings from *The Lancet Regional Health* demonstrate that nutrition interventions guided by daily digital data reduce stunting risk by 35% more effectively than monthly scheduled interventions [26]. This underscores the need for a paradigm shift from administrative routines to precision nutrition.

Precision Nutrition Theory emphasizes that each child has unique nutritional needs, and timely adjustments are essential to prevent growth faltering [26]. In Dolo, this requires: 1) real-time detection of growth faltering using e-PPGBM data; 2) immediate adjustment of protein dosage based on daily or weekly anthropometric trends; 3) rapid deployment of cross-sector support (sanitation, food assistance, home visits). Thus, data must function not as a reporting tool but as a clinical decision-making instrument guiding frontline workers in tailoring interventions to each child's needs.

Ensuring real-time data integration for early detection

The SWOT analysis highlights data integration as a critical weakness. Reforming nutrition interventions requires ensuring that real-time e-PPGBM data is used to detect early signs of growth faltering; particularly stagnation in weight gain before children fall into irreversible stunting. This reform includes: 1) strengthening cadre capacity for accurate anthropometric measurement; 2) establishing weekly data review meetings at the subdistrict command center; 3) integrating e-PPGBM with sanitation and economic data to identify multi-risk households; and 4) using digital dashboards to prioritize home visits. Timeliness is essential. When data entry is delayed, children may pass the critical window for intervention. Precision nutrition therefore depends on data accuracy, timeliness, and cross-sector integration.

Reforming supplementary feeding through centralized PMT

One of the most persistent failures in Dolo's nutrition interventions is sharing feeding, where supplementary foods intended for stunted children are consumed by other household members. This leakage reduces dosage fidelity and undermines program effectiveness. Research by Leroy et al. shows that home-based supplementary feeding often fails to improve linear growth due to intra-household food redistribution [21]. To address this, the distribution model must shift from home-based raw food provision to centralized supplementary feeding (PMT) at Posyandu or Puskesmas. Centralized PMT ensures: 1) the target child consumes the full portion; 2) menus are standardized and nutritionally adequate; 3) cadres can monitor intake directly; and 4) leakage is minimized. Menus should be based on local food resources, such as freshwater fish and moringa leaves, which are abundant, culturally acceptable, and nutritionally dense.

Leveraging local food systems as a nutritional safety net

Dolo Subdistrict possesses substantial agricultural and fisheries potential. However, these resources remain underutilized due to coordination gaps. Reforming the local food system requires integrating agricultural programs with stunting data to create a nutritional safety net for vulnerable households. This includes: 1) prioritizing families with stunted children as beneficiaries of Pekarangan Pangan Lestari (P2L); 2) providing seeds, livestock, and fish fingerlings to ensure household-level protein production; 3) linking local farmers and fishers directly with Posyandu as PMT suppliers; and 4) stabilizing protein prices through local procurement systems. This approach aligns with SEM's community and institutional levels, strengthening household resilience and reducing dependency on external food assistance.

Cross-sector convergence to strengthen local food chains

Cross-sector convergence is essential for connecting agriculture, fisheries, and health systems. In practice, this means: 1) agricultural extension workers collaborating with Posyandu cadres; 2) local farmers supplying eggs and fish for PMT; 3) sanitation officers ensuring hygienic environments for food preparation; and 4) village governments coordinating subsidies for protein-rich foods. This convergence ensures that local food systems support nutrition interventions directly and sustainably.

Reforming local food systems to counter myths and food neophobia

Local food systems also play a critical role in addressing behavioral barriers such as food neophobia and nutrition myths. Using familiar local foods; such as fish, eggs, and moringa helps children overcome reluctance to try new foods. This approach is supported by behavioral nutrition research showing that children are more willing to accept foods that are culturally familiar and frequently consumed within the household. Local

foods also help counter myths such as prohibitions against eating fish or misconceptions about dragon fruit seeds. By integrating local foods into PMT menus and community cooking demonstrations, cadres can reinforce evidence-based nutrition practices. The World Bank confirms that daily consumption of one locally sourced egg is the most cost-effective intervention for reducing stunting in rural Indonesia [27]. This finding underscores the importance of strengthening local food systems as a core strategy.

Summary of strategy 2

This strategy transforms nutrition interventions from fragmented, generalized, and leakage-prone systems into precision-based, data-driven, and locally anchored interventions. It leverages Dolo's rich agricultural and fisheries potential, strengthens household food security, and integrates local food chains with Posyandu operations. By combining real-time data, centralized PMT, and cross-sector convergence, this strategy addresses both biological and systemic determinants of stunting.

Environmental and Behavior Change Intervention Strategy

Based on the SWOT diagram positioning the stunting-reduction program in Quadrant III (Turnaround), environmental and behavioral interventions must be prioritized to address internal weaknesses that hinder program effectiveness. This strategic pillar integrates physical environmental improvements with social and behavioral change mechanisms, reflecting the multi-layered nature of stunting as conceptualized in the Social Ecological Model (SEM). In SEM, child nutrition outcomes are shaped not only by individual behaviors but also by interpersonal relationships, community norms, organizational systems, and broader policy environments.

Environmental interventions to break fecal–oral contamination pathways

Field findings indicate that one of the most critical environmental weaknesses in Dolo is the close proximity of households to livestock pens. This spatial arrangement significantly increases exposure to fecal contamination, creating a high-risk environment for Environmental Enteric Dysfunction (EED). EED is a chronic inflammatory condition of the small intestine caused by repeated ingestion of pathogenic bacteria, which leads to villous blunting, increased intestinal permeability, and impaired nutrient absorption [23].

To mitigate this risk, environmental interventions must focus on breaking fecal–oral contamination pathways, including: 1) zoning reforms to separate child play areas from livestock areas; 2) relocation of livestock pens through village-level regulations (Perdes); 3) improvement of WASH infrastructure, including clean water access and household sanitation; and 4) acceleration of healthy latrine construction to reduce open defecation and environmental contamination. Evidence from *The Lancet Regional Health* shows that sanitation improvements combined with livestock separation education reduce stunting risk 2.8 times more effectively than food-based interventions alone [23]. This underscores the importance of environmental interventions as foundational determinants of child growth.

Behavior change communication (BCC) to counter myths and food neophobia

Behavioral reform is essential for addressing food neophobia, snack dependency, and harmful nutrition myths. In Dolo, myths such as the belief that dragon fruit seeds are dangerous for children, or cultural prohibitions against eating fish, significantly reduce dietary diversity and micronutrient intake. To address these barriers, Behavior Change Communication (BCC) must be culturally grounded and socially reinforced. This includes: 1) personalized nutrition education delivered through trusted community figures; 2) integration of stunting-prevention messages into Friday sermons and religious gatherings; and 3) use of religious leaders as cultural validators to counter hoaxes and reinforce evidence-based nutrition practices.

Religious leaders in Dolo hold significant influence and can shape community norms. Their involvement enhances message credibility and supports mothers in rejecting misinformation. This aligns with findings by Rioux, who emphasizes that maternal health literacy is a primary determinant of animal-source protein intake [10]. The turnaround strategy here is to ensure that mothers develop confidence and self-efficacy to ignore hoaxes and prioritize scientifically validated nutrition practices.

Strengthening family roles and cadre capacity for persuasive counseling

Family involvement is crucial for sustaining behavior change. Parents must be empowered to adopt healthier feeding practices, reduce snack dependency, and encourage children to try new foods. To support this, Posyandu cadres must be trained not only in technical skills but also in persuasive counseling techniques. Cadres should be able to: 1) deliver motivational interviewing rather than one-way lectures; 2) conduct cooking demonstrations using local foods (eggs, fish, moringa); 3) educate families on preventing sharing feeding, ensuring that PMT portions are consumed by the intended child; and 4) reinforce positive feeding behaviors through regular home visits. This approach aligns with SEM's interpersonal and community levels, where sustained behavior change requires supportive social norms and consistent reinforcement.

The World Bank reports that locally sourced nutrition interventions; such as one egg per day combined with routine cadre education significantly improve dietary diversity among poor rural households in Indonesia [27]. This confirms the importance of integrating local food systems with behavior change strategies.

Multi-level convergence for environmental and behavioral interventions

Recent research by Headey & Palloni in *World Development* emphasizes that successful stunting reduction in developing countries depends not merely on food provision but on multi-level convergence, where interventions across environmental, behavioral, and institutional levels operate simultaneously on the same target households [28]. This reinforces the need for integrated strategies that combine: 1) environmental sanitation; 2) livestock management; 3) nutrition education; 4) local food system strengthening; 5) cadre capacity building; and 6) household empowerment. Only through convergence can interventions achieve sustained impact.

Synthesis and implications for program improvement

The analysis above demonstrates that the root causes of stunting in Dolo are multidimensional, involving environmental contamination, cultural beliefs, behavioral patterns, and systemic governance weaknesses. Therefore, program improvement strategies must integrate: 1) specific nutrition interventions; 2) sensitive interventions (sanitation, water, agriculture); 3) local food system strengthening; 4) cross-sector governance reform; 5) behavior change communication; and 6) environmental risk mitigation. The TPPS must serve as the coordinating body to ensure that all interventions converge on the same households, supported by accurate e-PPGBM data, strengthened cadre capacity, and improved cross-sector governance.

Study limitations

This study has several limitations. First, it is cross-sectional (snapshot), capturing program conditions at a single point in time [29-31]. Changes in national policy, economic fluctuations, or new disasters may rapidly shift the SWOT quadrant. Second, the analysis relies heavily on the accuracy of e-PPGBM data, meaning that any errors or delays in data entry directly affect the validity of findings. Future research should incorporate longitudinal designs and triangulate digital data with independent field measurements.

CONCLUSION

Based on the findings and the preceding discussion, the conclusion of this study is that the determinants of stunting in Dolo Subdistrict arise from a complex interaction of behavioral factors, environmental exposures, and systemic failures, encompassing immediate causes, underlying causes, and basic structural causes. It is therefore necessary to implement program-improvement strategies that include strengthening governance and cross-sector coordination, reforming specific nutrition interventions and the local food system, and advancing environmental and behavior-change interventions through targeted mitigation.

Ethical consideration, competing interest and source of funding

- The study adhered to ethical principles of autonomy, beneficence, non-maleficence, and justice, ensuring that the research process respected the rights and well-being of all participants.
- There is no conflict of interest.
- The source of funding is the authors.

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