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Review Article

Reality of implementation, barriers, and local-based innovations of stunting reduction programs in Papua region, Indonesia: A systematic review

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Abstract

Stunting remains a major public health problem in Indonesia, with a disproportionate burden in Papua, where many districts are classified as 3T regions (frontier, outermost, and least-developed areas) characterized by limited infrastructure, restricted access to services, and distinct socio-cultural challenges. The aim of this study was to comprehensively examine the implementation of stunting reduction programs in Papua's 3T regions, including program delivery, barriers, and local innovations, through a systematic review. Articles were identified through searches of five major databases and grey literature and were selected using the PRISMA framework. Eligible studies reported on program implementation, barriers, risk factors, and/or strategies related to stunting reduction in Papua. A total of 45 studies met the inclusion criteria and were synthesized using a thematic narrative approach. The review indicated that stunting reduction efforts in Papua have included both nutrition-specific and nutrition-sensitive interventions, supported by the establishment of acceleration teams, the use of integrated health service posts (*Posyandu*), supplementary feeding, micronutrient supplementation, and the 1,000 days of life initiative. However, program effectiveness is constrained by geographical isolation, health workforce shortages, weak cross-sectoral coordination, and a persistent gap between national policy design and local implementation capacity. Frequently reported risk factors included suboptimal caregiving practices, inadequate dietary intake, recurrent infections, poor sanitation, poverty, and a double burden borne by women, all of which impede program success. Conversely, locally grounded strategies—such as local food-based interventions, strengthening cadres and traditional leaders, community education, and pentahelix collaboration—emerged as more contextually appropriate and community-accepted approaches. Overall, these findings underscore the need to adapt policies to local conditions, strengthen convergence governance, and expand long-term evaluative research to improve the effectiveness and sustainability of stunting interventions in Papua's 3T regions.

Keywords: Stunting, Papua, 3T region, program implementation, health policy

Introduction

Stunting is a significant public health problem in Indonesia. This condition is characterized by growth failure in children under five due to chronic malnutrition, which has implications for physical growth disorders, delayed cognitive development, increased risk of non-

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communicable diseases, and decreased productivity in adulthood [1,2]. The 2022 Indonesian Nutrition Status Survey reported a national stunting prevalence of 21.6%, but provinces in Papua region showed much higher rates, Papua at 34.6% and West Papua at 26.2%, with some districts such as Pegunungan Bintang and Asmat exceeding 50% [3,4]. These figures are well above the National Medium-Term Development Plan target of 14% and indicate a relatively slow decline in high-burden districts, where areas such as Pegunungan Bintang, Asmat, and Keerom remain above the WHO threshold of 20% [5]. This situation is inseparable from the characteristics of regions in Papua, which are frontier, outermost, and least developed (in Indonesian called the 3T areas), which have complex challenges in providing health services and implementing stunting reduction programs.

Globally, data from the Joint Child Malnutrition Estimates 2025 shows that stunting still affects around 149.2 million children under the age of five, with 22% of the world's toddlers experiencing stunting [6]. Although there has been a decrease from 171 million in 2014, global progress shows stagnation, with the average annual reduction required to achieve the WHO 2025 target being 6.08%, far from the actual achievement [7]. The highest prevalence remains concentrated in Sub-Saharan Africa (43% of the global total) and Asia (52% of the global total), where Indonesia is included in the category of countries with a substantial burden of stunting [8,9].

Global evidence shows that the implementation of successful stunting programs requires an integrated multisectoral approach. A systematic review study in 33 Sub-Saharan African countries revealed the importance of cross-sectoral collaboration between health, agriculture, water, sanitation, and hygiene (WASH), and social protection in significantly reducing the prevalence of stunting [10]. Some countries have achieved dramatic success through comprehensive approaches: Peru successfully reduced stunting from 28% in 2005 to 13% in 2016 through high political commitment, results-based financing, and strong multisectoral coordination [11]. Ethiopia reduced stunting from 44% in 2011 to 38% in 2016 through sustained multisectoral collaboration, integrating health, agriculture, and social sectors under the National Nutrition Program and Seqota Declaration [12]. Senegal also showed a decline in stunting from 30% in the early 2000s through a holistic community-based strategy [13].

At the intervention level, a systematic review and meta-analysis demonstrated that food-based interventions significantly improved children's linear growth, with a pooled effect size of 0.20 (95%CI: 0.04–0.35, p=0.01) in improving linear growth [14]. Community-based interventions have been proven effective through integrated approaches to education, training, nutritional supplementation, and growth monitoring [15]. However, a comprehensive review also revealed that not all food intervention programs are effective, with variations in results depending on baseline characteristics, nutritional composition, intervention duration, and adherence to protocols [16].

Implementation challenges in developing countries, particularly in remote areas, show a consistent pattern globally. An analysis of 33 Demographic and Health Surveys in Sub-Saharan Africa revealed significant access gaps to nutritional determinants: more than one-third of the population had differences in access to food security and care practices of more than 5 percentage points between the rich and poor quintiles, while 24 countries showed WASH access gaps of more than 30 percentage points between the upper and lower economic groups [10]. A multi-country study involving Ethiopia, India, Peru, and Vietnam showed that household wealth in early life consistently predicts long- term growth outcomes, highlighting the importance of interventions that are sensitive to socioeconomic conditions [17].

Studies in Indonesia, particularly in Papua region, highlight limitations in health infrastructure, shortages of trained health workers, especially nutritionists, geographical isolation that hinders logistics distribution and access to services, unspecified allocation of Health Operational Assistance funds, weak cross-sectoral coordination, and the influence of socio-cultural norms on parenting practices and household consumption patterns [2,5,18]. These challenges are in line with global findings that the lack of systematic process and impact evaluations in pilot projects hinders effective program scale-up, where evaluations must include not only outcomes but also the quality, access, and geographical coverage of program implementation [19,20].

The Indonesian government has launched a strategic policy to reduce stunting through specific and sensitive nutritional interventions involving various sectors, including the formation of the stunting reduction acceleration team, the supplementary feeding program, iron-folic acid tablet supplementation, improved immunization coverage, the Bangga Kencana program, interprofessional collaboration in primary health care, and community-based approaches through the Family Assistance Team program [21,22,23,24,25]. However, in the 3T regions of Papua, implementation faces geographical, cultural, and socio-economic complexities that require specific adaptations, which are the focus of this systematic review. The aim of this systematic review was to identify implementation gaps and relevant adaptive strategies of stunting reduction programs in Papua, Indonesia. Papua was chosen as the focus of the study because it represents a regional context with complex structural challenges, including limited health system capacity, difficult geographical conditions, and high socio-cultural diversity. These characteristics are in line with the conditions faced by many regions in low- and middle-income countries. Therefore, the results are expected to provide lessons that can be transferred globally, especially to island regions, indigenous communities, and remote areas that face similar challenges in implementing nutrition and public health programs.

Methods

Study design

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and was registered with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42026287975). A systematic literature review methodology was utilized to identify, appraise, and synthesize published evidence examining the implementation of stunting reduction interventions in Papua's 3T regions, characterized by geographical isolation, limited health infrastructure, and substantial cultural diversity. This approach facilitated the systematic examination of intervention effectiveness, implementation barriers, context-specific adaptive strategies, and health system capacity gaps. Findings from this review are expected to provide insights relevant to nutrition program implementation in remote and resource-constrained settings globally, particularly in geographically isolated communities with comparable socio-ecological challenges [26].

Eligibility criteria

This systematic review included studies evaluating the implementation or effectiveness of stunting reduction programs conducted in frontier, outermost, and least-developed areas of Papua, Indonesia. Eligible studies focused on nutritional, community-based, policy, or multisectoral interventions, employed qualitative, quantitative, or mixed-methods designs, were published between 2013 and 2025 in Indonesian or English, and had accessible full texts; studies not meeting these criteria were excluded (**Table 1**).

Table 1. Inclusion and exclusion criteria

Aspect	Inclusion criteria	Exclusion criteria
Study focus	Studies examining the implementation, execution, or evaluation of stunting reduction programs or interventions	Purely theoretical articles without implementation data
Intervention type	Studies discussing nutritional interventions, integrated health policies, community-based interventions, or multisectoral approaches	Studies that only report stunting prevalence without intervention components
Geographic context	Conducted in 3T regions	Studies conducted outside 3T regions
Study location	Conducted in the Papua region (including Papua, Papua Barat, Papua Tengah, Papua Selatan, Papua Pegunungan, and Papua Barat Daya provinces), Indonesia	Studies conducted outside the Papua geographical region
Study design	Qualitative, quantitative, or mixed-methods studies with clear methodology	Pure clinical or laboratory-based trials

Aspect	Inclusion criteria	Exclusion criteria
Publication period	Published between 1 January 2013 and 31 December 2025	Published outside the specified time frame
Language	Written in Indonesian or English	Written in languages other than Indonesian or English
Accessibility	Full-text articles accessible	Full text unavailable
Scientific quality	Peer-reviewed articles with clear methods and credible journals	Studies with unclear methodology, editorials, opinion pieces, or publications from non-credible journals

Search strategy

This study was conducted on November 25, 2025, using five databases: GARUDA, Google Scholar, ScienceDirect, Scopus, and Springer Link (**Table 2**). The search strategy used Boolean operators (AND, OR) and Medical Subject Headings (MeSH) terms to the specific syntax requirements of each database.

Table 2. Databases and search terms used in systematic search

Database	Search terms
GARUDA	"Stunting" AND "Papua" AND "Implementasi" AND "3T"
Google Scholar	"Stunting" AND "West Papua" AND "Implementation" AND "3T areas"
ScienceDirect	TITLE-ABSTR-KEY ("Stunting" AND "Papua" AND "Implementation")
Scopus	TITLE-ABS-KEY ("Stunting" AND "Papua" AND "Implementation" AND "Remote")
Springer Link	"Stunting" AND "Papua" AND "Intervention" AND "Nutrition"

Data extraction

For each eligible study, data were systematically extracted on sample size, country of origin, mean age of participants with corresponding standard deviation, severity of stunting, and reported outcomes. Key variables related to stunting interventions were comprehensively assessed, including implementation strategies, therapeutic approaches, duration of treatment, implementation barriers, and clinical effectiveness. Intervention types were identified using the full program name accompanied by the corresponding reference code. The duration of implementation was recorded in months, and the frequency of implementation was documented according to the specific intervention protocol described in each study. Reported barriers to implementation were extracted directly from the study documentation. Effectiveness was evaluated based on reported outcome measures, including changes in stunting prevalence, height-for-age Z-scores (HAZ), findings from multisectoral analyses, clinical symptom assessments, program success rates, and other relevant indicators specified by the respective studies.

Quality assessment

Methodological quality was assessed using the Joanna Briggs Institute (JBI) critical appraisal tools. These standardized instruments are designed to evaluate the risk of bias across various study designs. The appropriate JBI checklist was applied according to the design of each included study, including randomized controlled trials, cohort studies, case-control studies, cross-sectional studies, qualitative studies, and quasi-experimental studies. Each study was evaluated across relevant methodological domains specified in the corresponding checklist. The overall risk-of-bias judgment was categorized as low risk when all domains were assessed as having low risk of bias, some concerns when at least one domain indicated potential risk of bias, and high risk when one or more domains were judged to have a high risk of bias.

Results

This systematic literature review followed the PRISMA 2020 guidelines. The systematic search across five databases identified 206 articles (**Figure 1**). Following PRISMA guidelines, duplicates were removed, and titles, abstracts, and full-text articles were screened independently by two reviewers based on predetermined inclusion criteria. A total of 45 articles met the criteria for inclusion in the narrative synthesis [2-5,18,21,25,27-31,34-38,40-56,57-63]. Relevant grey literature, including government reports and technical documents from international

organizations, was included to provide contextual understanding of stunting program implementation challenges in Papua's remote and resource-limited settings [1,32,33,39,55].

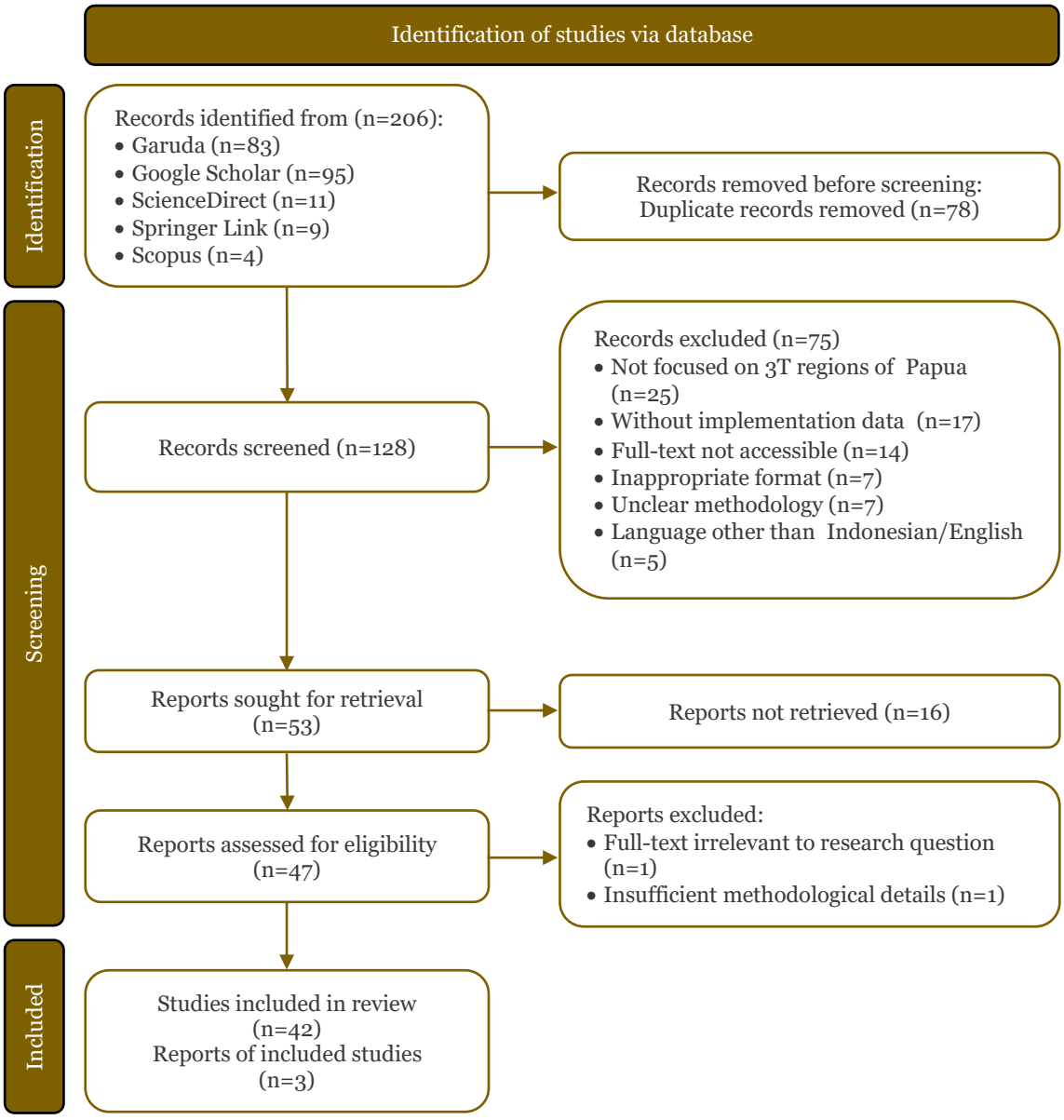

Figure 1. PRISMA flow diagram illustrating the study selection process, including identification, screening, eligibility assessment, and final inclusion of studies.

Study selection

A total of 45 studies are included, and their characteristics are presented in **Table 3**. Among the studies, most were published in 2024–2025 (75.6%), employed cross-sectional design (33.3%) or qualitative methods (26.7%), and focused on the Papua geographical region (100%), encompassing all six provinces resulting from regional expansion: Papua (55.6%), Papua Barat (17.8%), and other Papua provinces including Papua Selatan, Papua Pegunungan, Papua Tengah, and Papua Barat Daya (26.7%) (**Table 3**). Sample sizes ranged from 35 to 11,887 participants (mean=284), with 84.4% involving fewer than 500 participants. The geographic concentration and predominance of small-to-medium sample sizes reflect both research interest in the Papua geographical region and the logistical challenges of conducting large-scale studies in remote regions (**Table 3**).

Table 3. Characteristics of the studies selection

Author, year	Study design	Location	Sample (n)	Prevalence of stunting (%)	Intervention/program	Quality
Sulfiana *et al.*, 2024 [27]	Experimental RAL	Sorong City, Southwest Papua	30	27.2	Development of tuna fish sticks	Moderate
Lindawati *et al.*, 2024 [28]	Cross-sectional	Menawi Community Health Center, Yapen Islands	149	35.6	Analysis of exclusive breastfeeding	High
Allo *et al.*, 2024 [1]	Community service	Yaffi District, Keerom	73 neighborhoods	25.9	Stunting prevention awareness campaign	NA
Hukom *et al.*, 2023 [29]	Cross-sectional	East Sorong Community Health Center	77	28.6	Analysis of complementary feeding and income	High
Siagian *et al.*, 2021 [30]	Cross-sectional	Remu Selatan Village, Sorong	55	18.46	Diet and sanitation	High
Ekawati *et al.*, 2022 [31]	Cross-sectional	Kelurahan Kelapa Lima, Kabupaten Merauke, Papua	103	24.3	Maternal and child health factors	Moderate
Rumetor *et al.*, 2026 [32]	Community service	Kampung Meyes, North Manokwari, West Papua	40	N/A	Community education campaign on stunting prevention through milk consumption	NA
Manangsang *et al.*, 2024 [5]	Qualitative	Keerom Regency	11 informants	25.9	Strategic policy review	Moderate
Sileuw *et al.*, 2023 [33]	Qualitative	Yammua Village, Keerom	Women	N/A	Health awareness	NA
Rottin *et al.*, 2025 [34]	Cross-sectional	Wosi Community Health Center, West Papua	73	46.2	Risk analysis 6-24 months	High
Flassy and Hada, 2025 [3]	Mixed Methods	Sawa Erma District, Asmat	4 villages	54.5	Women's double burden	Moderate
Wulandari *et al.*, 2024 [35]	Cross-sectional	Nabire District	106	46.2	Eating behavior	High
Ramdany and Pongoh, 2022 [36]	Training	Malawei Village, Sorong	30	52.58	Blood clam nuggets	Moderate
De Fretes and Rohayu, 2022 [21]	Empowerment	Wartutin District, Fakfak	30	40.5	Early detection pocket book	Moderate
Kalampung *et al.*, 2025 [37]	Qualitative	South Sorong Regency	Purposive	N/A	Nutrition policy implementation	Moderate
Murib *et al.*, 2024 [2]	Qualitative	Papua Province	4 informants	N/A	Analysis of stunting programs	Moderate
Kumalasari *et al.*, 2020 [38]	Ethnography	Konda and Wamargege	54 toddlers	56	Study of the Tehit and Yaben tribes	Moderate
Frengky *et al.*, 2024 [39]	Empowerment	Ifar Besar Village	34 households	N/A	Comprehensive counseling	NA
Sokoy, 2023 [25]	Qualitative	Jayapura Regency	8 informants	13.8	Bangga Kencana Program	Moderate
Andriany *et al.*, 2025 [40]	Descriptive	Maibo Village, Sorong	24	17.22	Community-based strategy	Moderate
Agung and Majid, 2024 [41]	Qualitative	Merauke Regency	N/A	23.7	Optimization of the role of the health office	Moderate
Lestari *et al.*, 2025 [42]	Quasi Experiment	Sentani, Jayapura	14	16.42	Sago-gabus fish cookies	High

Author, year	Study design	Location	Sample (n)	Prevalence of stunting (%)	Intervention/program	Quality
Prasetya *et al.*, 2024 [43]	Qualitative	Merauke Regency	N/A	23.7	Role of the government and BPJS	Moderate
Tappy, 2024 [44]	Cross-sectional	Jayapura Community Health Center	100	9.9	Behavior of pregnant and breastfeeding mothers	Moderate
Jasper *et al.*, 2022 [45]	Cluster Analysis	Papua and West Papua	42 districts/cities	N/A	Mapping of stunting indicators	High
Laila *et al.*, 2023 [46]	Cross-sectional	Bomomani Community Health Center	82	52	Health Belief Model	High
Nurak and Bakri, 2022 [4]	Qualitative	Pegunungan Bintang Regency	N/A	55	Role of local government	Moderate
Hasnawati *et al.*, 2024 [47]	Cross-sectional	Arso 3 Community Health Center	283	9.9	Knowledge and income	High
Karubuy, 2024 [48]	Qualitative	Wondama Bay	Stunting reduction acceleration team	26.1	Policy implementation	Moderate
Maluangan *et al.*, 2023 [49]	Case-Control	Sarmi Community Health Center	60	19	Malaria-stunting	High
Kadar *et al.*, 2025 [50]	Qualitative	Southwest Papua	Stunting reduction acceleration team	31	Stunting reduction acceleration team collaboration	Moderate
Wulandari *et al.*, 2022 [51]	Cross-sectional	Papua	11,887	33.1	Maternal characteristics	High
Ngardita *et al.*, 2021 [52]	Cross-sectional	Keerom Regency	324	10.1	Breastfeeding and food consumption	High
Wenno, 2023 [53]	Qualitative	Yapen Islands	12 informants	17.9	BAAS Program	Moderate
Kogoya, 2023 [18]	Qualitative	Tagime, Jayawijaya	5 villages	0.1	Policy implementation	Moderate
Sianipar *et al.*, 2021 [54]	Qualitative	Asmat Regency	8 informants	28.5	Local food processing human resources	Moderate
Briawan *et al.*, 2023 [55]	Policy Brief	Maluku and Papua	4 provinces	29.5	Pentahelix strategy	NA
Wahyudianto and Prasetyo, 2024 [56]	Narrative policy analysis	Papua region	N/A	Not reported (policy/narrative focus)	Multisectoral synergy approach to stunting reduction	Moderate
Felle and Sahiddin, 2024 [57]	Case-Control	14 Community Health Centers in Papua	681	N/A	Maternal malaria-child stunting	High
Karundeng *et al.*, 2024 [58]	Community service	Kemala Health Center, Mimika	16	33	Stunting ID Card	Moderate
Arief *et al.*, 2025 [59]	Cross-sectional	Indonesia (Papua and Maluku)	78,049	26.2	Socio-environmental determinants	High
Astuti, 2022 [60]	Cross-sectional	Papua and West Papua	42 districts/cities	29.5	Sanitation and drinking water	High
Rusnaeni *et al.*, 2024 [61]	Cross-sectional	Papua Health Center	496	10.3	Posyandu stunting factors	High
Ashar *et al.*, 2024 [62]	Cross-sectional	Papua	2,937	20.7	Children under 2 years old	High
Putro *et al.*, 2020 [63]	Mixed Methods	South Sorong	85	54.1	Local wisdom	Moderate

Study bias risk

Overall, while most studies demonstrated adequate methodological quality, the findings highlight the need for more rigorous study designs, particularly in qualitative and intervention research, to strengthen the evidence base for stunting prevention and management in Papua. Five studies [1,32,33,39,55] were not assessable using JBI critical appraisal tools, as they represented community service reports or policy briefs without explicit research designs, systematic methodological frameworks, or standardized outcome measurements (**Table 4**). Despite this limitation, these publications were retained because they provided valuable contextual insights into stunting prevention efforts in Papua's remote and resource-limited settings. The "other designs" category included experimental, ethnography, descriptive, cluster analysis, narrative policy analysis, training, and empowerment (**Table 4**).

Table 4. Joanna Briggs Institute (JBI) critical appraisal quality assessment results

Study type	n	High quality (0.72–0.78)	Moderate quality (0.56–0.71)
Cross-sectional	15	13	2
Qualitative	12	0	12
Case-control	2	2	0
Mixed methods	2	0	2
Quasi experimental	1	1	0
Other designs	8	1	7
Total	40	17 (42.5%)	23 (57.5%)

Implementation of policies and programs to reduce stunting in Papua

A review of 15 studies on the implementation of policies and programs to reduce stunting in the 3T areas of Papua during the period 2020–2025 revealed substantial variation in implementation performance (**Table 5**). The overall weighted average success rate across the 15 reviewed studies was 6.72/10 (**Figure 2**), indicating moderate implementation effectiveness. Evidence-based planning achieved the highest average score (8.0/10) but was represented by only one study (6.7%), while community-based innovation also performed strongly (7.25/10) across four studies (26.7%). Capacity building and human resources recorded a solid average of 7.0/10 based on two studies (13.3%), and the comprehensive approach showed moderate performance (6.33/10; 20.0%).

In contrast, institutional strengthening strategy had the lowest average score (5.0/10) despite being the most represented category (33.3%). Temporally, implementation outcomes fluctuated, with high performance during 2020–2021 (8.5/10), declining in 2022 (6.0/10), and stabilizing during 2023–2025 at an average of 6.0/10 (**Figure 2**).

Structural barriers and challenges to program implementation

A total of 16 selected studies (2021–2025) were included to synthesize the structural barriers to the implementation of stunting reduction programs in Papua (**Table 6**). Based on this synthesis, 20 structural barriers were identified, reflecting interrelated challenges across social, service, and governance dimensions (**Table 6**).

Analysis of structural barriers (**Figure 3**) revealed consistent impact escalation across all categories. Socio-cultural and economic barriers showed the highest absolute impact (short-term: 4.8; long-term: 4.9; Δ=0.1), while infrastructure-geographic, human resource, governance, and environmental-sanitation barriers demonstrated more pronounced escalation (Δ=0.3), indicating systemic vulnerability without sustained investment and institutional reform. Based on the distribution of 20 identified barriers across 16 studies, human resources, governance and coordination, and socio-cultural and economic factors each constitute equal proportions of the predominant barriers (25.0%), followed by infrastructure-geographic constraints (15.0%), and environmental-sanitation issues (10.0%). These findings underscore the need for integrated approaches combining health system strengthening, culturally grounded community empowerment, and cross-sectoral governance reform in Papua's 3T regions.

Table 5. Categorization of studies on the implementation of policies and programs to reduce stunting in Papua

Category	Location	Focus/program	Success	Challenge	Key findings	Study
Community-based innovation	South Sorong	Nutrition House and Nutrition Reef Program	9/10	3/10	Sustainable model based on local wisdom	[63]
	Jayapura Regency	Bangga Kencana Program	8/10	4/10	Acceleration of effective implementation	[25]
	Sorong	SISAGU Program	7/10	5/10	Spatial distribution of identified cases	[20]
	Yapen Islands	BAAS Program	5/10	8/10	Geographical constraints and limited human resources	[53]
Institutional strengthening	Pegunungan Bintang	Role of local government	4/10	9/10	Extreme geography, limited human resources	[4]
	Wondama Bay	Stunting reduction acceleration team	4/10	8/10	Sectoral ego hinders stunting reduction acceleration team	[48]
	Merauke	Optimization of the health office	5/10	7/10	The role of the health office is not yet optimal	[41]
	Merauke	Collaboration between local government and BPJS	6/10	6/10	Synergy between local government and BPJS is not yet optimal	[43]
	Papua	Governance and policy integration	6/10	7/10	Weak interagency coordination and ineffective monitoring hinder stunting governance	[56]
Comprehensive approach	Keerom	Strategic policy	7/10	7/10	Decrease in prevalence; infrastructure challenges	[5]
	Papua (Province)	Provincial program	5/10	8/10	Significant input- process-output gap	[2]
	Papua	Holistic multisectoral strategy	7/10	6/10	A holistic approach integrating health, nutrition, and social sectors with community involvement reduces stunting prevalence	[56]
Capacity building and human resources	Asmat	Local food human resources	8/10	5/10	Effective local nutrition education	[54]
	Jayawijaya	District policy	6/10	7/10	Good communication is required; inadequate facilities	[18]
Evidence-based planning	Papua and West Papua	Priority mapping	8/10	3/10	Priority clusters for targeting	[45]

Figure 2. Success rate and distribution of studies by implementation category of stunting reduction policies and programs in Papua.

Table 6. Categorization of structural barriers to the implementation of stunting reduction programs in Papua

Category	Findings	Study
Infrastructure and geography	Difficult geographical terrain, limited access to health facilities, and minimal basic infrastructure.	[2,4,5,53]
Human resources	Shortage of healthcare workers, limited competencies, low fourth antenatal care visit coverage, and low motivation among cadres.	[4,5,18, 53,54]
	Communication and human resources are still lacking, low cadre motivation, and capacity in program implementation.	[25]
Governance and coordination	Sectoral ego, weak coordination between Regional Government Organizations, uneven shared power/responsibility, eight convergences comprising: antenatal care, skilled birth attendance, postnatal care, exclusive breastfeeding, growth monitoring, vitamin A supplementation, child immunization, and access to clean water and sanitation, were not optimally implemented.	[2,43,48,50]
	Weak cross-sectoral coordination, integration of health, nutrition, and social sectors not yet optimal, and a need for strengthened multisectoral synergy.	[55,56]
Socio-cultural and economic	Low nutrition knowledge, local culture, reluctance to visit *Posyandu*, behavior of selling own food products, unbalanced diet, poor sanitation, and recurrent infections are contributing factors to stunting.	[5,18,37, 39,41,54]
Environment and sanitation	Poor sanitation and low adoption of clean and healthy living behavior.	[18,31,37,54]

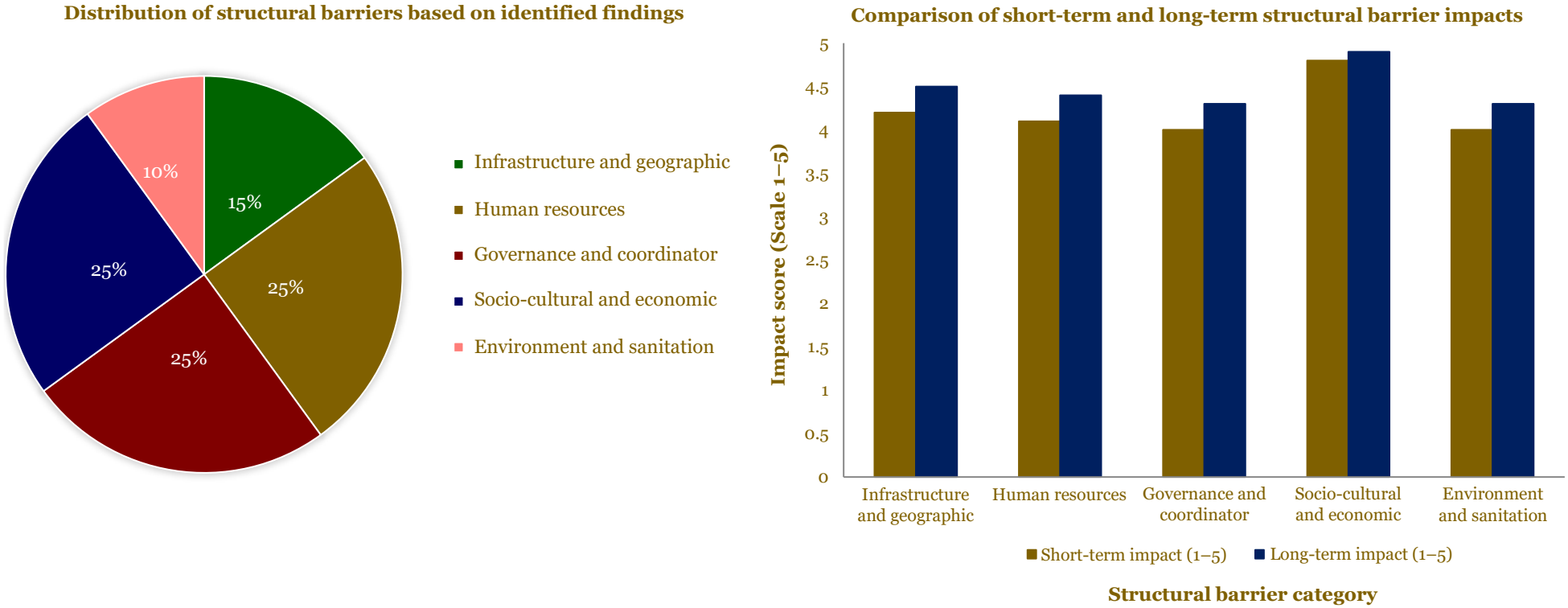

Figure 3. Distribution and short-term versus long-term impact comparison of structural barriers affecting stunting reduction programs in Papua.

Risk factors and determinants of stunting, and the influence on program effectiveness

A comprehensive analysis of risk factors and determinants of stunting and their influence on program effectiveness was conducted, synthesizing evidence from 16 empirical studies (2020–2025) (**Table 7**). This multi-level framework examined how these determinants influence stunting reduction program effectiveness across individual, household, community, and population levels.

Table 7. Risk factors and determinants of stunting and their influence on program effectiveness

Category	Findings	Reference
Nutritional determinants and family behavior	Exclusive breastfeeding and family nutritional behavior are significant determinants; feeding patterns and environmental sanitation are strongly associated with stunting	[28,30,35]
	Quality of complementary feeding and family income on stunting incidence	[29]
	Birth weight, birth length, and maternal nutritional status during pregnancy were significantly associated with stunting; child sex and maternal height were not associated.	[31]
	Exclusive breastfeeding, infection, and immunization are major risk factors	[34]
Maternal knowledge and behavior factors	Maternal knowledge and actions are associated with stunting; attitudes are not significant	[44]
	Components of the Health Belief Model (perceived benefit, barrier, and so on) are strong determinants	[46]
	Nutrition knowledge and family income are significant determinants	[47]
	Nutritional benefit, knowledge, and children's age <2 years as protective factors	[61]
Infection factors and maternal health	Malaria in toddlers as a dominant factor in stunting (OR≈4)	[49]
	Malaria in pregnant women as an independent risk factor	[57]
	Maternal characteristics (education, marital status) and stunting risk	[51]
Social and gender determinants and national and regional level analysis	The double burden on women (maternal nutrition, workload, violence) is related to high stunting rates	[3]
	Food consumption and exclusive breastfeeding are significant factors (albeit weak)	[52]
	Social and environmental determinants (immunization, diarrhea, water, Social Protection Card (*Kartu Perlindungan Sosial*/KPS), location) at the national level	[59]
	Access to sanitation and safe drinking water affects the prevalence of stunting in districts/cities	[60]
	Place of residence, maternal age, education, poverty, and EBFI as determinants of stunting	[62]
Socio-economic factors and specific communities	Parenting practices, poor eating habits, and sanitation in the Tehit and Yaben indigenous communities	[38]
	Socio-economic factors and consumption practices are causing malnutrition and stunting	[54]

Among 18 risk factors identified across five categories, nutritional determinants and family behavior as well as maternal knowledge and behavior factors were the most dominant, each contributing 22.2% of the findings, followed by social and gender determinants and national and regional analysis (27.8%), infection and maternal health factors (16.7%), and socio-economic and specific communities (11.1%) (**Figure 4A**). The evidence-based significance ratings identified infection and maternal health factors as receiving the highest score (4.8/5.0), followed by nutritional determinants and family behavior (4.6/5.0), maternal knowledge and behavior factors (4.3/5.0), social and gender determinants (4.2/5.0), national and regional level analysis (4.1/5.0), and socio-economic and specific communities (3.9/5.0), with an average significance score of 4.32/5.0 (**Figure 4B**).

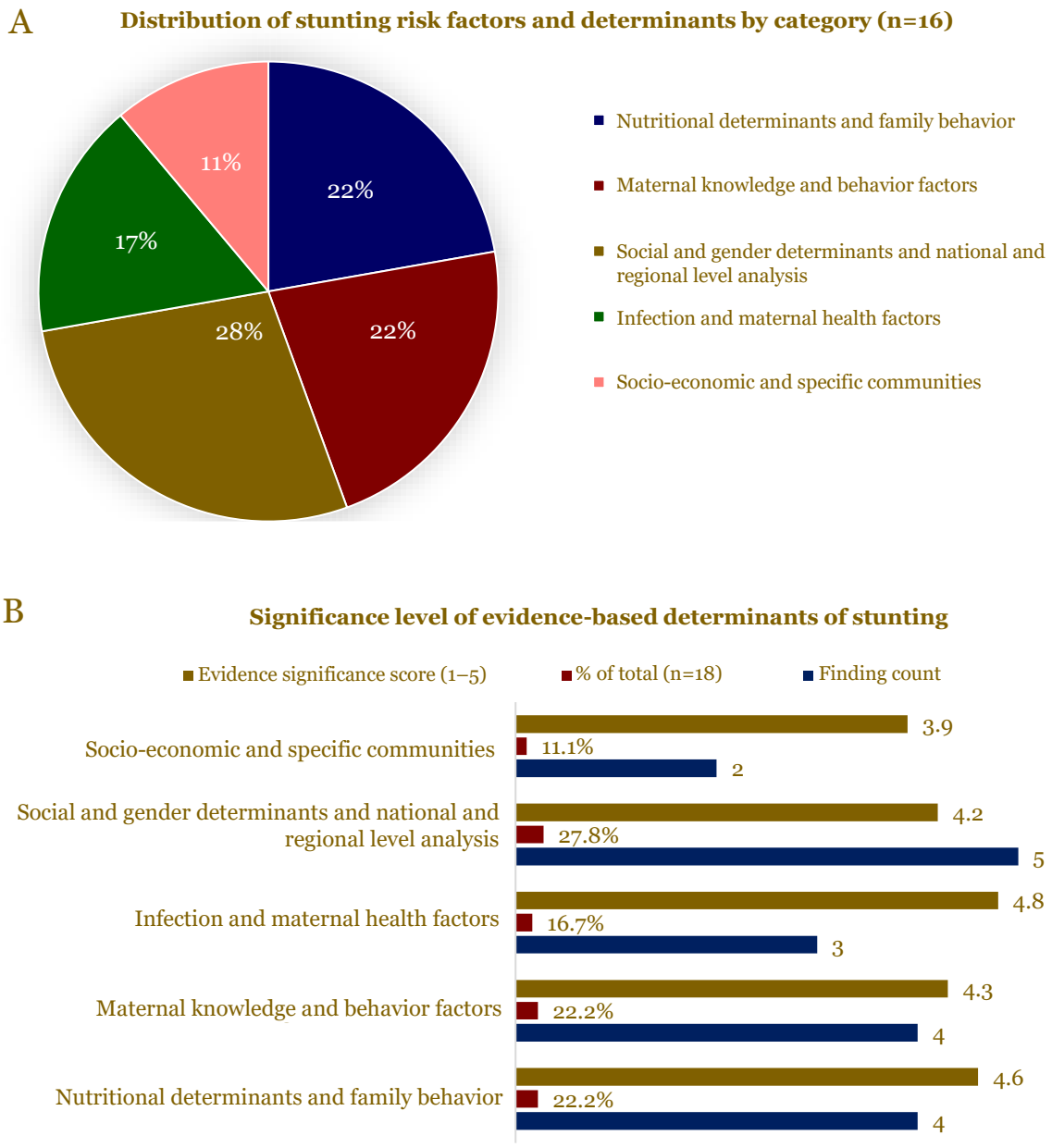

Figure 4. Distribution and significance of risk factors and determinants of stunting in Papua.

Cross-sector collaboration, program management and institutional roles

The dual-scoring framework assessing success and challenges in governance performance for stunting reduction is presented in **Table 8**. The evaluation included: (1) cross-sector collaboration emphasizing the pentahelix approach and multisectoral synergy; (2) program management, covering cluster mapping and institutional collaboration; (3) the role of health institutions, with a focus on multifunctional roles (facilitative, educational, technical); (4) governance and shared power in stunting reduction acceleration team; and (5) the role of local institutions, incorporating the PPKB office and district structures. This framework offers a comprehensive evaluation of collaborative effectiveness in stunting reduction efforts.

Table 8. Cross-sector collaboration, program management, and institutional roles in stunting reduction in Papua

Category	Location	Focus/program	Success	Challenge	Key findings	Study
Cross sector	Maluku and Papua	The local government's pentahelix approach	8/10	5/10	Collaboration between government actors, academics, and the community	[55]

Category	Location	Focus/program	Success	Challenge	Key findings	Study
					increases program legitimacy, but cross-sector coordination is still not institutionalized	
Collaboration	Papua	Multisectoral synergy of stunting programs	7/10	6/10	Cross-sectoral synergy expands the scope of intervention, but planning and budget integration remain weak	[56]
Program management	Papua and West Papua	Mapping of stunting clusters	8/10	4/10	A data-driven approach strengthens priority setting and resource allocation in a more targeted manner	[45]
	Merauke	Local government BPJS health collaboration	6/10	6/10	Collaboration improves access to services, but administrative obstacles and fragmentation of the financing system still exist	[43]
Role of health institutions	Merauke	Role of the health office (facilitative, educational, representational, technical)	7/10	5/10	The health office plays a strategic role as coordinator, but technical capacity is uneven	[41]
Governance and shared power	Southwest Papua	The dynamics of shared power in stunting reduction acceleration team	6/10	7/10	Trust and division of roles among actors are not yet stable, affecting the effectiveness of coordination	[50]
The role of local institutions	Papua	Synergetic role of the Family Planning Field Officer, Puskesmas, and district offices	7/10	6/10	The involvement of local actors accelerated implementation, but limited human resources and district authority were obstacles	[25]

The distribution of collaborative efforts in stunting reduction across five categories is presented in **Figure 5A**. Analysis of success and challenge scores (scale 1–10) revealed variability, with cross-sector collaboration showing the highest average success score (7.5/10) and program management (7.0/10) with moderate challenges, while governance and shared power show the lowest performance (success score 6.0/10, challenge score 7.0/10) (**Figure 5B**). The Net Performance Index (NPI = success – challenge, scale 1–10) highlighted the effectiveness of collaboration: cross-sector collaboration, program management, and health institutions' strategy each demonstrated a positive NPI of +2.0, indicating effective collaborative performance (**Figure 5B**). The role of local institution strategy showed a moderate NPI of +1.0, suggesting room for improvement in district-level implementation. In contrast, governance and shared power strategy recorded a negative NPI of –1.0, indicating that challenges outweigh successes and underscoring the urgent need for governance reform in stunting reduction acceleration team coordination. The distribution shows a focus on multi-stakeholder collaboration and local institutions, with a geographical concentration of studies in Papua and Merauke, indicating the importance of contextual approaches in stunting reduction strategies.

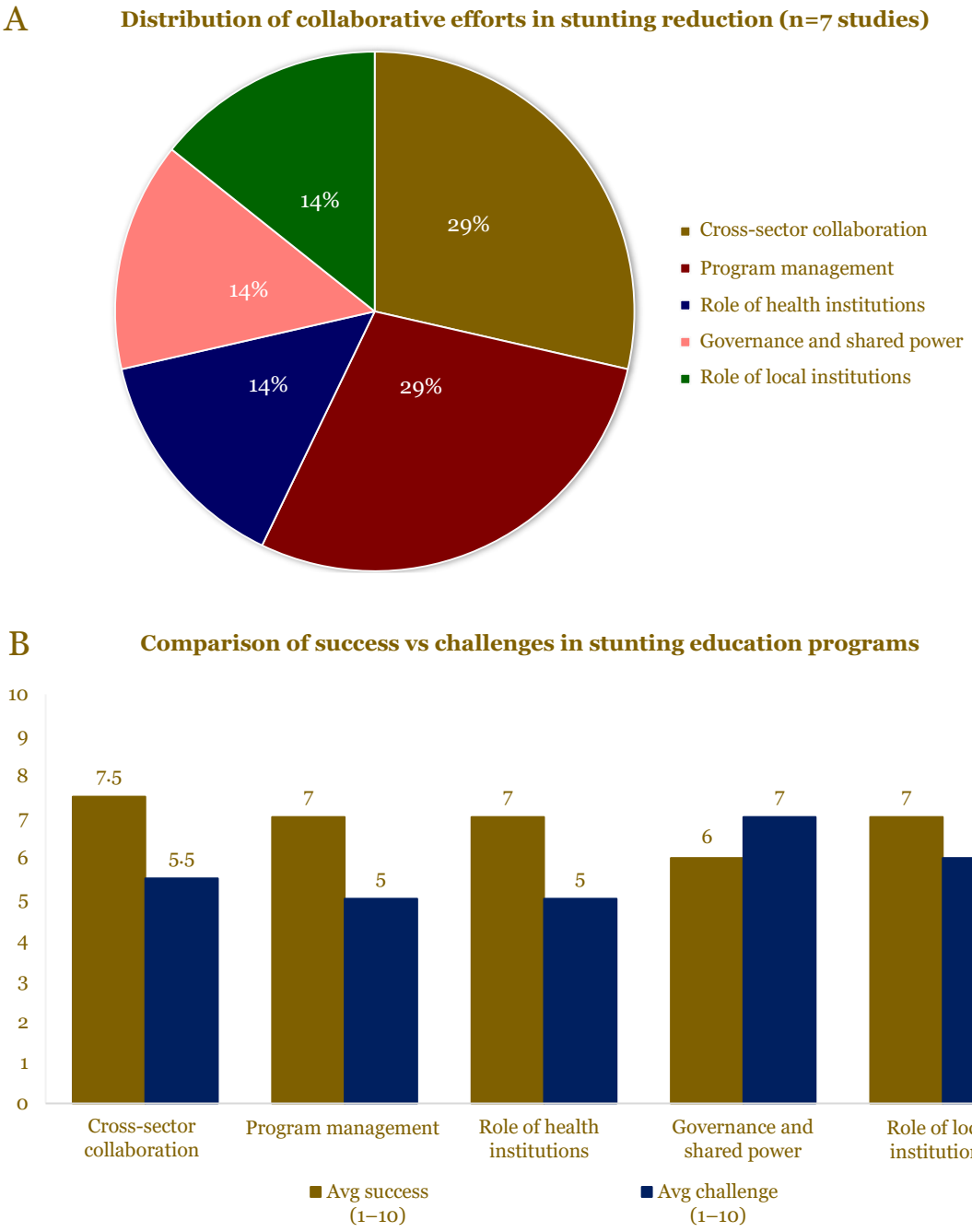

Figure 5. Distribution of findings and comparison of success vs challenges in stunting reduction collaboration in Papua.

Effective strategies and approaches relevant to the socio-cultural conditions in Papua region

A total of 13 studies were included to identify stunting prevention strategies in rural and remote areas of Papua. The distribution of studies and the reported effectiveness of each intervention based on the complete dataset are presented in **Table 9**.

Table 9. Effective strategies and approaches relevant to the socio-cultural conditions in Papua region

Category	Location	Approach	Effectiveness	Key findings	Study
Nutritious local food innovation	Papua	Yellowfin tuna fish sticks	High	The use of local food ingredients increases acceptance and sustainability of interventions	[27]

Category	Location	Approach	Effectiveness	Key findings	Study
	Papua	Blood clam nuggets as PMT	Moderate–High	Improved nutritional knowledge and family acceptance of locally based supplementary feeding	[36]
	Papua	Sago snakehead fish cookies	High	Effective in increasing the weight of stunted toddlers and in line with local consumption patterns	[42]
	Papua	Nutrition House and Nutrition Reef	High	Local wisdom strengthens family and community participation	[63]
Community education and socialization	Yaffi, Papua	Stunting Prevention awareness	Ongoing	Improving family knowledge through a participatory approach	[1]
	Keerom	Education on stunting, nutrition, and sanitation	Currently	Integration of health issues relevant to local needs	[33]
	Ifar Besar	Malaria, stunting, and healthy lifestyle education	Ongoing	Holistic approach in line with the context of double disease burden	[39]
	Papua	Nutrition campaign for prospective teachers	In progress	Young change agents expanding the reach of education	[35]
	Papua	Pocketbook on stunting for cadres and parents	Currently	Simple media to improve health literacy	[21]
	Papua	Stunting ID Card (game card)	High	Interactive methods to enhance cadre capacity	[58]
Strengthening the capacity of cadres and human resources	Papua	Strengthening local food processing human resources	High	Long-term strategies for program sustainability	[54]
	Papua	Pentahelix strategy	High	Collaboration between local actors increases program legitimacy	[55]
Multisectoral and pentahelix approach	Papua	Multisectoral based on the 1,000 days of life program and customary law	High	Empowering indigenous communities strengthens effectiveness	[56]

Community education and socialization accounted for the largest share of studies (46.2%, n=6) but showed the lowest success rate (33%) (**Figure 6**). In contrast, capacity strengthening of cadres and human resources (15.4%, n=2) and multisectoral and pentahelix approaches (7.7%, n=1) each achieved a 100% success rate. Nutritious local food innovations (30.8%, n=4) demonstrated a success rate of 75%, supporting the potential of locally sourced solutions (**Figure 6**). Collectively, these findings indicate that future work should prioritize high-impact interventions that integrate local knowledge and innovative implementation strategies to support sustainable stunting prevention in Papua.

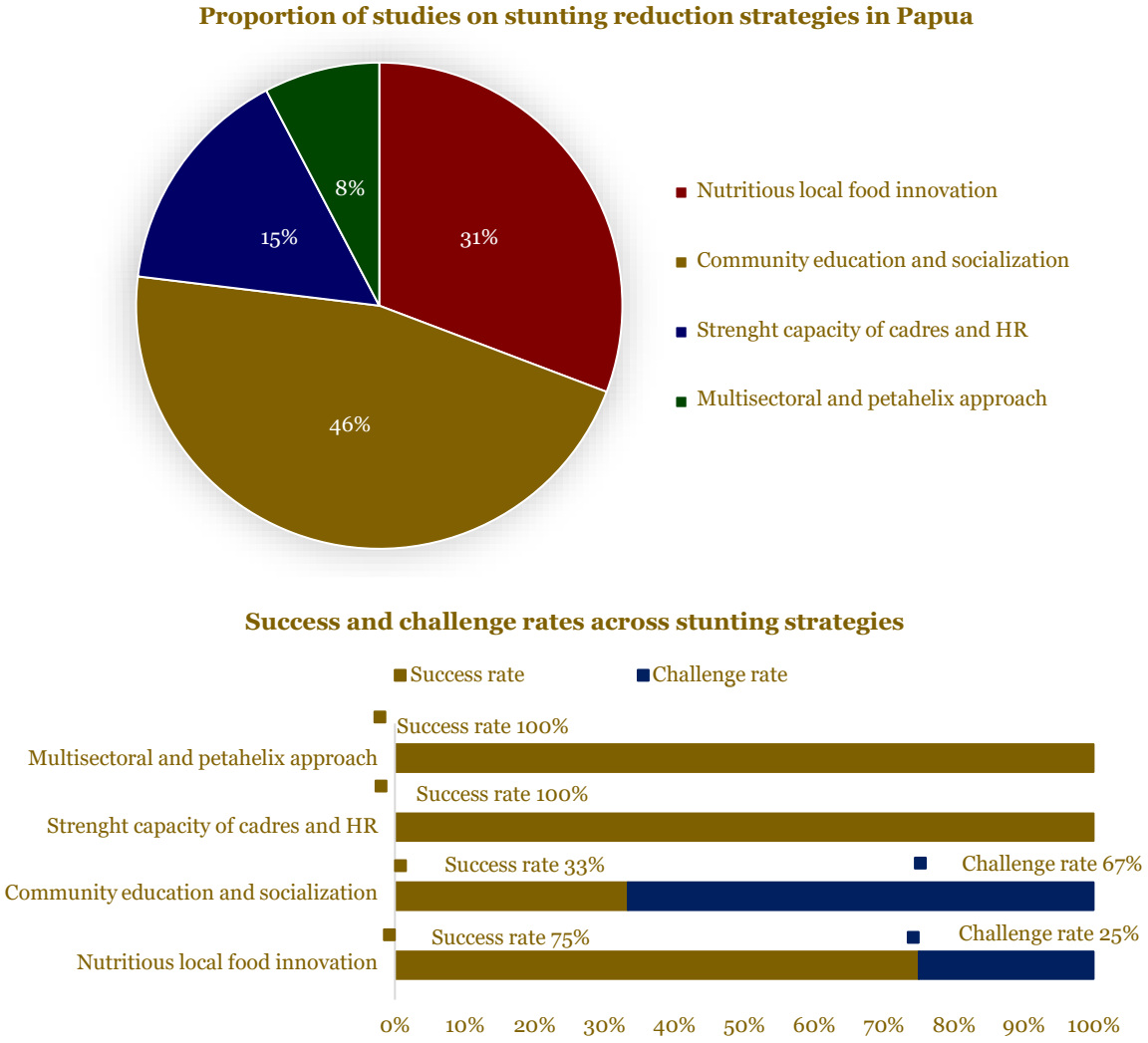

Figure 6. Distribution of studies and success rates for effective strategies and approaches in stunting reduction in Papua.

Discussion

A systematic review of 45 studies confirmed the implementation of a national framework comprising eight convergence actions and the stunting reduction acceleration team as a formal coordination mechanism across Papua's 3T regions. However, structural barriers continue to undermine program effectiveness. The burden of stunting remains highest in geographically isolated districts, with Pegunungan Bintang (55.4%) and Asmat (54.5%) far exceeding both the provincial mean (34.6%) and the national target (14%) [4,5]. Within Keerom Regency (25.9%), intra-district disparities are also evident, with cases ranging from 110 toddlers in Arso Barat to only 6 toddlers in Senggi, reflecting inequitable service reach [5]. At the health system level, nutrition officer positions are frequently filled by midwives and nurses whose primary competencies lie outside nutrition, which may compromise the fidelity of intervention delivery [2]. In addition, inactive stunting reduction acceleration team agendas, weak inter-agency coordination, and sectoral fragmentation further limit effective resource allocation [48]. These governance challenges are reflected in measurable outcomes; for example, stunting prevalence in Wondiboi District increased from 3.18% to 23.8% within a single year, driven by personnel shortages, financial constraints, and communication failures that prevented program information from reaching district officials and primary health centers [25,48].

The determinants of stunting in Papua are multidimensional, encompassing inadequate nutrition practices (such as suboptimal exclusive breastfeeding), endemic infectious diseases (including malaria, diarrhea, and acute respiratory infections), poor sanitation, limited access to clean water, and broader socioeconomic factors such as low maternal education and poverty

[32,51,59]. In Asmat, for instance, stunting prevalence increased from 19.54% in 2020 to 28.5% in 2021, with Unir Sirau Sub-district reaching 73.37%. This rise was driven not only by food availability but also by limited knowledge of local food processing, where communities often sold nutritious catches and harvests to purchase nutritionally inferior products [54]. These interacting determinants create a complex implementation environment in which standard top-down interventions frequently produce suboptimal outcomes. This pattern is consistent with implementation science evidence suggesting that intervention failure often reflects poor contextual fit rather than ineffective core components. Consequently, context-sensitive strategies have emerged as important adaptive approaches. Initiatives such as Nutrition Houses (*Rumah Gizi*) and Nutrition Reefs (*Karang Gizi*) in South Sorong [63], as well as community-based food processing education programs in Asmat [54], demonstrate that embedding interventions within local cultural practices—by leveraging traditional food systems, indigenous knowledge networks, and community participation structures—can substantially improve program reach and long-term sustainability compared with generic approaches.

These findings are consistent with global evidence highlighting the challenges of implementing nutrition interventions in remote settings, including weak health systems and limited access to essential services in low- and middle-income countries [64]. The conceptual framework of malnutrition proposed by Black *et al.* (2013) further illustrates the complexity of stunting determinants in Papua across three hierarchical levels: (1) immediate causes—insufficient dietary intake and infectious diseases such as diarrhoea and pneumonia, which are globally associated with approximately 875,000 child deaths attributable to wasting [65]; (2) underlying causes—household food insecurity, suboptimal caregiving practices, and limited access to health services and sanitation; and (3) basic determinants—poverty, socioeconomic inequality, weak governance, and inadequate investment in human capital. In Papua, these three levels operate simultaneously, making stunting a multidimensional problem that requires a comprehensive multisectoral response rather than reliance on single-sector clinical interventions alone [65].

The success of stunting reduction programs is therefore determined not only by the availability of nutritional interventions but also by mechanisms that promote community ownership and long-term sustainability. Evidence from the BAAS program in Takalar Regency (n=942) demonstrated significant improvements in height-for-age Z-scores, from −2.78 to −0.40 (p=0.000), through active multisectoral community engagement [66]. The implementation of BAAS in Papua, including in Yapen Islands Regency, indicates similar potential. However, it faces more severe structural constraints, including extreme geographical isolation, limited health infrastructure, and deeply embedded indigenous cultural practices [53]. These barriers are more pronounced than those faced by other indigenous populations, such as Aboriginal communities in Australia and Native American populations in the United States, where culturally sensitive and community-led interventions have been recognized as key determinants of program success [67,68]. Given Papua's persistently high stunting prevalence (29.5–39.4%) [69], culturally grounded community ownership and strengthened local health systems are therefore fundamental prerequisites for sustainable program implementation.

Local food-based interventions have also shown promising results in the Papuan context. Innovations such as tuna sticks [27], blood cockle nuggets [36], and *sagu–gabus* fish cookies [42] have demonstrated greater effectiveness and sustainability than generic approaches because they are based on familiar and culturally acceptable dietary practices [38,63]. In addition, community-based initiatives such as Nutrition Houses have successfully engaged local communities in food preparation and nutrition education, thereby strengthening local ownership and long-term program sustainability. These localized approaches align with growing global evidence suggesting that indigenous food systems and traditional knowledge can play a pivotal role in improving nutrition outcomes [70,71].

The policy implications are therefore clear. Strengthening local food-based interventions and adapting national programs to align with Papuan cultural contexts are essential for improving program effectiveness [54,63]. Moving away from generic, one-size-fits-all interventions toward culturally sensitive and community-driven approaches is critical for achieving sustainable stunting reduction. Furthermore, health policies should prioritize

strengthening the capacity of local health cadres and traditional leaders to serve as bridges between formal health systems and communities. Cross-sectoral coordination should also be reinforced through consistent implementation of the pentahelix model and governance reforms within the stunting reduction acceleration team to improve resource allocation and minimize program fragmentation [50,55].

Women's empowerment is critical because maternal health and caregiving capacity strongly influence child growth during the first 1,000 days of life. In Asmat, 81.03% of mothers were malnourished, and 90% had not completed primary education—conditions associated with the province's highest recorded stunting prevalence (54.5%) [3]. Accordingly, children born to undernourished mothers with limited health and nutrition knowledge may face a substantially higher risk of stunting. Endemic infections and inadequate sanitation further amplify this risk: malaria was associated with a fourfold higher likelihood of stunting among children aged 24–59 months in Sarmi [49], and each 1% decrease in access to improved sanitation in Papua was associated with a 1.56% increase in stunting prevalence [60]. These findings indicate that stunting reduction efforts in Papua are unlikely to succeed if they focus solely on food supplementation without concurrent strategies to improve maternal nutrition and health, strengthen malaria prevention and control, and expand sanitation coverage.

This review has several limitations. First, cross-sectional studies predominated (33.3%), limiting causal inference. Second, the evidence base was geographically concentrated in Papua and Merauke, which may reduce representativeness across all 3T regions. Third, the NPI derived from the collaboration analysis showed a negative score for Governance and Shared Power (–1.0), suggesting that challenges outweighed reported successes and indicating a need for governance reform; however, longitudinal validation of this metric was not available. Finally, limited long-term follow-up and a scarcity of macro-level policy publications constrained the assessment of intervention sustainability. Future research should prioritize longitudinal designs, implementation science–informed evaluations, and mixed-methods approaches to strengthen the evidence base for scalable and sustainable stunting reduction across Papua's 3T regions.

Conclusion

Effective stunting reduction in Papua's 3T regions requires culturally adapted, community-owned interventions that leverage indigenous food systems and traditional leadership, rather than relying solely on standardized national programs. Key barriers—geographical isolation, health workforce shortages, weak cross-sectoral coordination, and governance gaps—should be addressed through systemic reforms, including shared budgeting mechanisms, clear accountability, and greater regional flexibility. Multidimensional determinants, including maternal malnutrition, endemic disease, and poor sanitation, indicate that nutritional interventions alone are insufficient without concurrent health system strengthening and women's empowerment. Collectively, these findings offer evidence-informed guidance for other indigenous communities in geographically isolated settings, underscoring that sustainable stunting reduction is most likely when interventions are driven by community priorities rather than external mandates.

Ethics approval

Not required.

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

Artificial intelligence (AI) tools were used in a limited manner during manuscript preparation. ChatGPT and Claude AI were utilized solely for spelling and grammar checking, while Consensus was used to support identification of relevant scientific literature. No AI tools were used to generate research content, perform data analysis, or formulate interpretations or conclusions. The authors take full responsibility for the integrity and originality of all content presented in this article.

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