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Activating Community-Based Change Pathways for Stunting Prevention: Integrating Appropriate Technology and Primary Health Cadre Capacity in Rural Indonesia

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ABSTRACT

Introduction: Stunting continues to affect many children in rural areas of Indonesia. In these settings, households often face limited food access, constrained health services, and economic hardship. Programs that focus only on nutrition-specific interventions rarely address these broader conditions. Community-based approaches that combine appropriate technology, household food production, and strengthened roles of local health volunteers remain underexplored, particularly in village contexts.

Objective: This research examined changes in community knowledge, practical skills, and everyday practices after Women Farmer Groups (Kelompok Wanita Tani – KWT) and posyandu cadres received training in appropriate technology and nutrition education in Srikayangan Village, Kulon Progo.

Methods: A convergent mixed-methods approach was applied. The quantitative component used a quasi-experimental single-group pretest–posttest design involving 30 KWT members and 78 cadres. The qualitative component drew on field observations, focus group discussions, interviews, and documentation of program activities. Quantitative results were summarized descriptively and compared across time points, while qualitative materials were interpreted through thematic analysis and then considered together with the quantitative patterns. Anthropometric indicators such as HAZ/LAZ were not included; the evaluation centered on capacity building and shifts in community practice.

Results: Scores for knowledge rose markedly, with increases ranging from 40% to 86%. KWT participants also became more confident in using simple food-processing technologies, while cadres showed improvements in several aspects of nutrition service delivery. Field notes and interviews pointed to practical changes at the community level: greater use of locally available foods, growing interest in small-scale food enterprises, and more consistent child growth monitoring activities. Because the design did not include a comparison group, these patterns should be interpreted as observed improvements over time rather than direct causal effects.

Conclusion: Combining appropriate technology training with nutrition education appeared to strengthen several intermediate factors linked to child nutrition within households and the community. The study did not measure stunting prevalence, yet the approach offers a promising community model that may be adapted elsewhere. Further research is needed to examine longer-term outcomes.

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INTRODUCTION

Stunting refers to chronic undernutrition that disrupts children's linear growth, commonly identified when height or length-for-age falls below −2 SD based on international growth standards (1). The condition goes far beyond reduced stature. Children who experience stunting frequently face delays in cognitive and motor development, weaker immune responses, and reduced learning performance. The consequences may extend into adulthood, influencing productivity and long-term economic prospects (2,3). Because of these risks, preventive efforts during pregnancy and the first two years of life, the period often referred to as the First 1,000 Days of Life, receive particular attention in public health programs (4,5). Child growth, however, does not depend solely on biological factors. Family support, local norms, and broader social relations often shape caregiving practices and health behavior. Evidence reported by Riyadi et al. (6), for instance, points to the role of social capital in strengthening health intentions among adolescents. Such observations suggest that community initiatives may require more than technical instruction; social structures also matter.

Indonesia has placed stunting reduction high on the national development agenda. Policies in recent years involve coordination across several sectors, including health, food production, sanitation, education, and community empowerment (7). Yet progress remains uneven from one province to another, and even between neighboring districts. Access to primary health services is still inconsistent in some areas. Poverty and food insecurity continue to influence household diets. In other places, the availability of sanitation infrastructure or the capacity of community health cadres becomes a limiting factor. These variations shape how programs operate locally and partly explain why national strategies do not always yield similar outcomes across regions (8–10).

Such disparities are visible in many rural settings, including several sub-districts of Kulon Progo Regency where poverty levels remain relatively high. National statistics show gradual reductions in stunting prevalence, but community programs often encounter practical constraints once implemented at village level. Interventions that focus primarily on nutrition, supplementary feeding, micronutrient distribution, or short-term nutrition education, do not always translate into sustained improvements in child growth. The broader household environment still plays a large role. Food availability, sanitation conditions, caregiving practices, and economic resilience intersect in ways that shape children's nutritional trajectories. For that reason, many scholars have called attention to nutrition-sensitive approaches that link food security, income opportunities, sanitation improvement, and stimulation for early child development within a shared framework (11–14).

During the past decade, research exploring these integrated approaches has expanded. Several studies document how local food production combined with nutrition education can influence dietary diversity at household level. Animal-source foods, vegetables, and locally processed ingredients often become part of these strategies. One example from Ethiopia reported that agriculture-based nutrition programs accompanied by nutrition education improved children's length-for-age Z-scores (LAZ) (15). Reviews and meta-analyses published more recently describe similar patterns. Nutrition-sensitive interventions tend to improve dietary diversity and certain child nutrition outcomes, although the magnitude of change varies widely depending on socioeconomic conditions and household resources (14,16–18).

From a conceptual perspective, many programs draw on frameworks that distinguish nutrition-specific from nutrition-sensitive interventions. Other models emphasize pathways linking agriculture, food systems, and nutrition or highlight the role of behavioral change processes within communities. These frameworks have helped shape policy discussions and multisectoral strategies. In practice, however, program components are often implemented side by side rather than as a coordinated system at the community level. Research designs mirror this tendency. Some studies emphasize agricultural diversification, others concentrate on behavior change communication or caregiver education.

Despite the growing literature, comprehensive evaluations of multisectoral interventions remain relatively limited, particularly in rural and lower-income contexts. Many investigations focus on only one element; nutrition education, food production, or caregiving practice, without examining how these components interact in everyday community life. As a result, potential synergies between food production, economic activity, and caregiving behavior are not always well documented. In addition, mixed-methods approaches that combine quantitative indicators with qualitative insights are still uncommon in this field. Quantitative studies often report anthropometric or dietary outcomes, whereas qualitative research tends to explore perceptions and experiences separately. Integrating both perspectives could provide a more complete picture of how interventions unfold in real settings.

Several gaps emerge from this situation. First, many stunting prevention initiatives emphasize knowledge transfer through nutrition education but rarely integrate appropriate technology, economic training, and child growth monitoring services such as SDIDTK within a single operational model. Second, empirical data on how such integrated approaches influence measurable outcomes; knowledge, practical skills, household income, or caregiving routines, remain limited, especially when assessed through structured pretest–posttest designs. Third, although multisectoral strategies acknowledge the complexity of rural communities, their implementation is seldom examined using designs that deliberately combine quantitative measurement with contextual qualitative analysis. Fourth, documentation of implementation processes is often brief, leaving unanswered questions about how program activities interact with evolving community capacity.

The present research addresses these gaps by examining changes in participants' knowledge, skills, economic activities, and caregiving practices following a community-based intervention. The program combines several elements: appropriate technology training, local food innovation, including the development of IoT-supported Nutrition Gardens, productive economic activities among Women Farmer Groups (Kelompok Wanita Tani, KWT), and reinforcement of SDIDTK services conducted by community health cadres. Rather than presenting each component as a stand-alone technological innovation, the intervention is treated as an integrated community process. Technological adaptations and local initiatives are described as part of the implementation context that shapes outcomes.

Guided by these considerations, the study explores how an intervention linking technology use, nutrition education, and community capacity strengthening operates within a rural setting such as Kulon Progo. A convergent mixed-methods design is employed so that quantitative indicators; knowledge scores, skill development, economic participation, and caregiving practices, can be examined alongside qualitative accounts of community experiences, technology adoption, and questions of sustainability. Together, these perspectives offer a more grounded understanding of how integrated community programs may contribute to stunting prevention efforts.

METHOD

Study Design

A convergent mixed-methods approach guided the research process. In this design, quantitative and qualitative information are gathered during the same phase of the study, analyzed separately, and then interpreted together. The intention is to capture numerical changes produced by the intervention while also understanding how those changes are experienced within the community. Community programs rarely operate only through measurable outcomes; they also involve social interactions, local norms, and learning processes that develop over time. For that reason, combining statistical patterns with narrative accounts can provide a broader view of program implementation. This methodological orientation follows recommendations for evaluative research in public health and community empowerment programs, where integrating numerical results with contextual explanations is often encouraged (19).

The quantitative component adopted a quasi-experimental single-arm pretest–posttest structure. Participants first completed a baseline assessment before any exposure to training activities. Training sessions and mentoring activities were then delivered over several weeks. After the implementation phase had ended, the same indicators were measured again. The sequence of baseline assessment, training exposure, and post-intervention measurement had been defined at the beginning of the program so that changes observed later could be linked to the intervention period.

Quantitative and qualitative materials were collected within the same implementation window. Each dataset was initially examined on its own. Numerical results were summarized and compared across time points, while qualitative materials from interviews, observations, and discussions were reviewed to identify recurring patterns. Integration took place afterwards. Two steps were used during this phase. First, the interpretation stage compared statistical changes, such as score differences and estimated effect sizes, with themes emerging from qualitative analysis. The aim was to see whether the two strands pointed to similar conclusions, added complementary insights, or highlighted differences. Second, key results were organized in joint displays so that quantitative indicators and qualitative interpretations could be examined side by side. Through this process, the research team could explore not only whether change occurred, but also how those changes unfolded in the community setting.

Study Setting and Period

Field activities were carried out in Srikayangan Village, located in Kulon Progo Regency, Special Region of Yogyakarta. The village was selected purposively. Local government reports had identified the area as one where economic vulnerability and stunting concerns remained visible. At the same time, several community empowerment initiatives based on appropriate technology and local food production were already being introduced there. This situation provided an opportunity to observe how such initiatives operated in practice.

Data collection took place during 2023–2024 and followed the timeline of activities implemented within the partner community. The intervention itself ran for approximately six months. Activities began with a baseline assessment, followed by a series of core training sessions. Participants then continued with supervised practice and mentoring in their respective community groups. After this period of engagement, outcome measurements were repeated. The interval between baseline measurement and the post-intervention assessment ranged from roughly 12 to 16 weeks, which allowed participants time to apply the skills and practices introduced during training.

Quantitative Approach

Quantitative Population and Samples

Two participant groups formed the quantitative units of analysis.

Women Farmer Groups (Kelompok Wanita Tani – KWT). The population consisted of members involved in training related to appropriate technology and local food production. Thirty participants completed both baseline and post-intervention assessments and were included in the analysis.

Posyandu Cadres. The population consisted of posyandu cadres who participated in training on anthropometry, child growth and development monitoring (SDIDTK), and developmental stimulation. The final sample that met the inclusion criteria comprised 78 cadres.

Both samples were obtained using a total sampling technique, as all training participants were included in the evaluation process.

Quantitative Instruments

The research instruments consisted of pretest–posttest questionnaires developed based on AT training modules and cadre capacity-building materials. Indicator selection covered three domains, basic knowledge, practical skills, and application, to capture comprehensive changes in participant competencies.

The KWT instrument comprised 24 items, consisting of 10 knowledge items (multiple-choice), 8 practical skill assessment items (performance-based checklist), and 6 application scenario items (short structured responses). The cadre instrument consisted of 28 items, including 12 knowledge items, 10 skill demonstration items, and 6 application-based items.

The KWT instrument included topics such as; operation of solar dryers, processing organic waste into value-added products, food safety, and local food production management.

The posyandu cadre instrument included; standard procedures for anthropometric measurements, identification of nutritional problems, SDIDTK practices, and child developmental stimulation.

Knowledge items were scored dichotomously (1 = correct; 0 = incorrect), while application items were rated using a 0–2 rubric (0 = incorrect/no response; 1 = partially correct; 2 = correct and complete). Performance-based skill demonstrations were assessed using structured observation checklists with item scores ranging from 0–3 (0 = not performed; 1 = incorrect technique; 2 = partially correct; 3 = correct and complete execution).

Domain scores were summed and converted to a standardized scale of 0–100 to facilitate comparability across domains. Equal weighting was applied across the three domains to avoid overrepresentation of knowledge-based items relative to practical competencies.

Each instrument underwent content validity assessment by three experts in public health and community nutrition. Content validity was measured using the Content Validity Index (CVI), with I-CVI values ranging from 0.83 to 1.00 and an S-CVI/Ave score of 0.92, indicating strong content appropriateness.

Internal reliability testing was conducted during a pilot study with 20 respondents who had similar characteristics. The Cronbach's alpha values were 0.86 for the KWT instrument and 0.88 for the cadre instrument, demonstrating excellent reliability.

For performance-based assessments, two trained evaluators independently rated a subsample of 15 participants during the pilot phase. Inter-rater reliability was calculated using the Intraclass Correlation Coefficient (ICC), yielding values of 0.82 for the KWT skill domain and 0.85 for the cadre skill domain, indicating strong agreement between raters. Discrepancies were resolved through consensus discussion prior to final scoring.

Sample items included; 1) "Mention the first three steps in using a solar dryer" (knowledge), 2) "Demonstrate the correct position when measuring a toddler's body length" (skill) and, 3) "What action would you take if you encounter inconsistent measurement results?" (application).

Scoring protocols and observational rubrics were standardized prior to data collection through assessor training sessions to ensure procedural consistency and measurement stability.

The instruments were adapted to the local context through cognitive interviews with participant representatives to ensure language clarity and cultural relevance.

Quantitative Data Analysis

The baseline measurement was administered before any training activities began. Participants completed the pretest approximately one week prior to the first training session. The posttest was carried out after all intervention activities had ended, typically two to four weeks following the mentoring phase. This interval was intentionally provided so participants could begin applying the knowledge and skills introduced during the program in their daily activities.

Composite scores derived from the instruments represented ordinal-level measurements. Preliminary assessment of data distribution using the Shapiro–Wilk test indicated non-normality ($p < 0.05$). For that reason, results are summarized using medians and interquartile ranges (IQR) rather than mean values. This approach provides a more appropriate description of central tendency when distributions are skewed.

Changes between pretest and posttest scores were examined using the Wilcoxon signed-rank test for paired observations. Analyses were conducted separately for each outcome domain; knowledge, practical skills, and the application of skills in routine activities. For transparency in reporting, results include median differences, IQR values, Z statistics, exact p-values, and 95% confidence intervals (CI) for the median change.

To estimate the magnitude of change, effect sizes were calculated using the formula $r = Z/\sqrt{N}$. The resulting values were interpreted according to commonly used benchmarks: small effects (0.10–0.29), moderate effects (0.30–0.49), and large effects (≥0.50). Quantitative findings are therefore presented through a combination of median differences, dispersion measures, statistical test values, confidence intervals, and effect size estimates.

Because several outcome domains were examined within the same participant groups, the possibility of inflated type I error was considered. To address this issue, significance levels for the main domain comparisons were adjusted using a Bonferroni correction ($\alpha\_adjusted = 0.05$ divided by the number of domains tested). Both original and adjusted p-values are presented so that readers can interpret the results with full transparency.

Intervention Structure and Exposure Intensity

The intervention was organized as a combination of structured training sessions and follow-up mentoring. Activities were adapted to the roles and responsibilities of each participant group.

For KWT members:

Training for KWT members included four main instructional sessions, each lasting approximately three to four hours. Sessions were held every two weeks and focused on the use of appropriate technology, small-scale food processing techniques, and opportunities for local food-based entrepreneurship.

Participants also attended two practical workshops where they directly operated solar dryers and small food production equipment. These workshops emphasized hands-on experience rather than classroom instruction.

After the training phase, mentoring visits were conducted once per month over a three-month period. During these visits, the research team observed how the technologies were being used, discussed technical challenges with participants, and provided additional guidance when needed.

For posyandu cadres:

Cadres participated in three classroom sessions, each lasting around three hours. Topics included anthropometric measurement standards, the SDIDTK program for child growth and development monitoring, and practical approaches to nutrition counseling.

Two field-based practice sessions were then organized at active posyandu posts. During these sessions cadres practiced measurement techniques and documentation procedures under supervision to improve consistency across service activities.

Mentoring continued informally during routine posyandu service days. These visits allowed the research team to observe real service delivery conditions and offer feedback when required.

Attendance was recorded at every session. Participants were included in the final evaluation only if they attended at least 80% of the scheduled activities. Maintaining this level of participation was considered important to ensure sufficient exposure to the intervention components.

The structured sequence of training, practice, and mentoring was intended to provide participants with repeated opportunities to apply what they had learned. Documenting exposure intensity also allowed the research team to consider whether participation levels were plausibly linked to observed improvements in competence.

Mixed-Methods Integration

Quantitative and qualitative results were examined separately at first. After the initial analyses were completed, the research team reviewed both sets of findings together through a series of discussion sessions. These conversations focused on how numerical trends related to observations from the field.

In several instances, increases in quantitative scores were accompanied by qualitative accounts describing new practices or greater confidence in using the technologies introduced during training. Where patterns aligned, the interpretation was strengthened by the presence of evidence from both strands of the study. In other cases, qualitative information helped clarify why certain quantitative changes appeared smaller or more uneven across participants.

Situations where the two strands did not fully correspond were also discussed. Rather than treating these differences as inconsistencies, the team explored contextual explanations, such as variations in household resources, time availability, or local program conditions.

Through this iterative comparison process, the study generated integrated interpretations that combined statistical change with community experience. This approach follows widely recommended practices in mixed-methods research, where interpretation emerges from examining how different forms of evidence interact rather than from relying on a single analytical perspective.

RESULTS

Quantitative Findings

Respondent Characteristics

Respondent characteristics are presented in Table 1. Respondents consisted of members of Women Farmer Groups (KWT) and posyandu cadres with variations in age, educational background, and length of involvement in community activities.

Among KWT members (n = 30), 100% were female with a median age of 41 years (IQR 36–48). Among posyandu cadres (n = 78), 97.4% were female (76/78) and 2.6% male (2/78), with a median age of 38 years (IQR 32–45).

Most respondents were women in productive age groups actively engaged in posyandu services and local food processing.

Table 1. Characteristics of KWT Members and Posyandu Cadres

Characteristics	KWT (n = 30)	Cadres (n = 78)
Sex	Female 30 (100%)	Female 76 (97.4%); Male 2 (2.6%)
Age	30–55 years	25–50 years
Education	Junior–Senior High School	Senior High School–Diploma (D3)
Length of involvement	<3 yrs (46.7%); ≥3 yrs (53.3%)	1–5 yrs (33.3%); >5 yrs (66.7%)

Source: Primary Data, 2023.

Pretest–Posttest Results for KWT

Median (IQR) pretest–posttest scores are presented to align with ordinal data characteristics.

Table 2. Pretest–Posttest Scores of KWT Members (n=30)

Indicator	Pretest	Posttest	Increase (%)
Appropriate Technology (AT) Knowledge	52 (48-58)	84 (80-88)	+32
Food Processing Skills	48 (44-55)	82 (78-86)	+34
Hygiene & Sanitation	56 (50-60)	85 (82-90)	+29
Waste Utilization	45 (40–52)	80 (76–85)	+35

Source: Primary Data, 2023.

The Wilcoxon signed-rank test results are presented below (Table 3)
All p-values remained statistically significant after Bonferroni adjustment ($\alpha\_adjusted = 0.0125$).

Table 3. Wilcoxon Test Results for KWT Pretest–Posttest Scores

Indicator	Z	p-value	Effect size (r)	95% CI Median Change
AT Knowledge	-4.62	<0.001	0.60	28–35
Food Processing Skills	-4.71	<0.001	0.61	30-38
Hygiene & Sanitation	-4.55	<0.001	0.59	25-33
Waste Utilization	-4.68	<0.001	0.60	29–37

Source: Primary Data, 2023.

Wilcoxon tests indicated significant increases across all KWT indicators ($p < 0.001$; $Z = -4.55$ to -4.71), with large effect sizes ($r = 0.59–0.61$). These findings reflect substantial program-associated gains in appropriate technology knowledge, food processing skills, hygiene practices, and waste utilization. The observed improvements represent strengthened technical and managerial capacity at the household production level, conceptualized as intermediate determinants within community-based nutrition pathways rather than direct measures of child nutritional status.

However, as a single-group pretest–posttest design without a control group, the findings should be interpreted as program-level improvements rather than causal estimates. Potential influences such as testing familiarity, short-term motivation, or contextual training effects cannot be fully excluded.

Pretest–Posttest Results for Posyandu Cadres (n = 78)

Changes in knowledge and skills among posyandu cadres are shown in Table 4.

Table 4. Pretest–Posttest Scores of Posyandu Cadres (n=78)

Indicator	Pretest	Posttest	Increase (%)
Anthropometric Skills	60 (55-65)	88 (84-92)	+28
SDIDTK Knowledge	58 (52-63)	87 (82-91)	+29

Indicator	Pretest	Posttest	Increase (%)
Stimulation Techniques	54 (48-60)	84 (80-89)	+30
Parental Education Skills	50 (45-56)	83 (78-88)	+33

Source: Primary Data, 2023.

Table 5. Wilcoxon Test Results for Cadre Pretest–Posttest Scores

Indicator	Z	p-value	Effect size (r)
Anthropometric Skills	-7.88	<0.001	0.71
SDIDTK Knowledge	-7.74	<0.001	0.70
Stimulation Techniques	-7.60	<0.001	0.68
Parental Education	-7.92	<0.001	0.71

Source: Primary Data, 2023.

All cadre indicators demonstrated significant pre–post improvements ($p < 0.001$; $Z = -7.60$ to -7.92), with large effect sizes ($r = 0.68–0.71$). These results indicate substantial program-associated gains in anthropometric competence, SDIDTK knowledge, stimulation techniques, and parental education skills. The improvements reflect strengthened service-delivery capacity and quality of growth monitoring practices, conceptualized as proximal determinants within the broader causal chain of stunting prevention rather than direct evidence of stunting reduction.

Given the absence of a comparison group, these statistically large effects should be interpreted cautiously as strong program-level improvements rather than definitive evidence of causal superiority over alternative approaches.

Visual Representation of Quantitative Impact

To enhance conceptual clarity beyond tabular presentation, Figure 1 illustrates the magnitude of change across KWT and cadre indicators using effect size values. The visual comparison demonstrates consistently large effects across domains, with relatively stronger gains observed among posyandu cadres. This graphical presentation facilitates cross-group comparison and highlights patterns that may be less immediately visible in tabular form.

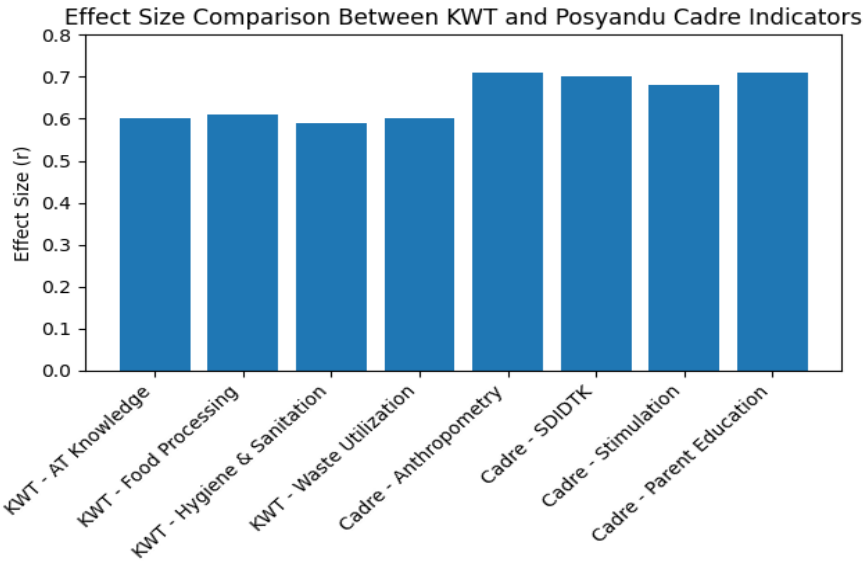

Figure 1. Effect Size Comparison Between KWT and Posyandu Cadre Indicators
Source: Primary Data, 2023.

Bar chart showing effect size (r) values from Wilcoxon signed-rank tests comparing pretest and posttest scores. All indicators demonstrate large effects ($r \geq 0.59$), with slightly higher gains observed among posyandu cadres.

Achievements of KWT

Achievements were assessed using a structured implementation checklist consisting of 10 binary (yes/no) indicators covering technology adoption, production practices, hygiene compliance, and product commercialization.

Table 6. KWT Achievements (Operationalized)

Indicator	n (%) Achieved (n=30)
Operated one unit of solar dryer	24 (80%)
Moringa powder, local chili paste, dried vegetables, egg-based products	21 (70%)
Products processed prior to sale	23 (76.7%)
Drying time reduced by 40–60%	18 (60%)
Members began planning AT-based production	19 (63.3%)

Source: Primary Data, 2023.

These proportions are based on direct observation during mentoring visits and cross-verified with production logs.

Achievements of Posyandu Cadres

Cadre performance was evaluated using a 12-item structured observational checklist aligned with national anthropometry and SDIDTK standards. Each item was scored 0 (incorrect) or 1 (correct). Competence was defined as achieving ≥80% correct performance.

Table 7. Achievements of Posyandu Cadres

Indicator	n (%) Competent (n=78)
Majority followed standard procedures	70 (89.7%)
Early identification of developmental delays	68 (87.2%)
Practiced during posyandu sessions	65 (83.3%)
Conveyed measurement results & follow-up advice	62 (79.5%)
More organized and standardized documentation	62 (79.5%)

Source: Primary Data, 2023.

No performance domain fell below 75%, replacing prior qualitative descriptors such as “majority followed standard procedures.”

Qualitative Findings

A total of 12 informants participated in the qualitative phase, consisting of seven members of the Kelompok Wanita Tani (KWT/Women Farmers’ Group), three posyandu cadres, and two field facilitators. The informants represented diverse roles within the program, varying levels of experience, and different lengths of involvement in community empowerment activities.

Table 8. Characteristics of Interview and FGD Informants

Characteristics	Category	f	%
Gender	Female	10	83.3
	Male	2	16.7
Group	KWT members	7	58.3
	Posyandu cadres	3	25.0
	Facilitators	2	16.7
Age	25–35 years	5	41.7
	36–50 years	6	50.0
	>50 years	1	8.3
Length of involvement	<3 years	4	33.3
	3–5 years	6	50.0
	>5 years	2	16.7

Source: Primary Data, 2023.

Most informants were women aged 36–50 years, representing diverse household production groups and posyandu units, while facilitators had more than five years of experience in community empowerment initiatives.

Thematic Analysis Results

The thematic analysis generated four major themes that captured participants' experiences throughout the program: the perceived benefits of Appropriate Technology (AT), strengthened cadre capacity, social learning dynamics, and implementation challenges.

Theme 1. Perceived Benefits of Appropriate Technology (AT)

Participants frequently spoke about the changes they noticed after the introduction of AT tools, particularly the solar dryer used in food processing activities. One of the most visible improvements concerned the drying process itself. Previously, drying depended heavily on weather conditions and often required long exposure under direct sunlight. With the new device, participants described the process as quicker and more controlled.

"We are no longer dependent on the weather; the drying is faster and cleaner." (KWT-03)

"It becomes easier to use once you get used to it." (KWT-07)

Several KWT members mentioned that the technology helped them maintain product quality more consistently. They also felt that the equipment reduced the risk of contamination compared with traditional open-air drying. For some participants, the shift was less about sophisticated technology and more about making daily production routines easier and more predictable.

Theme 2. Strengthened Capacity and Professional Identity of Cadres

Posyandu cadres described noticeable changes in how they approached their work after attending the training sessions. Learning sessions on anthropometric measurement, stimulation of early childhood development, and communication with parents appeared to increase their confidence when performing routine tasks.

"I feel more certain when measuring because now I know the correct procedures." (Cadre-04)

Several cadres explained that they had previously relied on experience or guidance from other volunteers. The training provided clearer standards, particularly for measurement techniques and documentation. As a result, some cadres felt more comfortable explaining results to parents during posyandu sessions. Recording procedures also became more systematic, which participants considered helpful when tracking children's growth over time.

Theme 3. Social Learning and Peer Support

Another pattern that emerged during discussions was the importance of learning together. Both KWT members and posyandu cadres emphasized that group activities made it easier to try unfamiliar practices.

"Learning together makes us more confident to try because we can discuss with others." (KWT-11)

Participants often exchanged advice, reminded each other about techniques, and shared small successes. In some cases, members demonstrated how they used the equipment or carried out certain procedures. This form of peer interaction appeared to encourage participation among those who were initially hesitant, especially individuals who had limited experience with new tools or with public health activities at the posyandu.

Theme 4. Challenges in Program Implementation

Despite the positive experiences reported, several obstacles were also discussed. Time constraints were the most frequently mentioned issue. Many women involved in the program balanced multiple responsibilities at home and in the community, making regular participation sometimes difficult.

"We still need follow-up mentoring so we don't misuse the tools." (KWT-06)

Participants also raised concerns about maintaining access to raw materials for food processing activities. In addition, not everyone learned new techniques at the same pace. Some individuals adapted quickly, while others needed more repeated practice. Because of these differences, several informants suggested that continued mentoring would help ensure that all members could apply the skills consistently.

Integration of Findings (Convergent Mixed Methods)

After the quantitative and qualitative analyses were completed, the research team examined both strands together. The aim was to see how statistical changes corresponded with the experiences described by participants. Quantitative analysis showed large effect sizes across the main outcome domains ($r = 0.59–0.71$). Interview narratives and field observations helped explain how these improvements were perceived and practiced within the community.

Three broad patterns became visible during this integrative review.

Convergence: Competence–Confidence Alignment

Improvements recorded in pretest–posttest scores were accompanied by participants' descriptions of increased confidence in performing their tasks. Cadres spoke about feeling more assured when conducting anthropometric measurements or explaining growth monitoring results to parents. KWT members, meanwhile, referred to greater familiarity with operating the technology and organizing small-scale food production activities.

Meta-inference: Skill development appeared to extend beyond higher test scores. Participants described a stronger sense of competence in their roles, suggesting that training outcomes were internalized as professional confidence and self-efficacy.

Complementarity: Learning-Mediated Performance Amplification

Quantitative results showed consistent improvements in knowledge and practical skills. Qualitative accounts revealed that these gains did not occur in isolation. Many participants emphasized the role of collective practice, peer reminders, and informal discussions during group activities.

Meta-inference: Social learning processes within KWT groups and posyandu activities likely reinforced technical training. Peer interaction acted as an additional learning mechanism, which may help explain the relatively large statistical improvements across domains.

Contextualization: Barriers Shaping Outcome Variability

Although median score increases were substantial, interview data indicated that improvements were not identical for every participant. Household responsibilities, initial skill levels, and access to continued mentoring influenced how quickly individuals adopted new practices.

Meta-inference: Community context played a moderating role in how intervention benefits were distributed. The large effect sizes therefore reflect an overall shift in group performance rather than uniform adoption among all members.

Figure 2 illustrates the joint display model that links these three patterns; convergence, complementarity, and contextualization, across quantitative and qualitative evidence.

Overall, the integrated interpretation points toward strengthened community capacity and improvements in service practices that sit upstream in the pathway of stunting prevention. Direct nutritional outcomes were not measured in this evaluation. For that reason, the results should be understood primarily as improvements in intermediate determinants rather than direct evidence of reduced stunting prevalence.

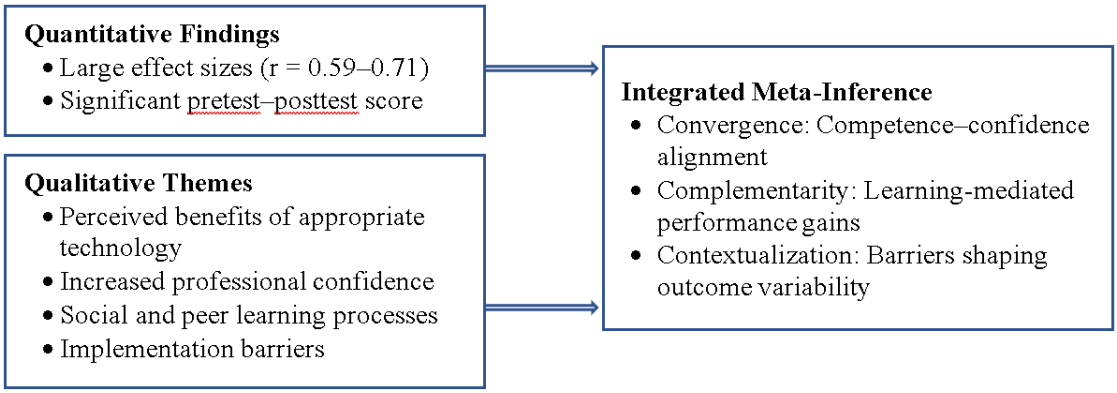

Figure 2. Joint Display Model (Convergent Mixed-Methods Integration)

A visual representation combining quantitative score gains and qualitative themes to produce integrated interpretations through convergence, complementarity, and contextualization. Source: Primary Data, 2023.

DISCUSSION

Synthesis of Key Findings

The program combined two main components: technical training on Appropriate Technology (AT) for members of the Kelompok Wanita Tani (KWT) and competency strengthening for posyandu cadres, particularly in anthropometry, early childhood developmental screening (SDIDTK), and stimulation practices. Across the training period, participant scores increased considerably. Pretest–posttest improvements ranged between 40% and 86%, indicating meaningful changes in both knowledge and practical ability.

Participants' narratives largely mirrored these numerical patterns. Several cadres described feeling more confident when conducting child growth assessments or explaining results to parents during posyandu sessions. KWT members, on the other hand, spoke about becoming more comfortable operating the drying technology and experimenting with new approaches to food processing. For some, the shift happened gradually; familiarity with the equipment grew only after repeated use.

A number of studies point out that interventions rarely succeed when they focus on only one component. Instead, community initiatives tend to work better when technical training is accompanied by mentoring, peer interaction, and local empowerment strategies (20,21). International reviews reach similar conclusions, showing that programs integrating individual capacity-building with supportive social environments are more likely to produce durable outcomes than narrowly focused interventions (22,23).

The changes reported among KWT members also reflect mechanisms commonly described in experiential learning literature. Rather than learning only through formal instruction, participants developed skills while practicing together and observing how others used the technology. Community development research frequently notes that this type of shared practice strengthens social capital and encourages longer-term adoption of innovations (24–26). In practical terms, technology becomes less intimidating when it is introduced through collective experimentation.

Among posyandu cadres, improvements in anthropometric practices and communication with parents highlight the continuing importance of front-line community health workers. In many parts of Southeast Asia, the quality of early childhood services depends heavily on volunteer cadres who conduct routine growth monitoring and health education. When their technical skills improve, the overall reliability of posyandu services tends to improve as well, including earlier identification of developmental concerns (27).

The motivational dynamics observed during training sessions can also be interpreted through ethical perspectives embedded in Islamic nursing traditions. Concepts such as khidmah (service), rahmah (compassion), and collaborative leadership led by women have long been discussed as foundations of community-oriented care. Marmi & Riyadi argue that leadership grounded in these values helps sustain trust between health volunteers and the communities they serve (28). The commitment expressed by cadres during this program, particularly their willingness to continue learning and assisting families, echoes aspects of this value-based orientation.

Taken together, the results point toward improvements in several upstream elements of stunting prevention. Technology adoption, stronger local skills, and supportive group dynamics appear to reinforce how community services operate. These changes should be understood primarily as strengthening delivery mechanisms rather than as direct proof of reduced stunting prevalence.

Community Empowerment as a Mechanism of Change

Experiences reported by participants repeatedly returned to one central element: the role of community empowerment. Within the KWT groups, the learning process unfolded largely through practice. Members tried operating the technology themselves, observed how others used it, and gradually adjusted their own techniques. Over time, this "learning by doing" approach seemed to reduce hesitation around the equipment. Confidence grew alongside technical ability.

The group setting also mattered. Participants often mentioned that working together made experimentation feel less risky. Mistakes could be discussed openly, and someone who had already mastered a particular step would demonstrate it again for others. These interactions created a small but important sense of collective ownership over the new technology.

Evidence from other regions supports similar interpretations. A systematic review by Janmohamed et al. (2020) highlights that participatory learning environments, articularly those involving peer exchange and group reflection, are closely linked with the success of community health programs. Peer support, shared norms, and collective problem-solving often shape how knowledge is translated into practice, especially in maternal and child health initiatives.

Comparable patterns have been observed in food and nutrition programs across South Asia and parts of Africa. Studies show that women's groups receiving both technical training and ongoing mentoring were more capable of adopting food-processing technologies and managing local food enterprises (29,30). The presence of supportive group structures appears to make a difference. In an East African program, researchers found that technology uptake among women improved not only because participants learned new skills but also because group cohesion and social capital strengthened their motivation to maintain the activities (31,32).

Motivation among posyandu cadres may also be viewed through a value-based leadership lens. While Islamic ethical leadership was not formally measured in this research, concepts such as khidmah (service), rahmah (compassion), amanah (responsibility), and ihsan (striving for excellence) offer a useful interpretive perspective. These values resonate with how many cadres described their role, as a form of service to children and families in the village (28). Within this study, such ideas function mainly as contextual interpretation rather than as variables tested empirically.

Appropriate Technology (AT) as an Innovation for Public Health and Food Security

In this program, the introduction of Appropriate Technology (AT), particularly solar-powered dryers and several simple food-processing tools, was closely linked with changes in how KWT members handled post-harvest food materials. Participants described improvements in drying efficiency and product consistency. In practical terms, vegetables, moringa leaves, and spices could be processed faster and with less exposure to environmental contamination. Over time, these adjustments also encouraged more organized and hygienic production routines within the groups.

Beyond technical skill development, the use of AT gradually shaped local food practices. KWT members reported experimenting with different processed products and becoming more attentive to cleanliness during preparation and storage. Such shifts are relevant for household nutrition, because small-scale food processing can

influence the availability of preserved nutrient-rich foods. In that sense, AT functions not only as a technical tool but also as a mechanism that connects local food production with nutrition-sensitive activities.

Evidence from other settings supports this pattern. Solar-based drying technologies have repeatedly been shown to reduce post-harvest losses, especially for plant-based foods that spoil quickly. Previous studies report that solar dryers shorten drying time by roughly 50–70% compared with conventional sun-drying methods while maintaining better physical quality and nutrient retention in the final product (33,34). Controlled temperature conditions also reduce contamination risks during dehydration, which contributes to safer food handling.

Looking at the issue through a food security lens helps clarify the broader implications. Integrating AT into community food initiatives can affect several dimensions simultaneously: the availability of processed foods, access to diverse ingredients, and safer methods of food utilization. Research conducted in South Africa illustrates similar outcomes. Community-based AT initiatives not only diversified household diets but also created small economic opportunities for women involved in local food enterprises (35,36). Comparable dynamics are described by O'Brien et al. (37), who observed that small-scale food-processing technologies managed by women's groups often produce layered effects, from improved production efficiency to greater consumption of nutrient-dense foods at home.

For stunting prevention, the relevance of AT lies mainly in its contribution to the supply of nutritious ingredients. Solar drying and simple processing tools make it easier to preserve foods such as moringa leaves, vegetables, and locally produced blended flours. These materials can later be incorporated into complementary foods or family meals. Some nutrition-sensitive programs that connect food production with nutrition education have reported improvements in children's micronutrient intake under similar conditions, although measurable effects on linear growth typically appear only in longer intervention periods (38,39).

The experiences observed in this program reflect that same pattern. AT expands the possibilities for producing nutrient-rich foods at the village level, yet improvements in nutritional status depend on a broader set of supporting factors. Hygiene practices, caregiver knowledge, and consistent food availability remain essential. Without these complementary elements, the potential benefits of local food processing may not fully translate into improved child growth outcomes.

Taken together, the evidence suggests that AT works best when embedded within a larger community-based nutrition strategy. Technology alone rarely produces lasting change. Its impact becomes more meaningful when accompanied by participatory training, technical mentoring, and practical pathways for sustaining production. Current global recommendations for nutrition-sensitive interventions echo this view: strengthening local food systems, supporting women's economic participation, and expanding access to appropriate technologies are increasingly recognized as key components for addressing structural drivers of stunting.

The intervention package implemented in this study also included two additional innovations: the Nutrition Garden IoT system and the Stimulation Mat. These components were introduced as complementary tools, although they were not quantitatively assessed and therefore were not central to the main outcome analysis. Field observations nevertheless provided useful insights.

Participants noted that the Nutrition Garden IoT system helped visualize children's nutritional needs and supported menu planning within households. At the same time, everyday use was limited by practical constraints. Internet connectivity in the village was inconsistent, and not all users were familiar with digital interfaces. As a result, the system functioned more as a demonstration tool than as a routine planning device.

The Stimulation Mat, designed to assist SDIDTK activities, received a generally positive response from posyandu cadres. Many cadres considered it helpful for guiding early childhood stimulation exercises. Yet consistent use during posyandu sessions proved difficult. Time pressure and the workload of volunteer cadres meant that the mat was not always integrated into routine service delivery. These experiences indicate that digital and developmental tools often require longer adaptation periods, ongoing mentoring, and clearer integration into posyandu workflows before they can contribute fully to child development monitoring and stunting prevention.

Local Supplementary Feeding (PMT): Opportunities and Limitations for Short-Term Nutritional Impact

Another outcome of the KWT activities involved the development of locally sourced supplementary foods. Members produced several nutrient-dense products using ingredients that were readily available in the surrounding

area, including moringa powder, egg-based preparations, dried vegetables, and various snack formulations. These foods were relatively simple to prepare and could be incorporated into daily meals without major cost.

Such products function as a form of local PMT (Pemberian Makanan Tambahan). When prepared from diverse ingredients, they offer a practical way to improve children's intake of protein, vitamins, and minerals. In villages where access to commercial fortified foods is limited, locally processed foods may fill an important nutritional gap.

Evidence from several Indonesian studies shows comparable results. PMT made from local ingredients; particularly moringa leaves, legumes, and animal-source foods, has been associated with measurable improvements in children's dietary intake over relatively short intervention periods. In some cases, increased protein and micronutrient consumption was observed within eight to twelve weeks of implementation (40,41). Similar outcomes were reported by Haile et al. (2021) who documented improvements in weight-for-age scores and dietary diversity among children aged 6–59 months receiving locally produced supplementary foods combined with maternal nutrition education.

However, improvements in short-term nutritional intake should not be interpreted as immediate changes in stunting prevalence. Linear growth reflects cumulative conditions that develop over a much longer period. Chronic dietary deficiencies, repeated infections, and environmental factors all interact over time to influence height-for-age indicators. Evidence from multi-country longitudinal analyses suggests that short-term food supplementation programs alone rarely produce measurable improvements in linear growth unless they are combined with interventions addressing sanitation, infection control, and broader household food security (42,43).

This distinction is important when interpreting the outcomes of local PMT initiatives. While supplementary foods can support better dietary intake and may improve weight-related indicators in the short term, sustained improvements in child growth require integrated strategies that extend beyond food provision alone.

A recent study in Indonesia demonstrated that local PMT effectively improves energy intake and child weight, but reductions in stunting require sustained programming for ≥12 months (44,45).

The results of this study are consistent with this pattern: local PMT serves as an operational component that improves the availability of nutrient-dense foods but cannot be expected to directly change stunting status within a short intervention period. Therefore, local PMT programs should be positioned as part of a broader nutrition-sensitive strategy, including maternal nutrition education, hygiene and sanitation practices, and integration with basic health services such as posyandu and Puskesmas.

Thus, the contribution of local PMT in this context lies primarily in:

Increasing the availability of nutrient-rich foods,

Enhancing children's short-term dietary intake, and

Strengthening the capacity of KWT as producers of locally sourced nutritious foods.

Although the duration of this study did not allow for measuring changes in height-for-age (LAZ/HAZ), the emerging findings suggest that the intervention has established foundational impact pathways relevant to linear growth when implemented over a longer period. Improved capacity for producing nutrient-dense foods among KWT, enhanced nutrition literacy through cadre education, and improved child-feeding practices represent three key pathways consistently identified in the literature as determinants of linear growth. Longitudinal studies show that stable consumption of nutrient-dense foods over ≥12 months, combined with developmental stimulation and improved household sanitation, contributes significantly to increased LAZ (Headey & Hoddinott, 2019). Therefore, although this study's duration did not permit detection of linear anthropometric changes, the intervention structure has activated mechanisms that theoretically and empirically hold strong potential to influence long-term child growth.

SDG 2 and SDG 3: From Food Security to Improved Health Outcomes

Activities carried out through the KWT groups, combined with technical training and the introduction of appropriate technology (TTG), were associated with several practical changes at the community level. Participants reported better access to processed nutritious foods, and cadres described improvements in how posyandu services were delivered. Although the study did not attempt to measure formal indicators of the Sustainable Development Goals, these developments can reasonably be viewed within the broader framework of SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being), where food security and primary health services are closely connected.

Efforts to strengthen local food systems, especially those led by community groups, have often been discussed as an important pathway toward SDG 2. Programs that combine small-scale food production, simple processing technologies, and community empowerment tend to improve the availability and use of nutrient-rich foods. Global analyses show that such integrated initiatives can lead to better dietary diversity and higher micronutrient intake among children (16). The experiences reported by KWT members in this program point in a similar direction. Training and the use of TTG allowed participants to process local ingredients more efficiently and encouraged them to incorporate those foods into daily consumption.

The relationship between food access and health outcomes has also been widely documented. Moradi et al. (46), note that reliable access to nutritious food is strongly associated with lower risks of wasting and underweight. While the pathways to reducing stunting are more complex, food security still operates as an important upstream determinant. Within posyandu services, improved practices among cadres, such as more careful anthropometric measurement and clearer nutrition counselling, relate closely to SDG 3 targets focused on maternal and child health (47). Evidence from community health programs suggests that cadres who receive hands-on technical training are better able to conduct growth monitoring accurately and to communicate health information effectively to caregivers (48).

At the same time, these connections should be interpreted with caution. The present study did not measure SDG outcomes directly, and the improvements observed here do not automatically translate into measurable progress toward global targets. Local realities continue to shape health and nutrition outcomes. Chronic food insecurity, limited access to healthcare facilities, and uneven household income remain influential factors. Gupta (49) argues that progress toward both SDG 2 and SDG 3 generally requires sustained multisectoral collaboration, ranging from sanitation improvements and women's empowerment initiatives to stronger primary healthcare systems.

Within this study, the SDG framework therefore functions mainly as an interpretive lens. It helps situate the observed changes within a broader development agenda rather than serving as a formally evaluated outcome.

Strengthening the Posyandu Service System: From Cadre Capacity to Service Quality

Training activities for posyandu cadres focused on anthropometric measurement, early childhood stimulation, and communication with parents. Participants reported that these sessions helped them perform routine tasks with greater confidence. Over time, several cadres described paying closer attention to measurement procedures and documentation during posyandu sessions. Small changes in practice, such as checking measurement positions or recording results more carefully, can have meaningful implications for the reliability of growth monitoring.

Accurate anthropometric measurement remains one of the foundations of child health surveillance. Height, weight, head circumference, and mid–upper arm circumference provide the basic information used to identify potential nutritional or developmental problems. Research on data quality in community health programs shows that even small inaccuracies in measurement can lead to misclassification of nutritional status and, ultimately, inappropriate program responses (50). In this context, the improvements observed among cadres suggest that the practical training component addressed an important gap. Brown et al. (51) similarly report that hands-on instruction combined with routine supervision tends to produce substantial improvements in measurement accuracy among frontline health workers.

Another noticeable change concerned interactions with parents. Several cadres described feeling more comfortable explaining growth results and discussing feeding practices with caregivers. These conversations are important because household-level care practices strongly influence child nutrition, particularly during the first 1,000 days of life. Reviews of community-based nutrition programs consistently show that education delivered through trained cadres can improve caregiver knowledge and feeding behaviors, contributing to better outcomes for young children (47).

Even so, strengthening cadre capacity alone does not resolve all systemic challenges within the posyandu system. Volunteers often manage multiple responsibilities during service sessions, and equipment quality varies across locations. Measuring tools may not always be standardized, and regular supervision from health professionals can be limited. Similar constraints have been documented in other regions. Hasanbasri et al. (52) highlight that long-term improvements in posyandu performance depend on broader institutional support, including reliable equipment provision, structured supervision mechanisms, and better integration with other health programs.

Cultural and ethical perspectives also help illuminate how cadres approach their roles. Research by Marmi & Riyadi (28) discusses how leadership values rooted in Islamic ethics; such as amanah (responsibility), ihsan (commitment to quality), and service-oriented care, can reinforce professionalism among community health volunteers. Elements of these values appeared in the attitudes expressed by cadres during training and service activities. Many participants described their work as a form of community service rather than simply a volunteer task.

Strengthening cadre skills therefore has clear implications for service quality, but sustaining these improvements requires coordinated support. Village administrations, primary health centers (puskesmas), and nutrition program networks all play roles in maintaining training continuity and operational resources. Without such support, improvements achieved through short-term interventions may be difficult to maintain.

In practical terms, reinforcing the posyandu system involves more than individual training sessions. Continuous mentoring, reliable equipment, and stronger institutional collaboration are needed to ensure that improvements in measurement practices and health education translate into earlier detection and more effective prevention of stunting at the community level.

Comparison with Previous Studies

The intervention implemented in this study combined several elements: appropriate technology (TTG), locally produced supplementary feeding (PMT), and strengthening of posyandu cadres. When these components operated together, they appeared to influence community capacity in more than one way. Participants developed new technical skills, food processing practices became more organized, and posyandu services were carried out with greater confidence.

Patterns like this have been described in earlier work on nutrition-sensitive programs. Initiatives that involve women's groups, technical skill development, and stronger primary health services often show improvements in caregiving practices and dietary behavior at the household level. Still, most studies also emphasize a limitation that is difficult to avoid: reductions in stunting rarely appear within short intervention periods. Progress tends to require longer program cycles and coordination across several sectors.

Within that broader literature, the present research adds several practical observations.

Integration of Solar-Powered Appropriate Technology within a Nutrition-Sensitive Framework.

While previous studies have examined household-scale food processing, fewer have documented the integration of solar-powered technologies within community-based nutrition interventions. In this study, the empirical contribution lies in documenting improvements in participant knowledge, technical skills, and post-harvest practices following exposure to AT training. The technological configuration (e.g., solar integration) is described as part of the intervention ecosystem rather than as an independently validated technological innovation. The observed improvements in efficiency, product quality, and entrepreneurial motivation add practical insight into how food-system technologies can support nutrition-sensitive programming.

Process-Oriented Evaluation Using a Convergent Mixed-Methods Design.

Unlike studies focusing solely on end-line quantitative outcomes, this research integrates quantitative change measurement with qualitative process documentation. Methodological guidance for complex public-health interventions emphasizes the importance of capturing mechanisms of change, contextual adaptation, and implementation barriers. The novelty of this study therefore lies primarily in its integration of outcome measurement with process analysis, rather than in asserting causal superiority over other multisector models.

Linking the Production–Consumption–Service Continuum.

Many prior studies examine PMT programs, cadre training, or food production separately. This study evaluates selected measurable outcomes within an intentionally integrated package connecting food production, household consumption practices, and posyandu service strengthening. It does not claim system-wide impact beyond assessed variables but provides contextualized empirical evidence of how multisector elements can be operationalized at village level.

Thus, the contribution of this study is best understood as context-specific evidence on community capacity strengthening within an integrated implementation framework, rather than as establishing a universal multisector stunting model.

Practical and Policy Implications

Within the scope of this program, the combined intervention, appropriate technology (TTG), locally produced supplementary foods, and cadre strengthening, functioned primarily as a mechanism for reinforcing community capacity. The contribution therefore lies less in proposing a universal model for stunting reduction and more in documenting how an integrated approach operates within a specific rural context.

Several practical insights emerged during implementation. Technical training improved participants' skills, yet those gains were not automatically stable. Without continued mentoring, some practices began to decline over time. This suggests that capacity-building initiatives require sustained accompaniment rather than one-time training sessions.

The sustainability of TTG also depends on factors beyond technical feasibility. Access to local markets and linkages with district-level nutrition programs appear to play an important role in determining whether food-processing activities remain viable. When production can connect to small economic opportunities, community members tend to maintain the practices more consistently.

Strengthening posyandu services presents a related challenge. Improvements in measurement practices and nutrition counseling were observed among cadres, but maintaining service quality requires systemic support. Standardized equipment, regular supervision, and coordination between sectors, particularly between village governance and primary health centers, are necessary for these gains to persist.

The intervention model also resonates with the national Roadmap for Accelerated Stunting Reduction, particularly in its emphasis on village-level convergence. Even so, the model should be interpreted cautiously. Rather than representing a direct stunting intervention with measurable anthropometric outcomes, it functions more appropriately as a systems-readiness framework that prepares community institutions for more comprehensive nutrition programs.

Another important observation concerns differences between households. Adoption patterns varied according to socioeconomic conditions. Families with limited resources tended to rely more heavily on the support provided through KWT and cadre activities. In contrast, households with stronger economic capacity adopted new practices more quickly and sometimes independently. These differences highlight the need for facilitation strategies that are sensitive to local vulnerability patterns. Programs implemented in heterogeneous communities cannot rely on uniform approaches.

Limitations and Considerations

A number of limitations should be considered when interpreting the results. The quantitative component involved a relatively small number of participants, which restricts the extent to which the findings can be generalized beyond the study setting. The analysis therefore reflects conditions within the participating community rather than representing broader population trends.

The study also did not track long-term nutritional outcomes. Anthropometric indicators such as height-for-age were not measured as part of the evaluation design. Because of this, the intervention's direct influence on stunting status cannot be determined. The results instead describe changes in intermediate factors; knowledge, technical skills, and service practices, that may contribute to improved nutrition environments.

Within the qualitative data, the possibility of social desirability bias should also be acknowledged. Some participants may have framed their responses in ways they believed were expected by facilitators or researchers. Although efforts were made to encourage open discussion, such influences cannot be entirely ruled out.

Another limitation concerns the measurement of household economic conditions. Variables such as income, food expenditure, and dietary consumption patterns were not captured through structured quantitative instruments. As a result, the analysis cannot fully explore the relationship between improvements in KWT production capacity and actual household nutrition intake. Future research would benefit from incorporating more detailed economic and dietary assessments in order to better understand how community food initiatives translate into nutritional outcomes.

CONCLUSION

The intervention described in this study brought together appropriate technology (TTG), nutrition education, and community-based service strengthening. Through this combination, women's farmer groups and posyandu cadres developed greater confidence in several practical areas: processing local foods, delivering nutrition information, and carrying out routine monitoring of child growth.

Anthropometric outcomes were not measured directly. Even so, the activities activated several pathways that are often discussed in stunting-prevention frameworks. Local food production increased the availability of nutrient-dense ingredients, caregivers gained additional knowledge about feeding practices, and posyandu services operated with improved technical capacity. These elements collectively contribute to a more supportive environment for child nutrition.

The main contribution of the study lies in illustrating how community empowerment can be organized within a rural implementation setting. Rather than focusing only on measurable outcomes, the approach emphasizes strengthening local systems; community groups, volunteer cadres, and food production networks, that support longer-term nutrition initiatives.

Looking forward, continued facilitation will be essential. Cross-sector collaboration between village institutions, health services, and local food initiatives could help sustain the gains already observed. Longer-term studies are also needed to determine whether improvements in community capacity eventually translate into measurable changes in child nutritional status.

AUTHOR CONTRIBUTION STATEMENT

All authors were jointly involved in the conception and design of the study, the processes of data collection, and the analytical procedures. Each author participated in drafting the manuscript and engaged in critical review and refinement of its content. All authors have examined and approved the final version prior to submission.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest that could influence the objectivity, interpretation, or integrity of the research presented in this manuscript.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

In preparing this manuscript, the authors utilized only standard language-editing tools, such as spelling and grammar checkers, and engaged in informal scholarly discussions. No aspect of the study design, data analysis, interpretation of findings, or formulation of conclusions was generated by artificial intelligence technologies. All scientific arguments, analyses, and writing were independently developed by the authors.

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