

Outcomes of Co-Designed, Place-Based Nutrition Interventions on the Nutritional Status of Women and Young Children in Rural North-Eastern Ghana: A Cluster-Randomized Controlled Trial

VINCENT ADOCTA AWUUH

adoctavincent@gmail.com

Kwame Nkrumah University of Science and Technology

Prof. Charles Apprey

Kwame Nkrumah University of Science and Technology

Professor Reginald Adjetey Annan

Kwame Nkrumah University of Science and Technology

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Abstract

Background

Maternal and child undernutrition remains a major public health challenge in rural North-Eastern Ghana, where food insecurity, anaemia, and acute malnutrition are widespread, and conventional top-down nutrition programmes have shown limited effectiveness and sustainability.

Objective

We evaluated the effectiveness of a co-designed, place-based nutrition intervention on the nutritional status of women of reproductive age and young children in rural North-Eastern Ghana.

Methods

We conducted a mixed-method, cluster-randomized controlled trial across ten communities, randomizing 248 mother-child pairs (124 per group) to intervention or control. A formative baseline survey and co-design phase (June–October 2023) preceded a six-month intervention (November 2023–May 2024) comprising culturally tailored nutrition education, community engagement, and women’s empowerment activities. Baseline and end line assessments captured anthropometric, haemoglobin, dietary, and food security data. Of 248 pairs enrolled, 211 (109 intervention; 102 control) completed end line assessment (15% attrition). Non-parametric tests evaluated within and between group changes.

Results

The intervention group showed statistically significant reductions in child wasting (27.4% to 12.8%, $p = 0.01$) and underweight prevalence (26.6% to 15.6%, $p = 0.04$) compared with controls. Child anaemia prevalence fell from 71.0% to 22.0% ($p < 0.001$), and maternal anaemia declined from 41.1% to 27.5% ($p < 0.001$). Haemoglobin levels rose significantly in children (median 10.2 g/dL to 12.0 g/dL, $p < 0.001$) and mothers (11.25 g/dL to 13.10 g/dL, $p < 0.001$) in the intervention group. No significant changes were detected in maternal BMI or child stunting.

Conclusions

Co-designed, place-based nutrition interventions can meaningfully improve acute malnutrition and anaemia among vulnerable rural populations. Scaling up the components driving this improvement, Community Nutrition Volunteer-led education and household counselling, promotion of micronutrient-rich local foods, and women’s economic-empowerment groups, within existing health and community systems could extend these benefits to similar settings.

Trial registration

The trial was registered retrospectively with the Pan African Clinical Trial Registry, (PACTR202412697952932) on 23 December 2024, <https://pactr.samrc.ac.za/Admin/Home.aspx>.

Background

Maternal and child undernutrition remains a major public health challenge worldwide, particularly across low- and middle-income countries (LMICs), where undernutrition, micronutrient deficiencies, and a rising burden of overweight increasingly coexist [1,2,3]. Globally, maternal and child undernutrition underlies an estimated 45% of deaths among children younger than five years, and serious micronutrient deficiencies (“hidden hunger”) affect billions more, undermining survival, cognitive development, and economic potential [4]. This double burden of malnutrition disproportionately affects women and young children in rural, agrarian communities, where seasonal food availability, limited dietary diversity, and constrained access to health services compound biological vulnerability during pregnancy and early childhood.

In Ghana, malnutrition remains entrenched and is sharply concentrated in the north. Nationally, 28% of children under five are stunted, 9% wasted, and 14% underweight, while anaemia affects 66% of children aged 6–59 months [3,4,5]. Northern Ghana bears a disproportionate burden, with stunting reaching 36.1% and both anaemia and food insecurity far above national levels (food insecurity 59% versus a national average of 5%) [3]. These disparities reflect the intersection of poverty, low maternal education, and limited access to diverse, nutrient-rich foods. Ghana's National Nutrition Policy and Multi-Sectoral Nutrition Plan of Action explicitly recognise this regional disparity and call for context-specific, community-driven programming in the northern regions, yet implementation has lagged in remote rural districts such as East Mamprusi, where health-system reach and programme coverage remain limited [6].

Undernutrition sets in motion a self-reinforcing cycle of infection, impaired growth, and diminished cognitive and economic potential, with consequences that extend across generations [7,8,9]. Because the first 1,000 days from conception to age two represent a critical and largely irreversible window for growth, interventions that improve the nutrition of women of reproductive age and young children are especially important [10,11,12]. Multisectoral and nutrition-sensitive frameworks emphasise that interventions addressing the immediate, underlying, and basic determinants of undernutrition together, rather than any single determinant in isolation, are more likely to achieve sustained impact, particularly when they engage household, community, and institutional levels concurrently [13,14, 15].

Given this burden, a range of community-based and participatory approaches have been tested to strengthen nutrition and maternal-child health outcomes in sub-Saharan Africa, with mixed and context-dependent results. In Ghana, the Newhints trial demonstrated that community-based surveillance volunteers delivering structured home visits during pregnancy and the first week of life could improve newborn-care practices, although the accompanying reduction in neonatal mortality was more modest than hypothesised, underscoring that volunteer-delivered interventions do not automatically translate into large effect sizes without high fidelity and coverage [16]. A systematic review and meta-analysis of

women's groups practising participatory learning and action across Bangladesh, India, Malawi, and Nepal found consistent reductions in neonatal mortality, particularly where a high proportion of pregnant women engaged with the groups, reinforcing the principle that community ownership and dialogue-based engagement, rather than externally imposed messaging, can shift health behaviours [17]. Similarly, a community-based participatory nutrition promotion programme in rural Ethiopia that layered structured, facilitator-led nutrition sessions onto existing government programmes achieved significant reductions in stunting and underweight after twelve months of follow-up, although notably these gains emerged only after a full year of exposure rather than within a shorter window [18]. Broader reviews of community health worker programmes across low- and middle-income countries similarly conclude that trained, community-embedded volunteers can meaningfully reduce childhood undernutrition when programmes are well-supervised and adequately resourced, but that effectiveness varies widely with training intensity, supervision, and community buy-in [19]. Within Ghana specifically, community-based health interventions in the Upper East Region have shown that locally embedded health promotion can shift maternal and child health indicators, and qualitative work in rural northern Ghana has documented that community members themselves identify culturally rooted barriers, such as food taboos, gendered decision-making, and distrust of externally designed programmes, as central obstacles to effective nutrition programming [20,21]. Nevertheless, few of these interventions were formally co-designed with communities through structured participatory workshops from inception, and fewer still have been evaluated for effects on acute malnutrition and anaemia specifically, within a compressed timeframe of six months, in a cluster-randomised design in Ghana.

Beyond nutrition education alone, evidence increasingly points to women's empowerment and economic agency as pathways to improved household nutrition. In Ghana, greater decision-making power and control over income among women in agricultural households have been associated with improved dietary diversity and nutritional status of women and children, even after accounting for household wealth [22]. A randomised controlled trial of a nutrition-sensitive agriculture programme in Burkina Faso similarly found that gains in women's empowerment partially mediated improvements in child nutrition outcomes, suggesting that livelihood and empowerment components can meaningfully complement nutrition education rather than serve only as an ancillary activity [23]. Comparable agriculture-nutrition integration trials in Ghana and homestead food-production programmes in Tanzania have likewise demonstrated that combining nutrition education with income-generating or food-production activities can improve child growth and dietary diversity beyond education alone [24,25]. Methodologically, the broader literature on community-led and co-designed trials cautions that intervention co-design is neither quick nor automatic: negotiating community ownership can surface unexpected tensions, including shifts in gender dynamics as women take on more visible roles in community activities, and requires sustained facilitation to reach workable consensus [26]. These considerations directly informed the design of the present trial, which combined community nutrition education and household counselling with a structured women's economic-empowerment component and explicit, facilitated negotiation of food taboos and gender dynamics during the co-design phase, rather than treating community engagement as a single consultative event.

Although numerous interventions exist, their rate and scale of implementation remain a challenge in Ghana [27, 28]. Barriers to multisectoral implementation include weak intersectoral coordination, unclear mandates, inadequate technical capacity, poor accountability systems, and limited community ownership [28,29, 30]. Persistent barriers, coupled with resource constraints, limit the effectiveness of programs designed to improve maternal and child nutrition. Moreover, while national-level data are available in Ghana, limited research has examined the effect of co-produced place-based interventions on the most affected localities. This gap necessitates place-based, culturally sensitive research co-designed to address the persistent high rates of malnutrition among women and children under five in northern Ghana, where poverty, food insecurity, and social inequalities intersect to exacerbate nutritional vulnerability. Specifically, no trial in this setting has tested whether an intervention that is co-designed with the affected communities, rather than delivered top-down, can outperform routine nutrition services. This trial was designed to address the question: can a co-designed, community-driven nutrition intervention reduce malnutrition among women and children in rural Ghana more effectively than routine services? To our knowledge, this is the first cluster-randomized trial of a community co-designed, place-based nutrition package in northern Ghana. The trial was registered with the Pan African Clinical Trial Registry (PACTR202412697952932; recruitment and intervention November 2023–May 2024). This study fills a critical gap as it provides the first cluster-randomized evidence that a community co-designed, place-based nutrition package can reduce acute child malnutrition and maternal and child anaemia more than routine services within six months, and it identifies the specific low-cost, community-embedded components responsible: volunteer-led education and household counselling, promotion of micronutrient-rich local foods, and women’s economic-empowerment groups thereby providing directly actionable evidence for integration and scale-up within existing health and community systems. Addressing this challenge requires context-specific, culturally grounded solutions tailored to the conditions of rural northern Ghana. This study therefore evaluated whether a co-designed, place-based nutrition intervention could improve the nutritional status of women of reproductive age and young children, generating locally relevant evidence to inform sustainable, community-based nutrition policy and practice.

By combining a rigorous cluster-randomised evaluation with a genuinely co-designed, multi-level intervention, this study aims to generate evidence that is both methodologically robust and directly actionable for scale-up within Ghana's existing community health infrastructure.

Methods

Study Design and Setting

A mixed-methods, cluster-randomized controlled trial (cluster RCT), with randomization at the community (cluster) level was conducted, to evaluate the outcomes of a co-designed, place-based nutrition intervention on the nutritional status of women of reproductive age (WRA) and children less than five years in rural north-east Ghana. A formative baseline survey was conducted in June/July 2023, and findings from this survey informed the co-design and development of the intervention between June and October 2023. Recruitment of trial participants and implementation of the six-month intervention took place from

November 2023 to May 2024, with end-line data collected in May 2024. The intervention was implemented over six months, with baseline and endpoint assessments to evaluate maternal and child nutritional outcomes. East Mamprusi was purposively selected for its high prevalence of maternal and child undernutrition, food insecurity, and limited culturally relevant nutrition programs. Ten communities Namangu, Kasape, Zarantinga, Yingari, Jerigitinga, Zaari, Kolgona, Teanoba, Nagbai, and Jagoo, were randomly included, representing five sub-districts.

Study Population and Eligibility Criteria

Eligible participants were WRA (18-49 years) with at least one child aged 6-59 months who were permanent residents (≥ 6 months) and consented to participate. Households that were enrolled in other nutrition programs, planning relocation, or with acutely or chronically ill members were excluded. For the qualitative component, key informants and community leaders were purposively recruited.

Sample Size Determination and Sampling Procedures

The sample size was initially calculated using G*Power software for an individually randomized comparison and a moderate effect size (Cohen's $d = 0.50$), 95% power and a 2-sided significance level of 5%, and the sample size was increased by 10% due to the anticipated dropouts, since the study used cluster randomization at the community level. Assuming an average cluster size of approximately 25 households and ICC of 0.05 the DEFF was estimated at 2.2. We recognise that the original G*power calculation was based on individual level randomisation, so the design effect has been added to account for the clustering. However, the study was not large enough for cluster-level inference, and results were analyzed with appropriate caution due to a limited number of clusters randomized. A total of 248 households (124 interventions, 124 controls) were recruited. A multistage cluster sampling approach was used. The five sub-districts served as strata, from which two communities each were randomly selected. One community from each sub-district was assigned to the intervention and one to the control group. Within communities, 24 households were randomly selected (Figure 1).

Nutrition Intervention

The Mother–Child Nutrition Friendly Household Initiative (MCNFHI) (Figure 2) is a co-designed, community-led intervention that was developed through participatory workshops with women's groups, community leaders, health professionals and local institutions based on the baseline results. The intervention was based on the theory of change approach to tackle the high prevalence of food insecurity, maternal and child malnutrition and anaemia in the East Mamprusi Municipality. The MCNFHI worked on four interconnected levels: community, household, group/economic and institutional to support culturally relevant nutrition practices, increase food security and improve community ownership and sustainability. The project included involvement of community leaders at the community level who were instructed in the role of Community Nutrition Volunteers (CNVs) and trained to provide culturally appropriate nutrition

education and information, to provide household counselling, and to model how to prepare healthy meals with locally available foods. At the household level, CNVs did monthly household visits and organized family meetings that helped raise awareness of and encouraged men in nutrition-related decision making, exclusive breastfeeding, appropriate complementary feeding, and micronutrient supplementation. Five women's support associations have been set up at the group/economic level to support women's empowerment through income generating activities (IGA) including groundnut paste production, cereal processing and vegetable gardening: Tisugtaaba, Teesisumma, Panobi, Sugtaaba and Kutaawon. The members were trained on financial literacy, entrepreneurship and cooperative management and provided with seed capital and linkages with microfinance institutions. The institutional support was provided through partnerships with local financial institutions, with municipal health services, which enabled the delivery of technical assistance, the strengthening of the community's engagement and the creation of sustainability mechanisms by mobilising local resources and creating local accountability mechanisms. Participatory baseline activities, focus group discussions, key informant interviews, and surveys were conducted with traditional and religious leaders, women's groups, healthcare workers, and community volunteers to co-develop the intervention, and recurring community dialogues were held to address food taboos and gender dynamics that affect household nutrition as a structured way of negotiating power relations during intervention design. The co-design phase included two participatory workshops, each three hours long, in June to October 2023 in each of the intervention communities facilitated by the research team with structured focus group guides. The sessions for women were held separately from the mixed sessions of community dialogues, and structured turn-taking was implemented to ensure equitable women, youth and lower status household participation. CNVs were identified locally and trained on key nutrition actions, behaviour change communication and group facilitation, while also getting technical support from nutrition experts. The CNVs were paid a monthly allowance of 100 Ghana Cedis to cover the costs of their transport. After training, CNV competency was evaluated by a supervised practice and delivery of at least one household counselling and one group session prior to the independent deployment. Monthly CNV visits to the households and bi-monthly household meetings with nutrition and health experts, and group meetings for peer learning and practical food demonstrations for mothers using locally available food were carried out. Participatory processes were used to create education materials and messages which are culturally relevant. Reliability was maintained by on-going expert supervision. The intervention description above follows the TIDieR checklist for replicability [48]. Intervention communities were; Kasape, Kolgona, Nagbai, Zaari, and Jerigitinga (124 households) while the control communities were; Namangu, Zarantinga, Yingari, Teanoba and Jagoo (124 households). Short-term outputs comprised of better IYCF knowledge by CNVs and mothers, use of nutrition friendly practices and food quality and distribution in the household. The immediate medium-term goal of the program was to bring sustainable reduction in malnutrition and anaemia, better maternal and child nutrition outcomes and better public health. The long-term impacts were expected to be: community ownership, ongoing behaviour change and resilient, nutrition-rich households. The MCNFHI conceptual model is represented in Figure 2 below, with intervention components, implementation pathways and expected outcomes at various levels of engagement.

Randomization and Control Group

Randomization was done at the cluster (community) level to minimise contamination between groups. Control communities continued receiving standard Ghana Health Service nutrition services, including facility-based counselling, vitamin A supplementation, deworming, and periodic growth monitoring. This approach ensured that any observed differences in outcomes between the intervention and control groups could be more confidently attributed to the MCNFHI intervention rather than to the routine nutrition and child health services available within the study area.

In each of the five sub-districts (strata), all eligible communities were given identical opaque folded-up slips of paper with their names on them, put into a container, and two community names were drawn out of the fish-bowl, in front of community leaders (or representatives) and research team members as witnesses, using the fish-bowl (lottery) method. This fish-bowl method was then repeated for each pair of communities selected to decide which community would be put in the intervention arm and which in the control arm. It was a public draw, with identical slips, and folded until they were drawn, thus offering an auditable and transparent allocation alternative suitable for the community context, rather than relying on a computer-generated draw. No special allocation-concealment system was used other than the use of identical, folded slips that were drawn blindly at the community level, as opposed to the research team. Community level randomization was done prior to household selection and individual enrollment. Individual consent was sought after, and with knowledge of, the community's assigned study arm, in the 24 households within each community. Because of the nature of the interventions (Community-level nutrition education, Household counselling and Economic empowerment activities for women), blinding of communities, participants, community nutrition volunteers and field data collectors was not practicable. Blood samples were collected by outcome assessors at baseline and end-line who used standardised and scripted procedures to reduce observer bias, and the laboratory staff analysing the blood samples were blinded to the allocation status. Group allocation was not concealed from data analysts when analysing data.

Data Collection Procedures

Baseline and endline surveys were conducted using structured, interviewer-administered questionnaires on Android tablets via Kobo Collect. Data were collected on sociodemographic characteristics, diet, household food security, anthropometry, and biochemical parameters. Enumerators received intensive training and were supervised by field coordinators to ensure quality control. Qualitative data were gathered through Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs), recorded, transcribed, and analyzed thematically using MAXQDA software. All core modules of the questionnaire used in this study are derived from validated standardized scales. The household food insecurity module is sourced from HFIAS [31], the dietary intake module from DQQ [49], and all remaining sections, which cover three types of dimensions, are self-developed. The complete English version of the research tool is included in Additional File 1.

Anthropometric and Biochemical Assessments

Maternal height and weight were measured to calculate BMI using WHO protocols. For children, height/length, and weight were measured, and z-scores for height-for-age (HAZ), weight-for-height (WHZ), and weight-for-age (WAZ) were computed using WHO AnthroPlus software. Venous blood (6 mL) was drawn into silica-coated tubes by certified phlebotomists for full blood count analysis at the Nalerigu College of Nursing and Midwifery Laboratory. Anaemia was classified according to the WHO haemoglobin thresholds. Stool and urine samples were collected and examined for parasitic infections to assess their relationship with nutritional outcomes.

Dietary Assessment and Food Security

Dietary intake was assessed using the validated Diet Quality Questionnaire (DQQ) to derive indicators such as the Minimum Dietary Diversity for Women (MDD-W), Minimum Acceptable Diet for children, and Food Group Diversity Scores (FGDS). The Household Food Insecurity Access Prevalence (HFIAP) indicator was used to classify households as food secure or mildly, moderately, or severely food insecure, following Coates et al [31]. These measures provided a comprehensive assessment of dietary quality, feeding adequacy, and household food access, thereby enabling the evaluation of important determinants of maternal and child nutritional outcomes.

Qualitative Data Analysis

KIIs and FGDs explored local perceptions of nutrition, barriers to optimal practices, and community perspectives on intervention implementation. Data were analysed using Braun and Clarke's [32] thematic analysis approach in MAXQDA. Triangulation, member checking, and peer debriefing ensured trustworthiness and validity. Findings were used in the codesigned MCNFHI. The detailed qualitative findings (barriers, facilitators, and participant experiences) are beyond the scope of this outcomes paper and are reported separately; only their role in informing the co-design is described here.

Outcomes

The primary outcomes were (1) child wasting prevalence ($WHZ < -2$), (2) child underweight prevalence ($WAZ < -2$), and (3) child anaemia prevalence ($Hb < 11.0$ g/dL). Secondary outcomes were (4) maternal anaemia ($Hb < 12.0$ g/dL), (5) maternal body mass index (BMI), (6) child stunting ($HAZ < -2$), and (7) household food security. All outcomes were assessed at baseline and at end-line after the six-month intervention.

Data Management and Statistical Analysis

Data were analysed using SPSS version 24. Normality was assessed using Kolmogorov–Smirnov and Shapiro-Wilk tests. Non-parametric tests (Mann–Whitney U, Wilcoxon signed-rank, and Chi-square) were used for comparisons between and within groups. Effect sizes (r) were calculated to estimate the magnitude of change. Anthropometric z-scores were generated using WHO AnthroPlus software, and statistical significance was determined at a threshold of $p < 0.05$. Due to the small number of clusters randomized ($n = 10$), mixed-effects modeling at the cluster level was underpowered and not conducted as the primary analysis. The non-parametric tests presented here are thus exploratory comparisons at the individual level, and not cluster adjusted estimates.

Ethical Considerations

Ethical approval was obtained from the Kwame Nkrumah University of Science and Technology Committee on Human Research, Publications, and Ethics (CHRPE/AP/149/23) and permission from the East Mamprusi Municipal Health Directorate (GHS/NER/EMM/10/2023). The study was retrospectively registered with the Pan African Clinical Trial Registry (PACTR202412697952932) on the 23 December 2024. Written informed consent was obtained from all participants, with parental consent for children. For participants who were unable to read or write, the consent and information sheets were read in the local language by the enumerator, and participant's agreement was indicated by a thumbprint, witnessed and co-signed by an independent literate witness who was not part of the research team. Participants diagnosed with anaemia or malnutrition was referred to local health facilities for care. Confidentiality and voluntary participation were strictly upheld in accordance with the Declaration of Helsinki.

Results

Socio-Demographic Characteristics of Study Participants

The study sought to assess the outcomes of a co-designed, place-based nutrition intervention on the nutritional status of women of reproductive age and children under five years in rural Northeastern Ghana. A total of 248 mother–child pairs participated in the study conducted across 10 rural communities in the East Mamprusi Municipality of Ghana's North-East Region. These participants were recruited from ten rural communities in the East Mamprusi Municipality and provided information on household characteristics, nutrition-related behaviours, dietary practices, food security, anthropometric measurements, and haemoglobin status.

The demographic features of the participant are presented in Table 1. The average age of the children was 20.9 ± 11.4 months, and a slightly higher proportion were male (56.0%) compared to female (44.0%). Most mothers had no formal education (74.2%), while 22.6% had primary or junior high school (JHS) education, and only 3.2% had completed senior high school (SHS), technical, or vocational training. The majority of mothers (73.4%) were engaged in farming, whereas 26.6% worked as traders or homemakers. Nearly all households were male-headed (98.8%), which reflects the prevailing social structure of the study area. In terms of ethnicity, more than half of the participating households identified as Mamprusi (56.5%), followed

by Komkomba (27.4%) and other ethnic groups (16.1%). The religious composition included Christians (52.4%), Muslims (46.8%), and a small proportion adhering to other faiths (0.8%). Regarding sanitation and water access, 60.5% of households reported using Kumasi Ventilated Improved Pit (KVIP) latrines, while 28.6% practiced open defecation and 10.9% had access to water closets. Similarly, 60.5% of households obtained their drinking water from boreholes or pipe-borne systems, whereas 39.5% relied on open wells, streams, or dams. Child-feeding practices revealed that 42.7% of children were fed from separate bowls, whereas 57.3% shared meals with their mothers or siblings. Household food insecurity was high, with 81.5% classified as food-insecure and only 18.5% as food-secure (Table 1). Table 1 also compares the intervention and control arms at baseline: the two groups did not differ significantly on child sex, child age, feeding practice, maternal education, occupation, or household headship (all $p > 0.05$). Ethnicity, source of drinking water, sanitation, and household food security, however, differed significantly between arms at baseline ($p < 0.001$, $p < 0.001$, $p < 0.001$, and $p = 0.034$, respectively), reflecting the geographic and infrastructural clustering of the communities rather than individual-level selection; this imbalance, an expected risk of randomizing a small number of clusters, is discussed further under Limitations. Key maternal and child anthropometric and haemoglobin indicators were nonetheless well balanced between arms at baseline (all $p > 0.05$; Table 6).

Table 1
Socio-Demographic Characteristics of Study Participants, Overall and by Study Arm (N = 248)

Variable	Category	Total (N = 248) n (%)	Intervention (N = 124) n (%)	Control (N = 124) n (%)	p- value
Child Characteristics					
Sex	Male	139 (56.0)	68 (54.8)	71 (57.3)	0.798
	Female	109 (44.0)	56 (45.2)	53 (42.7)	
Mean age (months)		20.9 ± 11.4	21.5 ± 12.0	20.5 ± 10.9	0.517
Feeding practice	Separate bowl	106 (42.7)	71 (57.3)	63 (50.8)	0.372
	With mother/siblings	142 (57.3)	53 (42.7)	61 (49.2)	
Mother's Characteristics					
Education	No formal education	184 (74.2)	95 (76.6)	89 (71.8)	0.137
	Primary/JHS	56 (22.6)	23 (18.5)	33 (26.6)	
	SHS/Technical/Vocational	8 (3.2)	6 (4.8)	2 (1.6)	
Occupation	Farmer	182 (73.4)	84 (67.7)	98 (79.0)	0.062
	Housewife/Trader	66 (26.6)	40 (32.3)	26 (21.0)	
Household Characteristics					
Head of household	Male	245 (98.8)	124 (100.0)	121 (97.6)	0.245
	Female	3 (1.2)	0 (0.0)	3 (2.4)	
Ethnicity	Mamprusi	140 (56.5)	53 (42.7)	87 (70.2)	< 0.001
	Komkomba	68 (27.4)	43 (34.7)	25 (20.2)	

Note: P-values from Pearson's chi-square test of independence comparing intervention vs. control at baseline (categorical variables) or independent-samples t-test (child age, continuous). For variables with more than two categories, the p-value reflects the omnibus test across all categories. Source: Authors' computation.

Variable	Category	Total (N = 248) n (%)	Intervention (N = 124) n (%)	Control (N = 124) n (%)	p- value
	Others	40 (16.1)	28 (22.6)	12 (9.7)	
Religion	Christian	130 (52.4)	71 (57.3)	59 (47.6)	0.137
	Muslim	116 (46.8)	53 (42.7)	63 (50.8)	
	Others	2 (0.8)	0 (0.0)	2 (1.6)	
Source of drinking water	Borehole/Pipe-borne	150 (60.5)	92 (74.2)	58 (46.8)	< 0.001
	Open well/Stream	98 (39.5)	32 (25.8)	66 (53.2)	
Sanitation (toilet type)	KVIP	150 (60.5)	92 (74.2)	58 (46.8)	< 0.001
	Open defecation/Other	98 (39.5)	32 (25.8)	66 (53.2)	
Household food security	Food secure	46 (18.5)	30 (24.2)	16 (12.9)	0.034
	Food insecure	202 (81.5)	94 (75.8)	108 (87.1)	
Note: P-values from Pearson's chi-square test of independence comparing intervention vs. control at baseline (categorical variables) or independent-samples t-test (child age, continuous). For variables with more than two categories, the p-value reflects the omnibus test across all categories. Source: Authors' computation.					

Dietary Diversity and Household Food Security Outcomes by Study Arm

Table 2 presents Minimum Dietary Diversity for Women (MDD-W, ≥ 5 of 10 food groups), child Minimum Dietary Diversity (MDD, ≥ 4 of 8 food groups, among children 6–23 months), and household food security status.

The proportion of mothers meeting MDD-W was similar between arms at baseline (33.9% intervention vs. 24.2% control, $\chi^2=2.37$, $p = 0.124$) but diverged sharply by end-line, rising to 84.4% in the intervention arm compared with 30.4% in the control arm ($\chi^2=61.02$, $p < 0.001$). This represented a highly significant within-arm improvement in the intervention group ($\chi^2=58.57$, $p < 0.001$), whereas the control arm showed no significant change over time ($\chi^2=0.80$, $p = 0.371$). A comparable pattern was observed for children's minimum dietary diversity: comparable at baseline (46.8% vs. 40.3%, $\chi^2=0.80$, $p = 0.370$) but diverging by

end-line (67.9% vs. 41.2%, $\chi^2=14.13$, $p < 0.001$), with a significant within-arm improvement in the intervention group ($\chi^2=9.69$, $p = 0.002$) and no significant change in the control group ($\chi^2=0.37$, $p = 0.543$).

Table 2
Dietary diversity and household food security by study arm, baseline and end-line

Indicator	Intervention Baseline	Control Baseline	P- value	Intervention End-line	Control End-line	P- value
MDD-W met (mothers)	42/124 (33.9%)	30/124 (24.2%)	0.124	92/109 (84.4%)	31/102 (30.4%)	< 0.001
MDD met (children)	58/124 (46.8%)	50/124 (40.3%)	0.370	74/109 (67.9%)	42/102 (41.2%)	< 0.001
Household food secure	30/124 (24.2%)	16/124 (12.9%)	0.034	93/109 (85.3%)	52/102 (51.0%)	< 0.001
<i>Note: P-values from Pearson chi-square tests of independence (2x2 tables), comparing intervention vs. control arms at each time point. MDD-W = Minimum Dietary Diversity for Women (≥ 5 of 10 food groups, WHO/FAO). Child MDD = Minimum Dietary Diversity among children 6–23 months (≥ 4 of 8 food groups, WHO IYCF indicator). Household food security based on HFIAS binary classification. Source: Authors' computation.</i>						

Household food security (Table 3) improved in both arms but to a substantially greater degree in the intervention communities. The proportion of food-secure households rose from 24.2% to 85.3% in the intervention arm ($\chi^2=84.54$, $p < 0.001$) compared with 12.9% to 51.0% in the control arm ($\chi^2=36.78$, $p < 0.001$); a modest between-arm difference was already present at baseline ($\chi^2=4.51$, $p = 0.034$) and widened considerably by end-line ($\chi^2=27.33$, $p < 0.001$). Examining the full four-category HFIAS classification (Table 3c), the distribution of food-security categories was comparable between arms at baseline ($\chi^2=6.03$, $p = 0.110$) but differed significantly by end-line ($\chi^2=17.82$, $p < 0.001$), driven mainly by a near-elimination of severe food insecurity in the intervention arm (65.3% to 0.9%) compared with a smaller reduction in the control arm (78.2% to 16.7%).

Table 3
Household food insecurity severity (HFIAS categories) by study arm, baseline and end-line

HFIAS Category	Intervention Baseline	Control Baseline	Intervention End-line	Control End-line
Secure	30 (24.2%)	16 (12.9%)	79 (72.5%)	59 (57.8%)
Mild	6 (4.8%)	6 (4.8%)	20 (18.3%)	15 (14.7%)
Moderate	7 (5.6%)	5 (4.0%)	9 (8.3%)	11 (10.8%)
Severe	81 (65.3%)	97 (78.2%)	1 (0.9%)	17 (16.7%)
<i>Note: Group $\times$ category χ^2 test: baseline $\chi^2=6.03$, $p = 0.110$ (arms comparable); end-line $\chi^2=17.82$, $p < 0.001$ (arms differ, driven principally by the severe-insecurity category). Source: Authors' computation.</i>				

Nutritional Status Outcomes for Mothers and Children at Baseline and End-line

The analysis examines changes in maternal body mass index, child anthropometric indicators, and anaemia status over the six-month intervention period. These findings provide evidence on the effectiveness of the co-designed, place-based nutrition intervention in improving maternal and child nutritional outcomes. Table 4 presents mothers' and young children's baseline and end-line nutritional status in intervention and control groups.

In the intervention group, the percentage of underweight mothers decreased slightly from 8.1% at baseline to 6.4% at end-line ($P = 0.97$). Conversely, in the control group, the underweight rate increased from 8.9% to 15.7% by end-line ($P = 0.27$). Both groups had a decrease in the percentage of mothers with a normal BMI. In the intervention group, the rate went from 83.9% to 85.3%, while in the control group, it dropped from 78.2% to 67.6%. The proportion of overweight and obese mothers remained relatively stable in both groups over time.

The percentage of children with normal height-for-age (non-stunted) slightly increased in both groups from baseline to end-line, with no significant difference in either group ($P = 0.89$ for intervention and $P = 0.69$ for control). Stunting decreased marginally in the intervention group (30.6% to 29.4%) and the control group (37.9% to 35.3%). These findings suggest that the six-month intervention period may have been insufficient to produce substantial changes in linear growth, which typically reflects the cumulative effects of long-term nutritional and health conditions.

A significant improvement was observed in the intervention group, with the percentage of children with normal weight-for-height increasing from 72.6% at baseline to 87.2% at end-line ($P = 0.01$). The control group saw a smaller, non-significant increase from 63.7% to 71.6% ($P = 0.21$). Wasting declined notably in the intervention group, from 27.4% to 12.8%, compared to a less pronounced decrease in the control group (36.3% to 28.4%).

Normal weight-for-age increased in the intervention group, from 73.4% at baseline to 84.4% at end-line ($P = 0.04$), indicating a statistically significant improvement. The control group saw a small, non-significant change (71.0% to 70.6%). Underweight prevalence decreased significantly in the intervention group (26.6% to 15.6%), while it remained nearly unchanged in the control group.

There was a dramatic improvement in anaemia levels within the intervention group, with the percentage of non-anaemic children rising from 29.0% at baseline to 78.0% at end-line ($P < 0.001$). The control group also saw an increase, though smaller, from 51.6% to 65.7% ($P = 0.04$). Anaemia rates in the intervention group dropped substantially from 71.0% to 22.0%, reflecting a significant positive outcomes.

Anaemia in mothers improved significantly in both groups. In the intervention group, the percentage of non-anaemic mothers increased from 58.9% to 72.5% ($P < 0.001$). In the control group, there was also a significant improvement from 36.3% to 54.9% ($P = 0.01$). Anaemia prevalence declined in both groups, with

a larger decrease observed in the intervention group (41.1% to 27.5%) compared to the control group (63.7% to 45.1%).

Table 4
Nutritional status of Mothers and young children within groups at baseline and end-line

Nutrition Indicator	Intervention group			Control group		
	baseline	End-line	P-Value	baseline	End-line	P-Value
Mothers BMI						
Underweight	10(8.1%)	7(6.4%)	0.97	11(8.9%)	16(15.7%)	0.27
Normal	104(83.9%)	93(85.3%)		97(78.2%)	69(67.6%)	
Overweight	9(7.3%)	8(7.3%)		13(10.5%)	15(14.7%)	
Obesity	1(0.8%)	1(0.9%)		3(2.4%)	2(2.0%)	
Child Stunting Status						
Normal	86(69.4%)	77(70.6%)	0.89	77(62.1%)	66(64.7%)	0.69
Stunting	38(30.6%)	32(29.4%)		47(37.9%)	36(35.3%)	
Child Wasting Status						
Normal	90(72.6%)	95(87.2%)	0.01	79(63.7%)	73(71.6%)	0.21
Wasting	34(27.4%)	14(12.8%)		45(36.3%)	29(28.4%)	
Child Underweight Status						
Normal	91(73.4%)	92(84.4%)	0.04	88(71.0%)	72(70.6%)	0.95
Underweight	33(26.6%)	17(15.6%)		36(29.0%)	30(29.4%)	
Child Anaemia status						
Normal	36(29.0%)	85(78.0%)	< 0.001	64(51.6%)	67(65.7%)	0.04
Anaemic	88(71.0%)	24(22.0%)		60(48.4%)	35(34.3%)	
Mother Anaemia status						
Normal	73(58.9%)	79(72.5%)	< 0.001	45(36.3%)	56(54.9%)	0.01
Anaemic	51(41.1%)	30(27.5%)		79(63.7%)	46(45.1%)	
The level of statistical significance is P-value < 0.05						
Source: Authors' computation						

Comparison of Maternal and Child Nutritional Status Between Intervention and Control Groups at Baseline and End-Line

The study assessed whether significant differences existed between groups before the intervention and whether the intervention contributed to improved nutritional outcomes at the end of the study period. These comparisons provide further evidence of the effectiveness of the co-designed, place-based nutrition intervention in improving maternal and child nutritional status relative to routine nutrition services. Table 5 presents the nutritional status of mothers and young children in both intervention and control groups at baseline and end-line, with P-values indicating the statistical significance of differences between groups.

At baseline, the proportion of underweight mothers was similar between the intervention (8.1%) and control groups (8.9%) ($P = 0.57$). However, by the end-line, the intervention group had a lower proportion of underweight mothers (6.4%) compared to the control group (15.7%), showing a significant difference ($P = 0.03$). Most mothers in both groups fell within the normal BMI range at both baseline and end-line, with a slight increase in the intervention group (83.9% to 85.3%) and a decrease in the control group (78.2% to 67.6%). There was a small reduction in overweight mothers in the intervention group (7.3% to 7.3%), while overweight prevalence increased in the control group (10.5% to 14.7%).

Both groups had similar stunting status at baseline and end-line, with no statistically significant difference. The intervention group showed a slight improvement from 69.4% to 70.6% in the normal category, while the control group showed a minor increase in the stunted category by end-line. The absence of significant differences between groups suggests that the intervention had a limited effect on linear growth during the study period, possibly because changes in height-for-age typically require longer-term nutritional improvements to become evident.

There was a prominent improvement in the intervention group, where the proportion of mothers in the normal category increased from 72.6% to 87.2%, compared to a smaller improvement in the control group (63.7% to 71.6%). This difference at the end-line was statistically significant ($P = 0.01$). The intervention group saw a marked decrease in wasted mothers from 27.4% to 12.8%, while the control group saw a smaller reduction (36.3% to 28.4%).

The intervention group showed an increase in mothers with normal weight status from 73.4% to 84.4%, whereas the control group only showed a slight increase (71.0% to 70.6%). This difference at the end-line was statistically significant ($P = 0.02$). The finding suggests that the intervention contributed to improvements in overall child growth and nutritional well-being, resulting in a reduction in the prevalence of underweight children within the intervention communities.

Child anaemia improved significantly in the intervention group, where the proportion of normal-status children increased from 29.0% at baseline to 78.0% at the end-line. The control group also saw improvement (51.6% to 65.7%), but this difference at the end-line was statistically significant ($P = 0.05$). This finding suggests that the intervention contributed substantially to improving children's haemoglobin status and reducing the burden of anaemia among participating households.

The intervention group showed significant improvement in mothers' anaemia status, with the proportion in the normal category rising from 41.1% to 72.5%, compared to a smaller improvement in the control group (36.3% to 54.9%) ($P = 0.008$). This substantial increase suggests that the intervention was effective in improving maternal iron status and reducing the prevalence of anaemia among women of reproductive age. The observed improvement may be attributed to enhanced nutrition education, increased awareness of micronutrient-rich foods, and greater adoption of recommended dietary and health practices promoted through the intervention.

Table 5
Nutritional status of Mothers and young children between groups at baseline and end-line

Nutrition indicator	Baseline			End-line		
	Intervention group	Control group	P-Value	Intervention group	Control group	P-Value
Mothers BMI						
Underweight	10(8.1%)	11(8.9%)	0.57	7(6.4%)	16(15.7%)	0.03
Normal	104(83.9%)	97(78.2%)		93(85.3%)	69(67.6%)	
Overweight	9(7.3%)	13(10.5%)		8(7.3%)	15(14.7%)	
Obesity	1(0.8%)	3(2.4%)		1(0.9%)	2(2.0%)	
Stunting Status						
Normal	86(69.4%)	77(62.1%)	0.23	77(70.6%)	66(64.7%)	0.36
Stunting	38(30.6%)	47(37.9%)		32(29.4%)	36(35.3%)	
Wasting Status						
Normal	90(72.6%)	79(63.7%)	0.13	95(87.2%)	73(71.6%)	0.01
Wasting	34(27.4%)	45(36.3%)		14(12.8%)	29(28.4%)	
Underweight Status						
Normal	91(73.4%)	88(71.0%)	0.67	92(84.4%)	72(70.6%)	0.02
Underweight	33(26.6%)	36(29.0%)		17(15.6%)	30(29.4%)	
Child Anaemia status						
Normal	36(29.0%)	64(51.6%)	< 0.001	85(78.0%)	67(65.7%)	0.05
Anaemic	88(71.0%)	60(48.4%)		24(22.0%)	35(34.3%)	
Mother Anaemia status						
Normal	51(41.1%)	45(36.3%)	0.434	79(72.5%)	56(54.9%)	0.008
Anaemic	73(58.9%)	79(63.7%)		30(27.5%)	46(45.1%)	

The level of statistical significance is P-value < 0.05

Source: Authors' computation

Absolute and relative effect sizes for key binary outcomes at end-line (intervention vs. control)

To complement the within- and between-group comparisons in Table 5, risk differences, risk ratios, and odds ratios with 95% confidence intervals were calculated (Table 5a) for the principal binary outcomes at end-line, using a normal approximation to the binomial distribution. The intervention was associated with a significantly lower risk of maternal underweight, child wasting, child underweight, and maternal anaemia (95% CI for risk ratio excludes 1.0 in each case); the reduction in child anaemia risk was borderline (risk ratio 0.64, 95% CI 0.41 to 1.00). For the intervention arm, 95% confidence intervals for the end-line prevalence estimates (Wilson method) were: child wasting 12.8% (95% CI 7.8–20.4), child underweight 15.6% (95% CI 10.0–23.6), child anaemia 22.0% (95% CI 15.3–30.7), and maternal anaemia 27.5% (95% CI 20.0–36.6); the corresponding intervention-arm baseline prevalences were child wasting 27.4% (95% CI 20.3–35.9) and child anaemia 71.0% (95% CI 62.4–78.2).

Table 5

a: Absolute and relative effect sizes for key binary outcomes at end-line (intervention vs. control)

Outcome (end-line)	Intervention n/N (%)	Control n/N (%)	Risk difference (95% CI), pct pts	Risk ratio (95% CI)	Odds ratio (95% CI)
Maternal underweight (BMI)	7/109 (6.4%)	16/102 (15.7%)	-9.3 (-17.7 to -0.8)	0.41 (0.18 to 0.95)	0.37 (0.15 to 0.94)
Child wasting	14/109 (12.8%)	29/102 (28.4%)	-15.6 (-26.4 to -4.8)	0.45 (0.25 to 0.81)	0.37 (0.18 to 0.75)
Child underweight	17/109 (15.6%)	30/102 (29.4%)	-13.8 (-25.0 to -2.7)	0.53 (0.31 to 0.90)	0.44 (0.23 to 0.87)
Child anaemia	24/109 (22.0%)	35/102 (34.3%)	-12.3 (-24.4 to -0.2)	0.64 (0.41 to 1.00)	0.54 (0.29 to 0.99)
Maternal anaemia	30/109 (27.5%)	46/102 (45.1%)	-17.6 (-30.4 to -4.8)	0.61 (0.42 to 0.89)	0.46 (0.26 to 0.82)
<i>Note: RD = risk difference (intervention minus control); RR = risk ratio; OR = odds ratio. Pct. Pts = percentage points. CI = confidence interval, calculated using a normal approximation (Wald method). Source: Authors' computation, derived from the group n's and proportions reported in Table 3.</i>					

Baseline Comparison of Maternal and Child Health Indicators Between Intervention and Control Communities

The analysis was conducted to determine whether the two groups were comparable before implementation of the nutrition intervention. Table 6 presents the results of the Mann–Whitney U test comparing maternal and child health indicators between the intervention and control groups at baseline.

The indicators include maternal BMI, child height-for-age, weight-for-height, weight-for-age Z-scores, and haemoglobin levels for both mothers and children.

Across all variables, there were no statistically significant differences between the intervention and control groups (all p-values > 0.05). Median values for both groups were nearly identical, and the effect sizes (r) were very small, indicating negligible differences. The findings suggest that the two groups were well balanced at the start of the study, thereby providing a strong basis for attributing any subsequent differences at end-line to the effects of the intervention rather than pre-existing disparities.

Table 6
Mann–Whitney U Test Comparing Maternal and Child Health Indicators Between Intervention and Control Communities at baseline

Variable	Group	N	Median (IQR)	Mean Rank	Mann–Whitney U	Z	p-value	Effect Size (r)
BMI of Mother (kg/m²)	Intervention	124	21.63 (19.84–23.73)	122.19	7401.0	-0.508	0.611	-0.046
	Control	124	21.63 (19.84–23.73)	126.81				
Height-for-Age Z-score	Intervention	124	-1.52 (-2.34--0.60)	126.00	7501.5	-0.330	0.741	-0.030
	Control	124	-1.52 (-2.34--0.60)	123.00				
Weight-for-Height Z-score	Intervention	124	-1.54 (-2.25--0.19)	125.70	7539.0	-0.264	0.792	-0.024
	Control	124	-1.54 (-2.25--0.19)	123.30				
Weight-for-Age Z-score	Intervention	124	-1.28 (-2.06--0.30)	124.57	7679.5	-0.015	0.988	-0.001
	Control	124	-1.28 (-2.06--0.30)	124.43				
Child Haemoglobin (g/dL)	Intervention	124	10.20 (9.70–10.90)	131.60	6807.5	-1.563	0.118	-0.141
	Control	124	10.20 (9.70–10.90)	117.40				
Mother Haemoglobin (g/dL)	Intervention	124	11.15 (9.60–13.28)	125.77	7530.5	-0.279	0.780	-0.025
	Control	124	11.15 (9.60–13.28)	123.23				
Note: $p < 0.05$ indicates statistical significance. Effect size (r) calculated using $r = \frac{Z}{\sqrt{N}}$ where $N = 248$								
Source: Authors’ computation								

Endline Comparison of Maternal and Child Health Indicators Between Intervention and Control Communities

This comparison assessed whether participation in the co-designed, place-based nutrition intervention resulted in measurable differences in nutritional and health outcomes between the two groups after six months of implementation. Table 7 shows the Mann–Whitney U test results comparing the same set of health indicators between intervention and control groups at endline. Unlike baseline results, several statistically significant differences emerged.

Children in the intervention group had significantly higher weight-for-height Z-scores ($p = 0.014$, $r = -0.169$) and weight-for-age Z-scores ($p = 0.004$, $r = -0.197$) than those in the control group, indicating improved nutritional status. Additionally, both child haemoglobin levels ($p = 0.025$, $r = -0.154$) and maternal haemoglobin levels ($p = 0.003$, $r = -0.208$) were significantly higher in the intervention group, suggesting better iron status and reduced anaemia prevalence. No significant differences were found in maternal BMI ($p = 0.845$) or child height-for-age Z-scores ($p = 0.118$).

Table 7
Mann–Whitney U Test Comparing Maternal and Child Health Indicators Between Intervention and Control Communities at endline

Variable	Group	N	Mean Rank (Mann-Whitney)	Mann-Whitney U	Z	p-value	Effect Size (r)
BMI of mother (kg/m²)	Intervention	109	106.79	5472.5	-0.195	0.845	-0.013
	Control	102	105.15				
Height-for-Age Z-Score	Intervention	109	112.35	4867.0	-1.561	0.118	-0.107
	Control	102	99.22				
Weight-for-Height Z-Score	Intervention	109	116.01	4468.0	-2.462	0.014*	-0.169
	Control	102	95.30				
Weight-for-Age Z-Score	Intervention	109	117.67	4287.0	-2.870	0.004*	-0.197
	Control	102	93.53				
Child Haemoglobin (g/dL)	Intervention	109	115.12	4565.0	-2.245	0.025*	-0.154
	Control	102	96.25				
Mother Haemoglobin (g/dL)	Intervention	109	118.26	4222.5	-3.017	0.003*	-0.208
	Control	102	92.90				
Note: $p < 0.05$ indicates statistical significance. Effect size $r = \sqrt{\frac{Z^2}{N}}$ where $N = 211$ for post-intervention analyses.							

Within-Group Comparison of Maternal and Child Nutritional Indicators in the Control Group Between Baseline and End-Line

Changes in anthropometric and haemoglobin measurements over the study period were examined to determine whether routine nutrition and health services alone were associated with improvements in maternal and child nutritional outcomes. The findings provide a basis for distinguishing changes attributable to standard care from those observed in communities that received the co-designed, place-based nutrition intervention. Table 8 presents the within-group comparison of maternal and child nutritional indicators in the control group between baseline and end-line using the Wilcoxon signed-rank test.

A Wilcoxon signed-rank test revealed that children’s haemoglobin (Hgb) levels in the control group were significantly higher at endline ($Md = 11.70, n = 102$) compared to baseline ($Md = 10.20, n = 102$), $z = - 5.05, p < .001$, with a large effect size, $r = .50$. Mothers’ haemoglobin levels also showed a significant increase from baseline ($Md = 11.05$) to endline ($Md = 12.35$), $z = - 2.76, p = .006$, with a moderate effect size, $r = .27$. However, there were no significant differences in mothers’ BMI ($z = - 0.44, p = .658$), children’s height-for-age ($z = - 0.54, p = .591$), weight-for-height ($z = - 0.05, p = .962$), or weight-for-age z-scores ($z = - 1.22, p = .222$). These findings suggest that while routine nutrition and health services may have contributed to improvements in haemoglobin status, they were insufficient to produce significant changes in broader anthropometric indicators during the study period. The absence of significant improvements in growth-related measures highlights the challenges of achieving measurable nutritional gains without targeted and intensive nutrition interventions.

Table 8

Wilcoxon Signed-Rank Test Results Comparing control group baseline and Endline Measurements (n = 102)

Variable	Median (Baseline)	Median (Endline)	Z	p-value	Effect Size (r)*
BMI of Mother (kg/m²)	21.96	21.70	-0.44	0.658	0.04
Height-for-Age Z-score (HAZ)	-1.52	-1.83	-0.54	0.591	0.05
Weight-for-Height Z-score (WHZ)	-1.37	-1.53	-0.05	0.962	0.01
Weight-for-Age Z-score (WAZ)	-1.29	-1.78	-1.22	0.222	0.12
Child Haemoglobin (Hgb, g/dL)	10.20	11.70	-5.05	< 0.001	0.50
Mother Haemoglobin (Hgb, g/dL)	11.05	12.35	-2.76	0.006	0.27
Notes: Test used: Wilcoxon Signed-Rank Test (two-tailed). *Effect size calculated as $r = \sqrt{Z^2/N}$ Threshold for significance: $p < .05$. Negative Z values indicate higher endline values compared to baseline, where the test was based on negative ranks.					

Comparing Intervention Group Baseline and End line

Baseline and end-line anthropometric and haemoglobin measurements were compared to assess the nutritional effects of the co-designed, place-based intervention among participants in the intervention communities. The study sought to delve into the extent to which participation in the intervention contributed to improvements in maternal and child nutritional outcomes within the intervention communities. Table 9 presents the within-group comparison of maternal and child nutritional indicators in the intervention group between baseline and end-line using the Wilcoxon signed-rank test. The results revealed that children’s haemoglobin (Hgb) levels in the intervention group were significantly higher at endline ($Md = 12.00, n = 109$) compared to baseline ($Md = 10.20, n = 109$), $z = - 6.98, p < .001$, with a large

effect size, $r = .67$. Mothers' haemoglobin levels also showed a significant increase from baseline (Md = 11.25) to endline (Md = 13.10), $z = -4.72$, $p < .001$, with a large effect size, $r = .45$. In addition, children's weight-for-height z-scores improved significantly from baseline (Md = -1.58) to endline (Md = -0.93), $z = -3.55$, $p < .001$, with a moderate effect size, $r = .34$. However, there were no significant differences in mothers' BMI (Md = 21.41 vs. 21.50, $z = -0.69$, $p = .488$), children's height-for-age z-scores (Md = -1.52 vs. -1.26, $z = -1.52$, $p = .128$), or weight-for-age z-scores (Md = -1.27 vs. -1.20, $z = -0.80$, $p = .427$). The outcomes of the study indicate that the intervention was particularly effective in improving haemoglobin concentrations and reducing acute malnutrition among children. The absence of significant changes in maternal BMI and child height-for-age suggests that some nutritional outcomes, especially those reflecting long-term growth and body composition, may require a longer intervention period before measurable improvements become evident.

Table 9

Wilcoxon Signed-Rank Test Results Comparing Intervention Group Baseline and Endline Measurements (n = 109)

Variable	Median (Baseline)	Median (Endline)	Z	p-value	Effect Size (r)
BMI of Mother (kg/m ²)	21.41	21.50	-0.69	0.488	0.07
Height-for-Age Z-score (HAZ)	-1.52	-1.26	-1.52	0.128	0.15
Weight-for-Height Z-score (WHZ)	-1.58	-0.93	-3.55	< 0.001	0.34
Weight-for-Age Z-score (WAZ)	-1.27	-1.20	-0.80	0.427	0.08
Child Haemoglobin (Hgb, g/dL)	10.20	12.00	-6.98	< 0.001	0.67
Mother Haemoglobin (Hgb, g/dL)	11.25	13.10	-4.72	< 0.001	0.45
Notes: Test used: Wilcoxon Signed-Rank Test (two-tailed). The effect size was calculated as $r = Z/\sqrt{N}$. Threshold for significance: $p < 0.05$. Source: Authors' computation					

Adverse events

Participants and Community Nutrition Volunteers did not report any adverse events or unintended harms during the intervention period, which lasted six months, associated with the MCNFHI intervention or study procedures (e.g., anthropometric measurements, blood sample collection). The participants identified as anaemic and/or acute malnourished during the screening process were referred to local health facilities for clinical management in line with the standard clinical approach.

Discussion

Maternal and child malnutrition spanning undernutrition, micronutrient deficiencies, and a rising burden of overweight remains a pervasive challenge in low-income settings such as northern Ghana [33,34, 35]. This study evaluated a six-month, co-designed, participatory nutrition programme (the MCNFHI) against routine services in rural north-eastern Ghana. The results indicate that such place-based interventions may lead to measurable changes in anthropometric indicators of mothers and children, and in haemoglobin concentrations within a relatively short intervention time window [36,37].

The underweight status of intervention mothers decreased slightly (8.1% to 6.4%) and increased in controls (8.9% to 15.7%), and the intervention arm had significantly fewer underweight mothers at end line (6.4% versus 15.7%; $P = 0.03$). The differences in BMI were not statistically significant, but this could mean that the intervention prevented the deterioration of maternal status observed in usual care, as in a quasi-experimental nutrition programme evaluation in Nepal, which found that the intervention reduced maternal underweight by 8.43 percentage points, compared with comparison areas ($P < 0.001$) [38].

In comparison, there was minimal change in linear growth of children during the 6-month period. At end-line, there was a slight difference between the two arms with the intervention showing a decrease in stunting (from 30.6% to 29.4%) and the control arm from 37.9% to 35.3%, but the difference was not significant ($P = 0.36$). The higher proportion of acute malnutrition (wasting) and anaemia over stunting is likely to reflect cumulative exposure over a longer periods of time, as wasting is likely to be a more short-term and reversible nutritional insult than stunting, which is likely to be a more chronic and lasting exposure [39]. This was not observed as an absence of effect of the intervention on stunting or maternal BMI, but is most likely attributable to the small duration of exposure (6-months) and lack of power to detect an effect on these slow changing outcomes. A similar pattern was observed in a six-month agriculture nutrition intervention in Ghana, where child growth and diet improved prior to longer-term anthropometric outcomes [24]. These findings are also similar to other trials within the region. In rural Ethiopia, a community-based participatory nutrition promotion programme, built on existing government services, had a high impact on stunting and underweight status after 12 months of follow-up, approximately twice the exposure time assessed in this study [18]. Similarly, the Ghanaian Newhints trial, which trained community volunteers to deliver structured home visits, showed measurable improvements in newborn care, after a longer follow up periods showing that well implemented, community-embedded interventions in Ghana can require sustained delivery long overtime to achieve statistically detectable downstream health outcomes [16]. Another study reported, a community-based women's groups and volunteer peer counselling resulted in modest reductions in mortality in rural Malawi, observed with a comparable delay in detectable effect, and for some outcomes, effects were not seen after multiple testing adjustment, consistent with the findings from the community delivered interventions in the current study [40]. A systematic review and meta-analysis of women's-group interventions in low-resource settings also identified that although better-designed programmes can reduce maternal and neonatal mortality, they are the ones that have larger population coverage and longer implementation times that have significant effects on downstream mortality, rather than the design itself [18]. Combined with this literature, the interpretation that the stunting effect was not observed in the current trial was thought to be

due to the fact that the exposure time was too short to observe a chronic, cumulative effect, and not a true null effect due to the MCNFHI model; a longer follow-up period (e.g. 12 months) would be required to test this directly.

Acute malnutrition improved markedly in the intervention arm. Wasting fell from 27.4% to 12.8% (normal weight-for-height rising 72.6% to 87.2%; $P = 0.01$) and underweight from 26.6% to 15.6% ($P = 0.04$), while controls changed little; both differences were significant between arms at end-line (wasting $P = 0.01$; underweight $P = 0.02$). These short-term weight gains align with integrated agriculture–nutrition trials in Ghana, where Marquis et al. [24] reported significant improvements in children's weight-for-age from a combined education and food-production package, even where linear growth responded more slowly.

Anaemia showed the largest gains. Child anaemia in the intervention arm dropped from 71.0% to 22.0% and maternal anaemia from 41.1% to 27.5% (both $P < 0.001$), with significantly higher non-anaemic proportions than controls at end-line (children 78.0% versus 65.7%, $P = 0.05$; mothers 72.5% versus 54.9%, $P = 0.008$). Median haemoglobin rose correspondingly in children (10.2 to 12.0 g/dL) and mothers (11.25 to 13.10 g/dL). These reductions are consistent with trials and meta-analyses showing that nutrition education and micronutrient-focused interventions substantially raise haemoglobin in high-burden settings [41,42].

Notably, haemoglobin also increased in control communities (child median 10.20 to 11.70 g/dL; maternal 11.05 to 12.35 g/dL; both $P \leq 0.006$) which is possibly due to routine iron supplementation, deworming and seasonal factors, while control anthropometry did not change. This is in line with evidence from rural Ghana, which demonstrates that continued use of iron-containing micronutrient powders alone is an effective intervention for increasing haemoglobin and decreasing anaemia levels in young children despite the absence of a wider nutrition intervention [43] and evidence indicating that anaemia burden among children in Ghana varies significantly throughout the malaria transmission season, and that intermittent malaria control interventions substantially reduced anaemia episodes during the same six-month period, independent of any nutritional programming [43]. This suggests that the standard care could help to improve iron status, but would not cause a shift in growth within 6 months [45].

Within the intervention group, there was a more rapid improvement in the same outcomes. Maternal BMI and height-for-age did not change, confirming that the intervention had the greatest impact on iron status and acute growth, respectively child haemoglobin (10.20 to 12.00 g/dL; $r = 0.67$); weight-for-height (median WHZ – 1.58 to – 0.93; $r = 0.34$). Better maternal capability was a plausible behavioural pathway, as process observation during this trial indicated that the intervention group had greater improvements in their maternal knowledge and practice Essential Nutrition Actions compared to the control group, which is consistent with observed reductions in wasting and anaemia, and with the broader evidence base, which showed that behaviour change interventions can reliably deliver improvements in maternal nutrition-related knowledge and practice in sub-Saharan Africa [46]. A second complementary pathway is through the economic empowerment of women that is embedded in the trial's agriculture intervention, as evidenced in Ghana where increased women's decision making power and control over household income in agricultural households was linked to improved diet diversity and nutrition status, independently of

household wealth [22] and in Burkina Faso, where empowerment improvements were partially responsible for nutrition improvements in children, as part of a nutrition-sensitive agriculture programme randomised trial [23]. The five women's income-generating associations created under the MCNFHI plausibly strengthened the education and counselling aspects of the project in just this way; mothers were provided with the knowledge and the means of putting it into practice. In general, community health worker programmes in low and middle income countries have been shown to significantly improve nutrition in communities; however this is heavily dependent on the quality of training, supervision, and the degree to which the communities are accepting the intervention [19], and in this trial, the monthly supervision, competency assessment and financial incentive provided to CNVs was deliberately designed around these known success factors. Last, the negotiated and structured process of food taboos and gender issues during the co-design process echoes a broader lesson learned from community-based trials methodology: participatory intervention design can provoke true social tensions, such as gender issues, which should not be taken for granted but actively engaged with [26].

Strengths and Limitations

The intervention was co-designed with the participating communities and this process could enhance acceptability, contextualization, and potential for sustainability. The mixed methods approach also provided a means to cross-validate quantitative results with community views. Furthermore, the end-line assessment was relatively high, with 211 of 248 mother–child pairs completing end line assessment (85%). The main outcomes were objective and were assessed in a standard way (anthropometry and laboratory haemoglobin), which minimised measurement bias. There are however some limitations to this study. The short timeframe of the intervention might have limited the ability to measure growth on a number of chronic markers such as stunting that require longer exposure to be effective, and to show measurable growth. Second, randomisation was at cluster/community level rather than individual level, fewer clusters (ten) and this meant that the power of the study was less than at the individual level and there was increased risk of residual confounding because of the community level characteristics. This risk was realised at baseline, where there were significant imbalance in ethnicity, source of drinking water, sanitation and household food security between arms (Table 1), likely due to the fact that whole communities were randomised, and neighbouring communities that shared infrastructure and/or ethnicity were not randomly distributed. However, these features are likely to be correlated with nutrition status and potential residual confounding cannot be ruled out, and the effect of the intervention reported here is best considered as associational, not necessarily a causal effect; no formal intra-cluster correlation or covariate adjustment was done because of the limited number of clusters. Furthermore, due to the nature of the intervention, participants, volunteer members of the communities, and staff in the field were not blinded to the intervention, which could have introduced social desirability or observer bias, particularly for the self-reported dietary and food security measures. Furthermore, reporting effect sizes and p-values from non-parametric tests is not as precise in quantifying of the magnitude of the effects of interventions as reporting of regression-based estimates with 95% confidence interval. Also, the precise reasons for loss to follow-up (LTFU) (37/248 mother–child pairs, 14.9%) remained incomplete and LTFU may have been differential between the arms and lead to attrition bias. Lastly, the results from a single-district study

in East Mamprusi do not necessarily translate to other ecological, cultural, or health-care system settings in Ghana or in other under-resourced rural areas which may be able to adapt the participatory, place-based approach of the MCNFHI model. Further, the data on dietary and food security was self-reported, and recall and social-desirability bias may have been present. Additionally, a cost-effectiveness analysis was not conducted in the trial, which is a key element needed for scale-up. Lastly, food security data were gathered during the time period from November to May (most of the dry season), which could restrict the generalisability of the findings to the rainy season when food security is likely to be more severe.

Implications for Policy and Practice

These findings have direct implications for nutrition policy and practice in Ghana and comparable settings. The components that drove the largest gains Community Nutrition Volunteer-led education and household counselling, promotion of locally available micronutrient-rich foods, and women's economic-empowerment groups are low-cost and embedded in existing community structures, making them strong candidates for integration into Ghana's National Nutrition Policy and the routine activities of the Ghana Health Service. Because the model delivers measurable reductions in acute malnutrition and anaemia within six months, it could complement, rather than replace, facility-based services in high-burden districts. Before wider scale-up, however, decision-makers will need formal cost and cost-effectiveness estimates, alongside a longer evaluation window to determine whether sustained delivery also shifts chronic indicators such as stunting. Evidence on community health worker programmes cautions that scale-up beyond a well-supervised trial setting often erodes fidelity and effect size unless training, supervision, and modest remuneration are preserved, so any expansion of the MCNFHI model should budget explicitly for CNV supervision and refresher training rather than assuming volunteer motivation alone will sustain quality.

Conclusions

The findings demonstrate that the MCNFHI, a co-designed and place-based nutrition intervention, was effective in improving the nutritional status of women and young children in rural Northeastern Ghana. Significant reductions were observed in child wasting, underweight prevalence, and anaemia, alongside substantial improvements in maternal and child haemoglobin concentrations, indicating meaningful gains in both acute malnutrition and micronutrient status. Although no significant changes were detected in maternal body mass index or child stunting during the six-month intervention period, the overall results suggest that community-driven, culturally responsive, and context-specific nutrition strategies can generate measurable improvements in maternal and child health outcomes. The study provides evidence that integrating community participation, household engagement, nutrition education, women's empowerment, and local institutional support can enhance the effectiveness of nutrition programming in resource-constrained settings. Scaling up similar co-designed interventions through existing health and community systems may contribute substantially to reducing the burden of malnutrition and anaemia among vulnerable populations in Ghana and other low- and middle-income countries facing comparable nutritional challenges.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Kwame Nkrumah University of Science and Technology Committee on Human Research, Publications, and Ethics (CHRPE/AP/149/23), and permission was granted by the East Mamprusi Municipal Health Directorate (GHS/NER/EMM/10/2023). The trial was registered with the Pan African Clinical Trial Registry (PACTR202412697952932). Written informed consent was obtained from all participants after community-level randomization and selection of households for participation in the study within the communities to which they were randomized. For participants who were unable to read or write, the consent and information sheets were read in the local language by the enumerator, and participant's agreement was indicated by a thumbprint, witnessed and co-signed by an independent literate witness who was not part of the research team. No separate legal guardian or legally authorized representative was used for adult participants. Participants identified with anaemia or malnutrition were referred to local health facilities for care. Confidentiality and voluntary participation were upheld throughout in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable

Availability of data and materials

All data underlying the conclusions in this study are included in the main text and Supplementary Information.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Vincent Adocta Awuuh: Conceptualization, Data curation, Formal analysis, Funding, Investigation, Methodology, Project administration, Visualization, Writing original draft, writing review & editing.

Charles Apprey: Conceptualization, Methodology, Supervision, Writing review & editing.

Reginald Adjetey Annan: Conceptualization, Methodology, Supervision, Writing review & editing.

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Figures

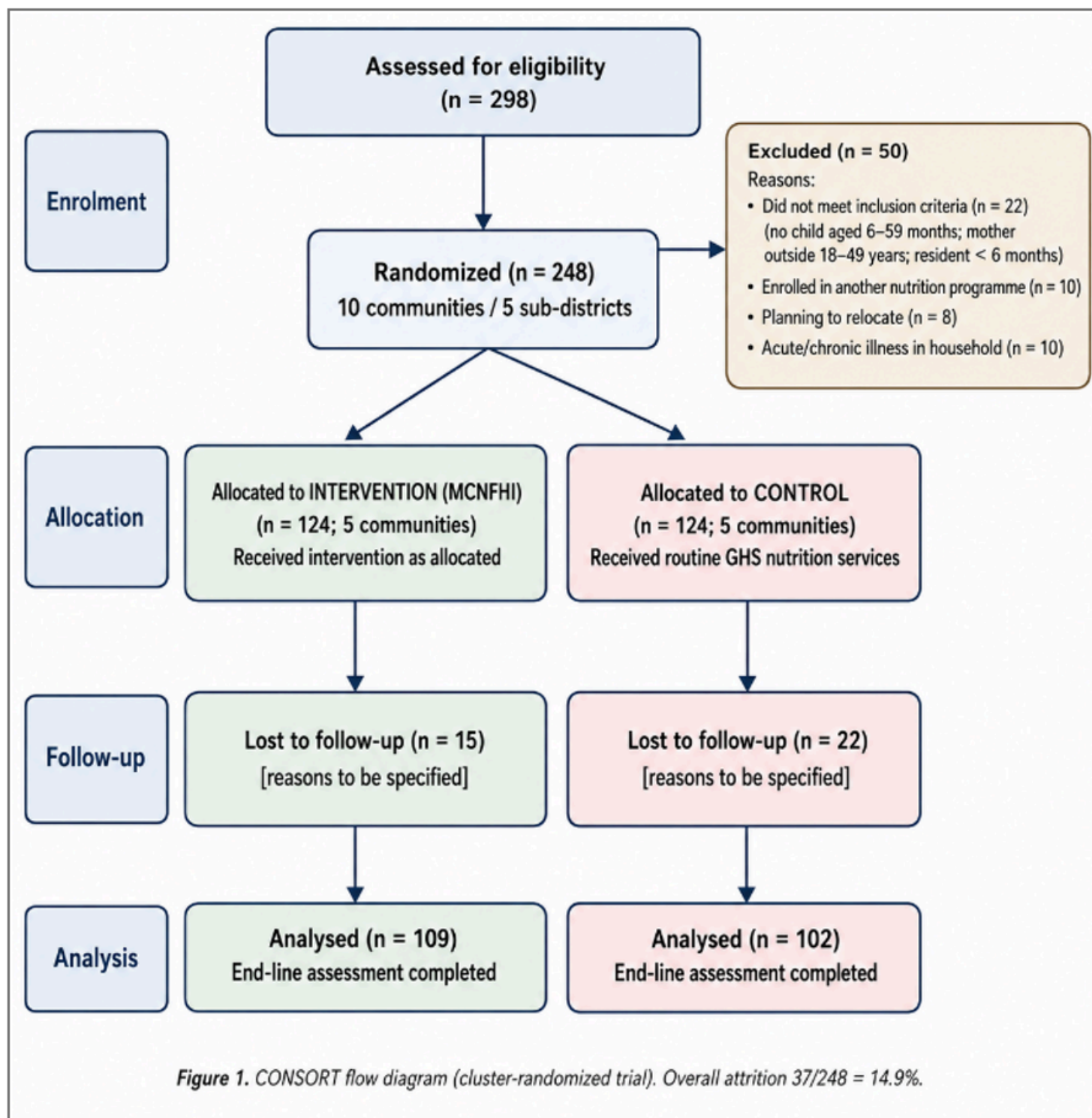


Figure 1

CONSORT flow diagram (reported in accordance with the CONSORT 2010 extension for cluster-randomized trials [47]) illustrating the flow of communities and participants through the trial. A total of 298 mother–child pairs were assessed for eligibility, 50 were excluded, and 248 participants from 10 communities (5 communities per study arm) were randomized to the intervention (n = 124) or control (n = 124) group. At follow-up, 15 participants in the intervention group and 22 in the control group were lost to follow-up,

resulting in 109 intervention participants and 102 control participants included in the end-line analysis (overall attrition: 37/248, 14.9%).

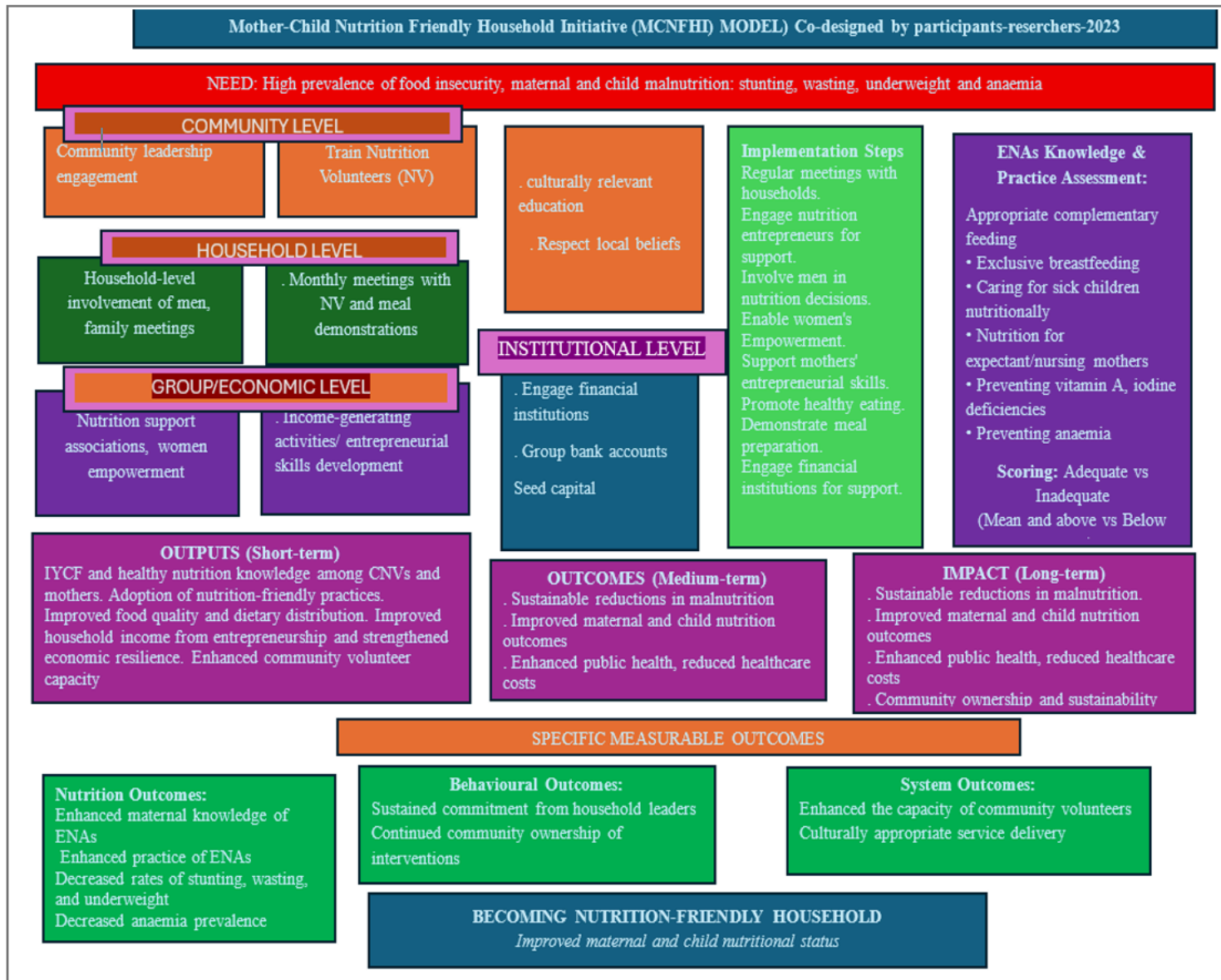


Figure 2

Conceptual framework (Theory of Change) for the Mother–Child Nutrition Friendly Household Initiative (MCFHI), showing the intervention components at the community, household, group/economic, and institutional levels, the implementation pathways linking them, and the expected short-term, medium-term, and long-term outcomes.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [3.CONSORTclusterchecklist.docx](#)