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Scaling-up equitable nutritional care for girls and women in South Asia

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Scaling-up equitable nutritional care for girls and women in South Asia

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Editorial: Scaling-up equitable nutritional care for girls and women in South Asia

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Editorial on the Research Topic
Scaling-up equitable nutritional care for girls and women in South Asia

The right to good nutrition is every woman's right to support her wellbeing and key to reducing the annual burden of low birth weight (~8 million) in South Asia. This Research Topic of 13 selected papers from a call for papers on "***Scaling-up equitable nutritional care for girls and women in South Asia***" in July 2023 draws attention to the evidence on the status, policy and program action and provides recommendations. These articles are published across Frontiers in Nutrition Epidemiology and Frontiers in Public Health and provide five messages described below.

Urgent action is needed to tackle the triple burden of maternal malnutrition

In South Asia, one in five women (22%) are underweight, one in five (20%) suffer from obesity and anemia in girls and women remains a persistent problem (49%). Malnutrition among married nulliparous women <24 years is particularly concerning. Kumar et al. using DHS data between 2010 and 2022 from six countries (Bangladesh, India, Maldives, Nepal, Pakistan, and Sri Lanka), showed that an estimated one in four nulliparous women 15–24 years were underweight or overweight in pooled analysis, with substantial variation between countries and declining trends of underweight and increasing trends of obesity and those from rural or urban poorer households or with lower education more likely to be underweight or low stature. Panchal et al. studied these patterns on refugees and revealed similar results, highlighting a need to deliver double duty actions based on geographic and demographic characteristics.

Strong nutrition policy frameworks, but implementation gaps persist

Despite strong policy intents and frameworks, effectiveness of nutrition programs is limited due to gaps in essential nutrition supplies, training, human resources, monitoring

and research to support programmes and budgets. The article by Sethi and Murira urges that effective nutrition policies and programmes in South Asia should address systems bottlenecks to deliver five essential multi-sector actions—(i) access to fortified and nutritious foods, (ii) micronutrient supplementation, (iii) nutrition information and counseling, (iv) infection prevention, and (v) services for women with nutritional risks (thin, short, overweight/obese, young and anemic) through co-operation between health, nutrition, agriculture, education, and social protection sectors. Sethi and Murira also urge to tap missed opportunities for integrating key maternal services into the same platforms that treat children, reaching women in the preconception period through antenatal nutrition platforms as well as differentiated strategies e.g., to reach the most marginalized communities.

Women's groups show promise but require sustained investments

Women's groups can play a key role in transforming the approach to nutrition programs from one oriented principally around service delivery to one based on women's rights. Seven key pathways for impact have been highlighted in the article by Shrivastava et al. for engaging with women's groups and organizations that are working on women's rights which do not necessarily include nutrition rights. These pathways include income generation, agriculture, health education, rights advocacy, food access, cash transfers, and integrated service delivery. Mondal et al. highlight that while self-help groups have a positive influence on the health and eating habits of women and children, they are found to be less effective in changing nutritional outcomes for women and children or neonatal mortality (1). The literature review by Verma et al. examines the role of women led self help and support groups in improving health and nutrition outcomes in India, Bangladesh, and Vietnam observed that—while the core focus of self-help group initiatives has tended to be rural economic empowerment, ensuring sustainability is a common challenge faced by such initiatives and recommend the need to allow time and sufficient resources for group maturation, to prevent group dissolution, and to maintain quality by ensuring facilitators receive refresher training at regular intervals.

Promising approaches from Bangladesh, India, Nepal, and Pakistan

- **Bangladesh**: An intervention by Abdulloeva et al. in rural Bangladesh found that integrating child growth monitoring and promotion services into the existing child immunization programme, improving local government accountability, implementing unified health records, and expanding integrated maternal and child health services resulted in enhanced growth monitoring and maternal nutrition services.
- **India**: Dhabhai et al. demonstrated two thirds of women who have not gained a healthy amount of weight during their pregnancy can achieve adequate weight gain in the subsequent four weeks when given a comprehensive package of nutrition services. The package included supplementation with high-quality, protein-rich food alongside close monitoring for adherence, delivering nutritional counseling, and referring to health facilities where necessary. Hazra et al. showed that initial grants and seeds to households for growing kitchen gardens can act as a seasonal source of vegetables for the household and may help improve dietary diversity.
- **Nepal:** Cunningham et al. demonstrate that delivering social and behavior change communication through at least two channels at the same time can significantly improve maternal and child nutrition practices in disadvantaged social and economic population groups. Saville et al. showed that virtual counseling can also improve awareness and consumption of iron-rich diets in pregnant women.
- **Pakistan**: Samnani et al. develop a Nutrition Friendly School Initiative which involved developing school policies, engaging with and educating parents and established pathways for assessing children's nutritional status periodically. Naz et al., showed that community midwife led intra-venous iron therapy following prescription from consultant obstetricians reduced moderate anemia in a cohort of pregnant women in Karachi.

Together these papers provide following recommendations for accelerating progress to tackle the triple burden of malnutrition in women:

- **Develop and update multi-sectoral plans**: create clear targets and allocate budgets for women's nutrition services-before, during and beyond pregnancy, including nutrition risk assessments, monitoring and counseling, macro and micronutrient supplementation when required and prevention and treatment of infections with special care packages for those at risk of all forms of malnutrition. Investments will be needed from multiple sectors, especially education, health, social protection and food systems. Investments to protect women from nutrient-poor and unhealthy ultra-processed foods and beverages and to account for the differential strategies for marginalized communities needs to be made on priority. This will also entail updated service delivery intervention packages and toolkits to ensure comprehensiveness and alignment with global guidelines/recommendations, strategies to address system bottlenecks and implement a minimum nutrition package for women before, between and beyond pregnancies.
- **Women as agents of change**: leveraging women's movements and coalitions will enhance the visibility of women's nutrition rights within the broader women's rights agenda. Women's groups whilst can support peer-to-peer counseling can also play a critical role in addressing harmful gender and social norms that underlie maternal malnutrition and especially can promote those that work toward keeping girls in school, delay age at marriage. Additionally, nutrition social enterprises can offer dual opportunities for women groups for improving both nutrition and livelihoods.
- **Target inequities**: this would require being intentional in scaling up efforts to address social and geographical nutrition inequalities as revealed by subnational data to identify and close service delivery gaps for marginalized

groups, particularly malnourished adolescent girls and women who are at economic, social or geographic disadvantage, particularly in humanitarian settings.

- **Invest in knowledge:** strengthen survey data systems to track trends in malnutrition, rigorously evaluate new interventions to support scale-up, promote academic-government collaboration for evidence-based policymaking, and encourage knowledge exchange within and between South Asian countries. Promoting effective use and dissemination of data will further ensure that progress in implementation of strategies are both accessible and accountable to the communities they aim to serve.

We are hopeful this Research Topic will trigger conversations for accelerating scaling-up efforts in improving nutrition of adolescent girls and women in South Asia, through convergent multi-sector nutrition solutions.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Management of iron deficiency anemia during pregnancy: a midwife-led continuity of care model

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Background: Globally, 36.5% of pregnancies are affected by anemia, particularly in low-and middle-income countries, posing significant risks to maternal and perinatal health. In rural Pakistan, 44.3% of pregnant women suffer from iron deficiency, contributing to the high prevalence of anemia. Limited accessibility to antenatal care exacerbates the challenge, necessitating innovative solutions. This study assessed a midwife-led continuity of care model, utilizing intravenous (IV) iron therapy for the management of anemia in Karachi, Pakistan.

Methods: We performed a retrospective analysis of data from a prospective cohort study conducted in two primary healthcare facilities, which employed a community midwife (CMW)-led continuity of care model for antenatal care, including IV iron therapy. We extracted data from February 2021 to March 2022 for women who were diagnosed with anemia based on hemoglobin (Hb) levels, categorized as mild (10.0 to 10.9 g/dL), moderate (7.0 to 9.9 g/dL), or severe (less than 7.0 g/dL). Assessment occurred at the initial antenatal care (ANC) visit to establish baseline anemia severity, and approximately 2 weeks after intravenous (IV) iron therapy administration to evaluate post-treatment changes were considered.

Results: We enrolled 114 pregnant women, where the majority presented with moderate (88.6%) anemia. After IV iron treatment, 48.5% improved to normal-mild levels, while 50% remained unchanged. Severe anemia affected 10.5% at baseline; 42% shifted to moderate and 50% to normal-mild post-treatment, with one remaining unchanged ($p<0.001$). Among women enrolled in the first and second trimesters, severe anemia improved to normal-mild (50%) and moderate levels (50%) (pre-treatment: $n=10$, post-treatment: $n=0$), and moderate anemia decreased by 48% (pre-treatment: $n=92$, post-treatment: $n=47$).

Conclusion: Our midwife-led model of care demonstrated an improvement in iron levels among pregnant women. The model addressed the challenges of anemia prevalence in Pakistan and underscored the significance of empowering front-line healthcare providers, such as community midwives (CMWs) for managing these common conditions.

KEYWORDS

anemia, pregnant women, intravenous iron therapy, midwife-led model of care, primary healthcare (PHC)

1 Introduction

According to the World Health Organization, approximately 36.5% of pregnant women are anemic worldwide; the majority of these (56%) women are from low-and middle-income countries (LMICs) (1). According to the National Nutrition survey, iron deficiency is present in 44.3% of pregnant women in rural Pakistan (2). The World Health Organization (WHO) currently recommends the definition of severe, moderate, and mild anemia in pregnancy based on hemoglobin (Hb) concentrations: less than 7.0 g/dL, 7.0 to 9.9 g/dL, and 10.0 to 10.9 g/dL, respectively (3). There is well-established literature linking adverse maternal and perinatal outcomes with maternal Hb levels lower than 11.0 g/dL. The effects on maternal health include fatigue, compromised immune function, an elevated risk of cardiac diseases and an increased risk of preterm birth, low birth weight, intrauterine deaths (IUFD), low APGAR scores at 5 min, and intrauterine growth restriction (IUGR). Preterm birth and low birth weight are significant contributors to neonatal deaths in Pakistan, which has one of the highest Neonatal Mortality Rates (NMR) globally at 39.4 deaths per 1,000 live births (4). Thus, it is essential to treat anemia in pregnant women (5). Oral iron supplementation is widely prescribed as the first-line treatment for IDA. However, a high frequency of gastrointestinal side effects and the long duration of therapy (4–6 weeks) negatively affect compliance with this therapy (6–8).

In contrast, Intravenous (IV) iron preparations can be safely used for the treatment of IDA during pregnancy and the postpartum period and are more beneficial than oral iron preparations in patients who do not respond to oral iron therapy, have adverse reactions, and have severe anemia requiring rapid iron repletion (9). Administration of IV iron is associated with mild side effects such as rash in 25% of patients, most of which are self-limiting, and about 2% may experience severe allergic reactions. Most of these reactions occurred immediately during the infusion of the test dose (10). IV iron therapy is usually administered in a hospital setting under trained medical staff to oversee these side effects and provide timely treatment to avoid complications (11). This may be difficult to achieve in a low-resource setting such as Pakistan, where women have limited access to antenatal care (ANC); only 41% of the women receive more than one visit, and around 19% of women do not receive any antenatal care (12). In 2006, the Government of Pakistan introduced a new cadre of Community Midwives (CMWs) to address the shortage of skilled health workers. Rural women with more than 10 years of education, typically equivalent to completing secondary education or higher, were recruited and underwent 18 months of midwifery training. They were then deployed back to their towns to provide maternity care. Since then, midwife-led models of care have effectively improved maternal and neonatal outcomes. CMWs now serve as the front-line healthcare workers in various primary healthcare centers (PHCs) across Pakistan to provide ANC, including managing iron deficiency anemia (13).

In this study, we aim to describe the performance of a midwife-led model of care in the management of anemia utilizing IV iron therapy, among pregnant women at a community-based primary healthcare center in Karachi, Pakistan.

2 Methodology

2.1 Study design and participants

We did a retrospective analysis of data from a prospective cohort study (14) to describe our experience of midwife-led IV iron administration during pregnancy from February 2021 to March 2022 at two primary health care facilities (PHCs) located in peri-urban fishing communities, Rehri Goth and Ibrahim Hyderi in Karachi, Pakistan. These PHCs offer midwifery-led ANC along with ultrasound and laboratory investigations to the community. We extracted data for women with a singleton pregnancy, who presented to the PHCs with anemia and sought ANC services, had Hb levels at their first and last ANC visits, and maternal and perinatal outcomes available. Pregnant women with pre-existing medical conditions such as kidney and liver disease, acute infections, women with severe allergic reactions to iron preparations prior to enrollment were excluded. All women were referred to a secondary-level health facility for labor and birth.

2.2 Midwife-led model of care at the PHCs

The community midwives (CMWs) employed at the PHCs have a diploma in midwifery. Their training incorporates didactic and practical components, conducted at allied hospitals and primary health care centers with a focus on continuity of care principles. The midwives at the PHCs underwent regular training sessions and refresher courses to enhance their technical skills. Each center has four midwives providing ANC services to 20–25 pregnant women per day. Thus, each CMW treated 5–6 pregnant women per day. All the CMWs were required to work full time, and one of them served as a supervisor, overseeing the care provided and providing guidance to the CMWs. Throughout the pregnancy, the midwives conducted individual consultations, delivered antenatal care, identified potential complications, and referred for specialist care when necessary. The CMWs followed up with women having health risks at the PHC while collaborating with specialist care. They served as educators, fostering open discussions on birth, breastfeeding, family planning, and reproductive health. All women were provided with the midwives' phone numbers for emergencies.

All pregnant women underwent a routine complete blood count (CBC) to assess their anemia status during their first antenatal care visit (3). If a pregnant woman was identified as anemic according to the WHO classification, CMWs consulted the obstetrician at the secondary-level health facility over the phone to discuss further

management. If IV iron therapy was prescribed by the obstetrician, a Venofer® (iron sucrose) injection was administered by the CMWs. The dose of iron sucrose administered was calculated using the following formula: the weight of the pregnant women (kg) * [(targeted Hb of 11 – current Hb) * (required increase in Hb)] (15). The total cumulative dose of Venofer® was administered as a maximum of 200 mg not more than 3 times per week; it was ensured that the doses were administered at least 24 h apart. We used a drug-to-diluent concentration of 100 mg Venofer® in 100 mL of 0.9% sodium chloride. The first infusion of Venofer® included a test dose which was administered as 10 mg in 10 mL over 15 min (volume to be infused (VTBI) was 10 mL; IV pump set at 100 mL/h), and if no side effects were reported, the remaining dose of 90 mg in 90 mL infusion was given over 40–45 min at an infusion rate of not more than 200 mL/h. Subsequent doses of 100 mg in 100 mL of 0.9% sodium chloride were administered at a maximum pump rate of 200 mL/h under the supervision of the midwife, and Hb levels were repeated 2 weeks after the prescribed dose was administered (Figure 1).

As part of the midwife-led model of antenatal care, we incorporated other measures to improve anemia, particularly focusing on dietary counseling during every ANC visit along with folic acid supplementation. However, we ensured that women were not concomitantly taking oral supplements with IV therapy. Women who were found resistant to treatment were referred to a secondary-level facility for further evaluation and management to mitigate potential complications associated with anemia.

Data regarding the women's ANC visits and postnatal home visits were electronically captured from the PHC registries through a custom-built Android application by community health workers and stored on a PostgreSQL database. The data was cross-checked with the registries to ensure validity and that all eligible births were included. All identifications were removed before the data were transferred to the final database at Aga Khan University servers.

2.3 Training for administration of IV iron

The community midwives were trained based on appropriate management protocols, including regular refreshers covering the safe administration of IV iron therapy. The training for IV iron was over 2 days, with weekly refreshers of 1 h every quarter. They were supervised by the midwifery school staff and obstetricians for administration of IV iron. The assessment was based on a checklist to ensure that the midwife asked about any possible allergic reactions, administered the test dose correctly, followed by administration of the full dose and monitoring of vitals. CMWs were trained to promptly identify signs of an adverse event during IV iron administration and to initiate immediate interventions depending on the severity of the reaction.

Mild reactions, characterized by symptoms such as hypertension, slight chest tightness, or urticaria, prompted a 15-min pause in the infusion, during which the patient's response was assessed, and the obstetrician was contacted. If improvement was noted, the infusion was cautiously resumed at a reduced rate with continued observation for at least 1 h. Moderate hypersensitivity reactions, characterized by dyspnea, hypotension, chest tightness, and tachycardia, necessitated immediate cessation of the infusion, whereas severe or life-threatening hypersensitivity reactions (anaphylaxis), marked by respiratory distress required emergency referral after administering the first dose of dexamethasone.

We obtained written informed consent from all pregnant women prior to IV administration. The informed consent process included explaining to women the potential risks and benefits associated with

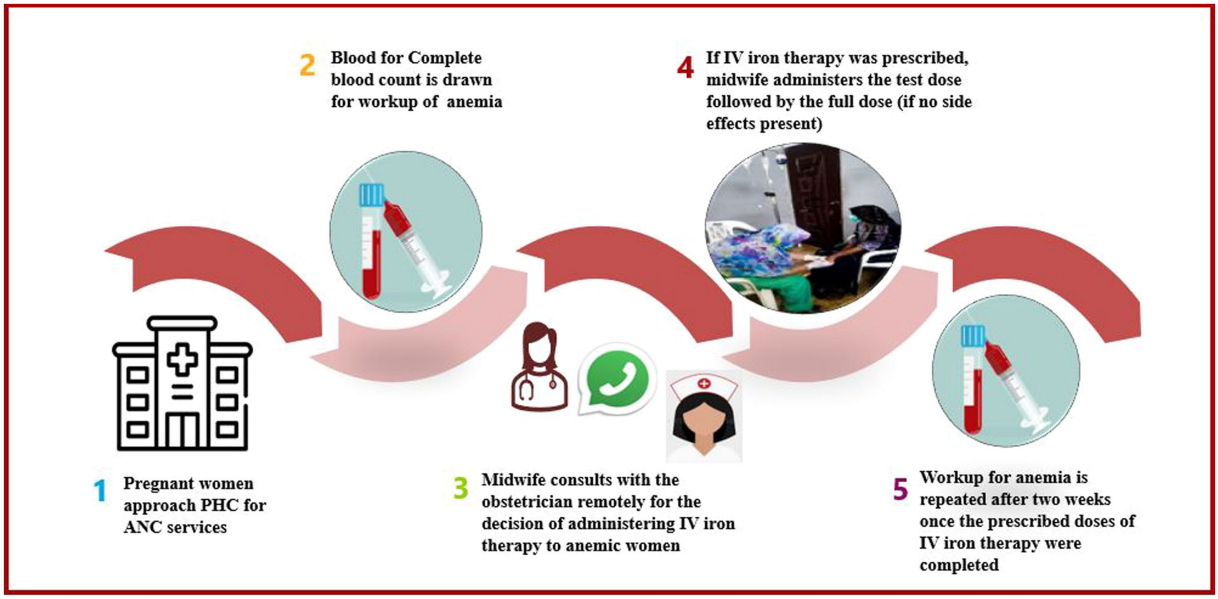

FIGURE 1
Management of anemia using IV iron therapy at a PHC facility. PHC, Primary Healthcare; ANC, Antenatal Care; IV, Intravenous Iron.

IV iron therapy. By obtaining consent, we ensured that women were fully aware of the procedure and its implications, thereby promoting patient autonomy. Only CMWs trained comprehensively in IV administration and management of adverse events were allowed to administer the doses. Standardized procedures were followed for the calculation of the iron doses, monitoring of vital signs and clinical symptoms during and after infusion, and management of adverse events.

2.4 Statistical analysis

Data related to sociodemographic, clinical, and birth-related characteristics were presented as mean ± SD or frequencies and percentages as appropriate. Anemia categories were defined as severe, moderate, and mild based on hemoglobin (Hb) concentrations: less than 7.0 g/dL, 7.0 to 9.9 g/dL, and 10.0 to 10.9 g/dL, respectively. We compared changes in the severity of anemia pre-and post-treatment with IV iron using a McNemar test. A p-value <0.05 was considered significant. We also presented frequencies and percentages for place of birth, mode of birth, primary birth attendant, gestational age at delivery, birth weight, and neonatal death based on IV iron dose received by the women. Data were analyzed using Stata® (Version 14.2 Statacorp Texas, United States).

2.5 Ethics

This study was approved by the Ethical Review Committee of Vital Pakistan Trust (Reference number: 001-VPT-IRB-20).

3 Results

A total of 114 pregnant women were enrolled in the study. Table 1 describes the sociodemographic characteristics of the study participants. We enrolled 35.1% (n = 40) of the women in the first trimester, 55.3% (n = 63) women enrolled in the second trimester, and 9.6% (n = 11) women in their third trimester. The mean age of the pregnant women was 26.17 +/− 5.37 years. Almost 66% (n = 75) of the women received no formal education, and 21.1% (n = 24) attended school up to secondary level. Approximately 34.2% (n = 39) of the pregnant women used gutka/tobacco, 18.4% (n = 21) were severely malnourished (<21), and 18.4% (n = 21) were moderately malnourished (21 to <23). During the study period, 43.9% (n = 50) of the pregnant women received a single dose, 32.5% (n = 37) received two doses, and 23.7% (n = 27) received three or more doses of IV iron.

The majority of pregnant women had moderate anemia (88.6%, n = 101) at baseline. Of these, 48.5% (n = 49) converted to normal-mild after correction with IV iron, whereas 50.5% (n = 51) remained unchanged. We observed 10.5% of the women to have severe anemia (n = 12) at baseline, 42% (n = 5) shifted to moderate, and 50% (n = 6/12) to normal to mild anemia after receiving treatment, whereas 1 remained unchanged (p = <0.001) (Table 2).

When comparing the change in anemia status during the first and second trimesters, severe anemia improved to normal-mild (50%) and moderate levels (50%) (pre-treatment: n = 10, post-treatment: n = 0), whereas there was a 48% reduction in moderate anemia (pre-treatment: n = 92, post-treatment: n = 47) (Table 3). However, among women enrolled in the third trimester, there was a 55% reduction in moderate anemia (pre-treatment: n = 9, post-treatment: n = 4) (Table 4). In our study, 14% (n = 16) of the women reported minor side effects, including dizziness (15%, n = 8), redness/swelling

TABLE 1 Clinical characteristics of the study participants.

Characteristics	N = 114 mean ± SD
Age in years	26.17 ± 5.37
BMI (kg/m^2)	21.69 ± 0.37
Gestational age at enrollment	24.8 ± 4.9

Characteristics	n (%)
Gestational age (trimester-wise) at enrollment	
First trimester	40 (35.1)
Second trimester	63 (55.3)
Third trimester	11 (9.7)
Education	
No formal education	75 (65.8)
Primary	12 (10.5)
Secondary	24 (21.1)
Higher	3 (2.6)
Employment status	
Unemployed	68 (60.7)
Skilled manual work	27 (24.1)
Unskilled manual work	17 (15.2)
ANC visits	
≤4	21 (18.4)
5 to 8	70 (61.4)
>8	23 (20.2)
Presence of one or more risk factors[a]	8 (7.0)
Hypertension	3 (2.6)
Tuberculosis	1 (0.9)
History of blood transfusion	1 (0.9)
Previous cesarean section	5 (4.4)
Consumed gutka or tobacco	39 (34.2)
MUAC (cm)	
Severely malnourished (<21)	21 (18.4)
Moderately malnourished (21 to <23)	21 (18.4)
Normal (> = 23)	72 (63.2)
Anemia status (g/dL)	
Mild (10–10.9)	1 (0.9)
Moderate (7–9.9)	101 (88.6)
Severe (<7)	12 (10.5)
Venofer dose	
1 Dose	50 (43.9)
2 Doses	37 (32.5)
≥3 Doses	27 (23.7)

[a]Self reported.
ANC, Antenatal care services; MUAC, Mid-upper arm circumference; BMI, Body mass index.

TABLE 2 Distribution of anemia status before and after treatment with IV iron.

Anemia status		After treatment *n* (%)			
		[a]Normal to mild	Moderate	Severe	Total
Before treatment *n* (%)	Mild	1 (100)	0	0	1 (0.9)
	Moderate	49 (48.5)	51 (50.5)	1 (1)	101 (88.6)
	Severe	6 (50)	5 (42)	1 (8)	12 (10.5)
	Total	56 (49)	56 (49)	2 (2)	114
	McNemar test	$p = <0.001$			

[a]This category included women with normal and mild anemia after receiving treatment.

TABLE 3 Distribution of anemia severity before and two weeks after treatment among women enrolled in the first and second trimesters, n (%).

Anemia status		After treatment			
		[a]Normal to mild	Moderate	Severe	Total
Before treatment	Mild	1 (100)	0	0	1 (1.0)
	Moderate	44 (48)	47 (51)	1 (1.0)	92 (89.3)
	Severe	5 (50)	5 (50)	0	10 (9.7)
	Total	50 (49)	52 (50)	1 (1.0)	103

[a]This category included women with normal and mild anemia after receiving treatment.

of arms or legs (19%, $n = 3$), nausea (12.5%, $n = 2$), irregular fetal heart rate (6%, $n = 1$), headache (6%, $n = 1$), and itching (6%, $n = 1$).

The pregnancy-related outcomes of the study participants are described in Table 5. The mean gestational age at birth was 38.56 ± 1.70 weeks. Preterm deliveries accounted for 10.5% ($n = 12$) of the live births. The majority of deliveries took place in a facility-based setting n = 97 (85.1%), with 14.9% percent occurring at home. Spontaneous vaginal birth was the predominant mode of delivery, constituting 81.6% ($n = 93$), while cesarean sections accounted for 18.4% ($n = 21$). The primary birth attendants were skilled attendants in the majority of the deliveries (85.1%, $n = 97$). There were (98.3%, $n = 112$) livebirths and (1.8%, $n = 2$) stillbirths. The average birth weight was 2.9 ± 0.86 kg. There was one early neonatal death reported (0.9%) and no late neonatal deaths in the study population. There was no preterm birth among women who received 3 or more IV iron doses. Stillbirths accounted for 0.9% in single and two-dose groups, and no stillbirths were reported in the three or more-dose group (Table 5).

4 Discussion

Iron deficiency anemia is one of the most common medical complications of pregnancy. Our midwife-led model of care for managing anemia through IV iron therapy demonstrated a 90% reduction in the prevalence of severe and approximately 50% reduction in the prevalence of moderate anemia throughout the trimesters at the PHCs without a need for referral to a secondary health facility. In addition, our study also demonstrated minimal side effects, with dizziness, redness/swelling of arms or legs, and nausea being the three commonly reported side effects.

Midwives are an important cadre that can take on various tasks related to maternal and reproductive health. To help alleviate the burden on the healthcare system, in 2006, the Government of Pakistan initiated the community midwifery program to improve access to maternity services across Pakistan (16). Previous evidence has shown that midwives served a key role in the community by providing services such as family planning, cervical screening, and treatment of sexually transmitted infections (17–19). However, these models, specifically those from Pakistan, seem more focused on clinical knowledge than technical and soft skills (17, 18). Although not formally tested, our study suggests that the midwives could efficiently administer injections with appropriate training, highlighting their capacity to integrate technical skills with the necessary clinical knowledge.

Our findings align with previous literature where a higher proportion of pregnant women with severe and moderate anemia achieved mild (10.0 to 10.9 g/dL) to normal (≥ 11 g/dL) status of Hb levels after receiving IV iron therapy (20, 21). However, these studies were conducted in healthcare settings where medical officers administered IV iron therapy instead of midwives (20, 21). In contrast, our study demonstrated that using midwives under the telephonic supervision of an obstetrician can be equally competent for managing IDA in community settings where access to higher-level healthcare facilities is challenging in terms of availability, time, and cost.

Our midwife-led model of care for managing anemia through IV iron therapy observed minor adverse reactions among 14% of pregnant women, such as dizziness, redness/swelling of arms or legs, and nausea, and none of them required discontinuation of the therapy. Our study findings are aligned well with the findings of Kriplani et al., which also found minor side effects among pregnant women (14%) who received IV iron therapy, including nausea, vomiting, diarrhea, and fever (21). However, this study administered IV iron therapy in a well-equipped healthcare setting.

Despite the effective role of IV iron therapy in treating IDA among pregnant women, the burden of anemia remains persistently high, especially in rural and peri-urban communities (20, 22). Several challenges exist to the implementation of IV iron therapy. The administration of IV iron is usually available in secondary care hospitals under close monitoring of registered nursing staff consulting with assigned physicians. Women residing in low-resource communities have

TABLE 4 Distribution of anemia severity before and 2 weeks after treatment among women enrolled in the third trimester, *n* (%).

Anemia status		After treatment			
		[a]Normal to mild	Moderate	Severe	Total
Before treatment	Mild	0	0	0	0
	Moderate	5 (55)	4 (45)	0	9 (81.8)
	Severe	1 (50)	0	1 (50)	2 (18.2)
	Total	6 (55)	4 (36)	1 (9)	11

[a]This category included women with normal and mild anemia after receiving treatment.

TABLE 5 Pregnancy-related outcomes among the study participants.

Pregnancy related outcomes	1 Dose (*n* = 50) mean ± SD	2 Doses (*n* = 37) mean ± SD	≥ 3 Doses (*n* = 27) mean ± SD	Total (*N* = 114) mean ± SD
GA at birth (weeks)	38.27 ± 1.58	38.57 ± 2.09	39.09 ± 1.17	38.56 ± 1.70
Birth weight (kg)	3.02 ± 1.22	2.88 ± 0.36	2.81 ± 0.51	2.9 ± 0.86

Pregnancy related outcomes	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Preterm birth (<37 weeks GA)	8 (7.0)	4 (3.5)	0	12 (10.5)
Place of birth				
Home	7 (6.1)	8 (7.0)	2 (1.8)	17 (14.9)
Facility based	43 (37.7)	29 (25.4)	25 (22.0)	97 (85.1)
Mode of birth				
SVD	36 (31.6)	33 (29)	24 (21)	93 (81.6)
Cesarean	14 (12.3)	4 (3.5)	3 (2.6)	21 (18.4)
Primary birth attendant				
Skilled	43 (37.7)	29 (25.4)	25 (21.9)	97 (85.1)
Unskilled	7 (6.1)	8 (7.0)	2 (1.8)	17 (14.9)
Pregnancy outcome				
Live Birth	49 (43)	36 (31.6)	27 (23.7)	112 (98.3)
Stillbirth	1 (0.9)	1 (0.9)	0	2 (1.8)
Neonatal deaths	0	1 (0.9)	0	1 (0.9)

GA, Gestational Age; SD, Standard Deviation; SVD, Spontaneous Vaginal Birth.

limited income sources with poor access to health facilities, making them less likely to benefit from IV iron therapy (6). Another reason is the fear of systemic side effects associated with IV administration (13). Our study overcame these barriers through the availability of trained midwives, enabling pregnant women to undergo treatment at a primary-level facility without needing referrals.

The collaboration between midwives and obstetricians ensured comprehensive care, while counseling regarding IV iron therapy promoted acceptance and adherence. In our study, we found some facilitators and barriers to the implementation of midwife-administered IV iron therapy during our regular monthly interactions with the midwives. They mentioned that women appreciated that they could get treatment near their homes, and this saved time and cost for traveling to a distant facility. In contrast, the barriers included the absence of equipment such as a crash cart. However, we observed minor adverse reactions among pregnant women, and none of them required discontinuation of therapy. In addition, the midwives mentioned that even though they have never seen a woman have a severe allergic reaction, they are worried about that situation and remain very alert while administering this.

The pregnant women attending the PHCs were young, the majority had received no formal education, and there was a high prevalence of tobacco use and malnutrition, highlighting the multifaceted challenges faced by pregnant women in the community. However, their pregnancy-related outcomes depicted a favorable scenario, with the majority of deliveries occurring in a facility-based setting and a high proportion of spontaneous vaginal deliveries in the presence of skilled birth attendants. The low stillbirth rate and neonatal death rate further support the possible positive impact of IV iron administration and midwife-led care, which can be explored in further research. The findings of the study require cautious interpretation since various factors beyond IV iron administration, such as socioeconomic status, food insecurity, and previous pregnancy history, may influence the observed effects of IV iron therapy on anemia and maternal and perinatal health.

Our study has certain strengths and limitations. To the best of our knowledge, this study is one of the first to assess the management of midwife-led IV iron therapy among pregnant women in a primary healthcare center, which is a novel approach for addressing a prevalent medical complication and improving accessibility to healthcare in underserved areas. Since we performed a retrospective analysis of data from a prospective cohort study (14) for women who received IV iron therapy for managing anemia, the absence of a comparison group is an important limitation of the study. In addition, we relied solely on hemoglobin levels for diagnosing anemia due to the lack of resources for conducting further investigation. However, as indicated by the National Nutrition Survey, approximately 60% of anemia in pregnancy is attributed to iron deficiency alone (2), thus leading to this treatment option.

5 Conclusion

The midwife-led model of care managing anemia among pregnant women in a primary healthcare (PHC) setting resulted in an improvement in their iron levels. This model can be implemented in remote settings, ensuring a safe and accessible approach to managing one of the most prevalent conditions impacting pregnant women.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by VITAL Pakistan Trust, Karachi, Pakistan. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SNa: Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. SS: Formal analysis, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. SNo: Formal analysis, Methodology, Validation, Visualization, Writing – original draft. IF: Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft. AJ: Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft. MK: Data curation, Formal analysis, Investigation, Software, Validation, Visualization, Writing – original draft. NY: Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft. UK: Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft. AR: Data curation, Formal analysis, Investigation, Software, Validation, Visualization, Writing – original draft. MN: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. FJ: Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Formal analysis, Funding acquisition. ZH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be considered as a potential conflict of interest.

Publisher's note

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Assessment of preschool preparedness intervention package on adoption of nutrition friendly school initiative in rural Sindh, Pakistan: a pre-and post-intervention design

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Background: In 1995, the World Health Organization launched its Global School Health Initiative intending to expand this health promotion approach throughout schools globally. In this study, we aim to assess the preparedness of preschools in the adoption of intervention packages under the Nutrition Friendly School Initiative (NFSI) checklist.

Methods: From three campuses of the Aga Khan School located in the Thatta and Sujawal districts of the Sindh province, Pakistan, all eligible preschool children were selected for this study. Using a pre-and post-intervention design, we assessed preschool preparedness using the NFSI checklist, knowledge of parents/caregivers regarding health and nutrition promoting behaviors, and anthropometric measurements (i.e., mid-upper arm circumference (MUAC), weight, and height) for preschool children. The NFSI checklist was analyzed with differential scores, while descriptive statistics were used for anthropometric and knowledge data. Continuous variables (i.e., height, weight, MUAC) were presented as means, while categorical variables (knowledge) were expressed as numbers and percentages. Paired t-tests for dependent samples were used to statistically assess mean differences in MUAC, height, weight, height-for-age Z-score, weight-for-age Z-score, weight-for-height Z-score, and changes in parental knowledge of preschool children.

Results: Data from 164 preschool children (ages 24–84 months, mean age 56.7 months) were analyzed over 3 months. School preparedness scores improved from 10 to 22 points (out of 26). Parental knowledge on nutrition and health increased by 7.2 points (out of 25). Children showed mean increases in MUAC (0.27 cm), weight (0.36 kg), and height (0.62 cm) ($p < 0.001$). Stunting and overweight/obesity rates remained the same (7.3 and 4.3%), while underweight and wasting rates dropped from 10.4 to 7.3% and 7.9 to 6.1%, respectively. The initiative effectively reduced underweight and wasting but did not impact stunting and overweight.

Conclusion: The NFSI has greatly enhanced preschool readiness for nutrition-friendly schools. Engaging the private sector in addressing nutritional challenges has paved the way for future public-private partnerships to tackle malnutrition.

The nutrition policy formulated through this initiative could serve as a blueprint for a National School Nutrition Policy.

KEYWORDS

early child development, nutrition interventions, malnutrition, nutrition friendly school initiative, preschool children, school community, school preparedness, school nutrition

Introduction

An essential component of a child's journey toward optimal growth and development is ensuring they receive adequate nutrition. Child malnutrition manifests in three broad forms: undernutrition, which includes stunting (low height-for-age), wasting (low weight-for-height), and underweight (low weight-for-age), overnutrition (overweight and obesity), and micronutrient-related malnutrition (1). The United Nations Sustainable Development Goal 2 calls for an end to all forms of malnutrition by 2030 (2).

In the realm of malnutrition, South Asia bears the greatest global burden, with statistics revealing that the region encompasses 52% of stunting cases, 70% of wasting instances, and 48% of overweight occurrences, a phenomenon often referred to as the "South Asian enigma" (3). Over half of malnourished children in South Asia are concentrated in Pakistan, Bangladesh, and India (3).

A scoping review synthesized evidence on malnutrition prevalence in South Asian children aged 5–19 years. Findings from 296 articles revealed varying rates of undernutrition: thinness (1.9–88.8%), wasting (3–48%), underweight (9.5–84.4%), and stunting (3.7–71.7%) (4). Overweight and obesity rates ranged from 0.2 to 73% and 0 to 38%, with upward trends (4).

Pakistan faces a triple burden of childhood malnutrition, with proportions of 40.2, 17.7, and 29.9% experiencing stunting, wasting, or underweight low weight-for-age, respectively, while 9.5% are overweight (5). In comparison to its neighboring country India, Pakistan has higher prevalence of stunting and overweight. In India, the prevalence of stunting among children under five stands at 35%, with corresponding figures for wasting and underweight at 17 and 33%, respectively. Moreover, 2% of children under five in India are categorized as overweight or obese (6). Additionally, a sizable portion of Pakistani children, totaling 53.7%, suffer from anemia, and 28.6% exhibit iron deficiency anemia. Deficiencies in other micronutrients, including zinc (18.6%), Vitamin A (51.5%), and Vitamin D (62.7%), are also prevalent (5). The prevalence of stunting improved from 1965 (48%) to 1994 (36.3%) but worsened from 2001 (41.6%) to 2011 (43.7%). As of 2018, it remains high at 40.2%, with an average annual reduction rate of 0.5%, insufficient to notably reduce stunting in Pakistan. Similarly, wasting has increased steadily since 1997, rising from 8.6% in 1997 to 17.7% in 2018. Sindh province has the highest rates of wasting (23.3%) and underweight nationwide (41.3%) (5).

In addressing malnutrition, the Government of Pakistan (GoP) has demonstrated significant commitment through various initiatives. The establishment of the National Nutrition Forum (NNF) within the Planning Commission serves as a crucial nutrition governance platform, aiming to lead in coordinating nutrition programs, aligning efforts, and formulating nationwide policies. Furthermore, the Federal Government has recently launched the Pakistan Nutrition Initiative (PANI), a comprehensive national program targeting malnutrition in 36 high-impact districts across the country (7). Recommendations have also been made for the development of a national nutrition dashboard to monitor key indicators, emphasizing the importance of Early Childhood Development (ECD) in fostering resilient and proficient individuals through cognitive, social, emotional, and physical development facilitation (7).

Preschool and school children are increasingly affected by malnutrition. Global shifts to energy-dense but nutrient-poor diets and decreased physical activity have led to rising rates of overweight, obesity, and diet-related noncommunicable diseases (NCDs) (8). Many school-age children skip breakfast, eat too few fruits and vegetables, and consume excessive sugary, salty, and fatty snacks. The low consumption of fruits and vegetables in childhood is particularly concerning given that children are more likely to continue with this similar deficit consumption pattern as adults (9).

The school food environment significantly influences nutrition-related behaviors. Effective school-based interventions that are multi-component and encompass whole-school activities, such as modifying school policies, curricula, and the social and physical environment, alongside engaging families and communities (10). In 1995, the World Health Organization (WHO) launched its Global School Health Initiative (GSHI) guided by the 1986 Ottawa Charter of Health Promotion to expand the Health Promoting School (HPS) approach globally (11). It was designed to improve the health of children and the community through schools at all levels (12).

To counteract the rise of chronic, non-communicable diseases, the WHO has advocated for the implementation of school policies and programs that endorse healthy eating habits and physical activity, operating within a comprehensive school policy framework (13). This initiative is further supported by the Nutrition-Friendly Schools Initiative (NFSI), which was introduced by the WHO after expert consultations on childhood obesity convened in Kobe, Japan in 2005 (12).

Given the crucial role of malnutrition in child development and its subsequent impact on national development, there exists a clear rationale for integrating nutrition interventions into preschool settings (nursery and kindergarten). The primary objective of this study was to assess the preparedness of selected preschools to adopt the NFSI intervention package in Thatta and Sujawal districts of Sindh province. Our secondary objectives were to assess: (i) pre and post-intervention knowledge of parents of preschool children regarding the importance of nutrition in the early years of life and health-promoting behavior, and (ii) pre and post-intervention nutrition status of preschool children of age 24–84 months using mid-upper arm circumference (MUAC) (for children 24–59 months only), height, and weight.

The five focus areas (pillars) conceptually outlined in NFSI (Figure 1) provide a framework for self-appraisal (baseline and end line) of preschool readiness. This research has provided an opportunity to establish a nexus between health, nutrition, and education by facilitating early identification through routine screening, establishing referral linkages for those in need, raising awareness among parents and the school community about health-promoting and parenting messages, and sustaining the initiative through school nutrition policies. These efforts aimed to enhance both wellness and long-term developmental trajectories.

Methods

Study design

This paper outlines the quantitative component of an exploratory sequential mixed-methods study design that employed a pre- and post-intervention approach. This design enables triangulation and iterative refinement of research questions or intervention strategies (15). In the context of this study, the initial exploratory phase (14) guided the refinement of the intervention package, enhanced understanding of the preschool environment, and assessed the feasibility of adopting and maintaining nutrition-friendly initiatives within available resources.

Study setting and sites

This study was conducted at three preschool campuses of Aga Khan Education Service, Pakistan (AKES, P) in rural communities in Thatta (Mirpur Sakro and Vur) and Sujawal districts of Sindh province. AKES, P operates 153 schools and five hostels across Pakistan (16). The rationale behind selecting private schools is the feasibility, flexibility, and likely readiness of school management to mobilize resources to implement, adopt, and sustain the intervention as described in NFSI. These schools have a structured pre-primary curriculum run by teachers trained in early childhood development which is not available in current public school's set-up.

Study participants

This study involved preschool children aged 24–84 months, along with their parents or direct caregivers. A cross-sectional (complete enumeration) method was employed for anthropometric assessment,

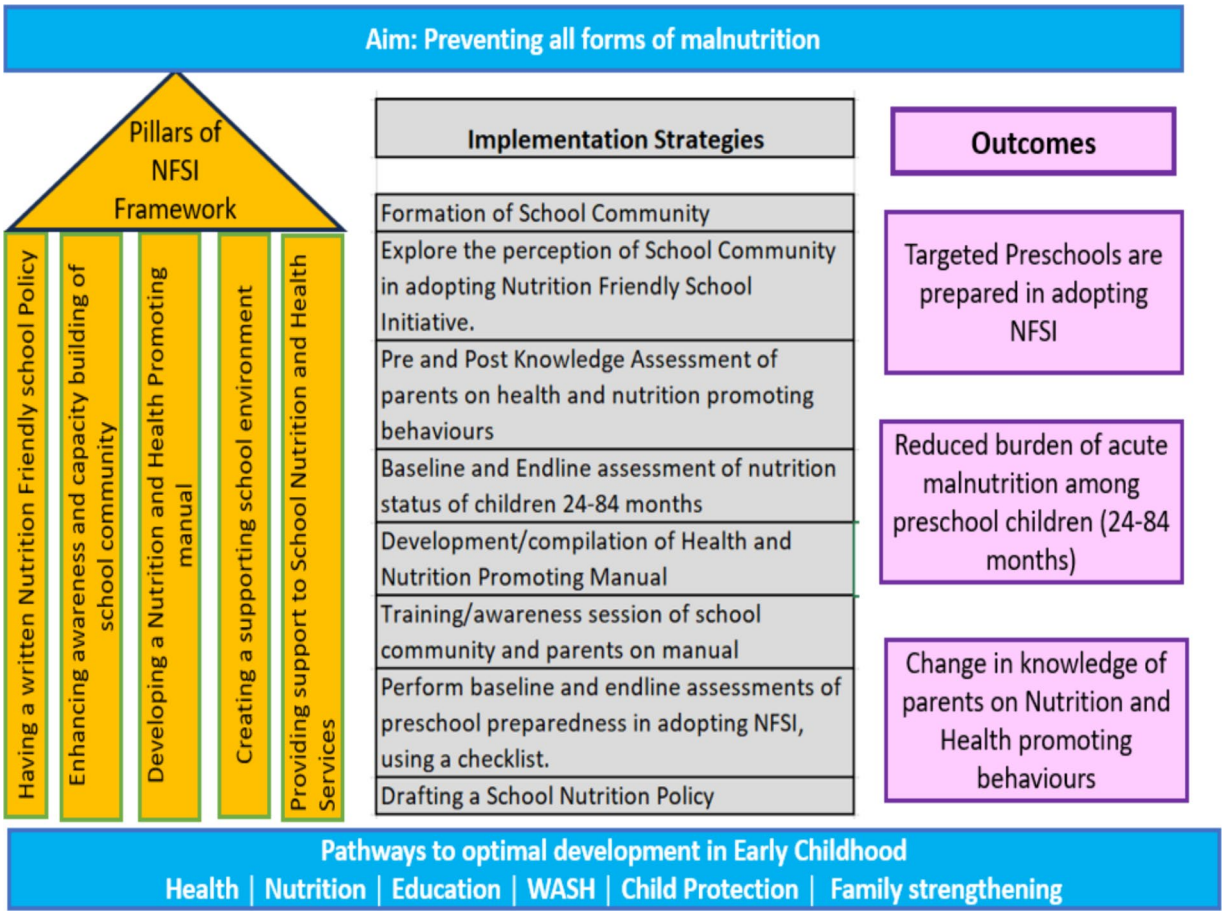

FIGURE 1
Action framework for implementing nutrition-friendly school initiative. Left side: Five pillars from the framework adopted from the WHO framework for nutrition-friendly school initiative (14). Center: Refined implementation strategies after the initial exploratory phase. Right side: The anticipated outcomes.

encompassing all preschool children attending the selected study sites. To be eligible for participation, children were required to be between 24-84 months of age, maintain at least 50% school attendance in the academic year (excluding new enrollees), exhibit no signs of specified medical complications as outlined in the National Guidelines for Community-based Management of Acute Malnutrition, 2015 (17), and be available at the time of anthropometric assessments.

Likewise, parents or direct caregivers of the same children were considered for training sessions. Eligible participants were those who possessed a basic understanding of Urdu and/or English and expressed willingness to partake in voluntary training sessions. Dropout rates among study participants were evaluated based on preschool child attendance criteria, mandating a minimum attendance of at least 70% during the study period. Notably, no children met the dropout criteria specified above, indicating high adherence to the study protocol.

Intervention package

The intervention package as outlined in Figure 1 was refined based on suggestions from the exploratory phase (14). It includes establishing a school community (SC), developing a health and nutrition-promoting manual which contains five modules (Early Years Development and its Importance, Malnutrition Consequences, Healthy Eating and Balanced Nutrition, Child Health, Hygiene and Safe Environment, and Parenting), drafting a school nutrition policy and aligned with school handbook under existing school policies (Health and Hygiene, Safety and Security, Parental and Community involvement, Gender Equity, annual school calendar policy, Discipline and Disciplinary Actions and Student Clubs and Societies), conducting awareness-raising sessions for parents (which covers the key messages from the manual), performing anthropometric assessments (height, weight, MUAC), establishing a referral contact point and follow-up for children identified with nutrition needs, and creating a nutrition-themed classroom/corner. All activities align with the NFSI checklist items applicable in the context of the selected school setting. The applicability (of checklist items) was discussed during the inception consultative meeting.

Data collection and analysis

The study spanned a total duration of 6 months, commencing in December 2021 and concluding in May 2022. The interval between baseline and endline anthropometric measurements was 3 months. Quantitative data were collected through the following means:

a *Preschool Preparedness Assessment using NFSI Checklist*: The NFSI checklist, adapted from the WHO report on nutrition actions in school, is comprised of five components and 26 items (13). Each item has three options (Yes, no, and not applicable). Items deemed not applicable were discussed and agreed upon during a consultative workshop with the school community before conducting the baseline assessment. The total score was assigned based on the applicable number of items. This assessment was jointly conducted during a consultative meeting at the time of project closure.

b *Knowledge Assessment of Caregivers:* Knowledge assessment of parents was conducted before and after a four-hour training session using a 25-question true/false based questionnaire. The assessment covered five modules: Early Years Development Importance, Malnutrition Consequences, Healthy Eating and Balanced Nutrition, Child Health, Hygiene and Safe Environment, and Parenting. Parents who consented and attended the training were assessed, and changes in knowledge levels were determined by comparing pre-and post-assessment scores (Supplementary Annexure 2).

c *Anthropometric Assessment*: Pre- and post- anthropometric assessments (MUAC, weight and height) were conducted for preschool children (Figure 2). MUAC among children aged 24–59 months were used to assess wasting in children aged 6–59 months, is a reliable predictor of childhood mortality. The tri-colored MUAC tape categorizes children as normal (green), moderately malnourished (yellow), or severely malnourished (red). The measurement involves marking the midpoint of the left upper arm, between the shoulder and elbow, with the arm bent. The MUAC tape is then wrapped around the arm at the midpoint, and the measurement is taken to the nearest 1 mm.

Preschool children's weight was measured using a SECA 813 electronic flat scale. Before measurement, shoes, and heavy clothing were removed, and the child stood upright. Measurements were recorded once nearest 0.01 kg. Height measurements were obtained using a wooden height board. Before measurement, shoes and any hair ornaments were removed to prevent interference with readings. Measurements were recorded to the nearest 0.1 cm.

Prior to screening, the school provided student data containing their full name, date of birth and gender, and class details to enable direct data entry onto an Excel spreadsheet and subsequently transferred to Statistical Package for Social Sciences (SPSS™) version 22 for further analysis of anthropometric data obtained at baseline and end-line. Corresponding z-scores were determined to assess stunting, underweight, wasting, and overweight using the WHO AnthroPlus software, which applies the WHO Reference 2007 for 5–19 years to monitor the growth of school-age children and adolescents (18). To ensure continuity with the WHO Child Growth Standards for 0–5 years, these standards are included in AnthroPlus (18).

The primary outcome assessed was the change in preschool preparedness (differential scores) using the NFSI checklist. Secondary outcomes included changes in knowledge among caregivers and the mean changes in MUAC, height, weight, height-for-age Z-scores, weight-for-age Z-scores, weight-for-height Z-scores, or BMI-for-age Z-scores.

Data were analyzed employing both descriptive and inferential statistical techniques. Descriptive statistics were utilized to present continuous variables (i.e., means), while categorical variables were represented as numbers and percentages. For inferential statistics, a Shapiro–Wilk test was conducted to assess the normality of the data obtained from anthropometric measures and knowledge scores. A p-value greater than 0.05 indicated that the data were normally distributed. Subsequently, paired t-tests were employed to ascertain significant differences in mean anthropometric measures and knowledge scores. The data were stratified by gender and age, and subsequent analyses were conducted to obtain adjusted p-values.

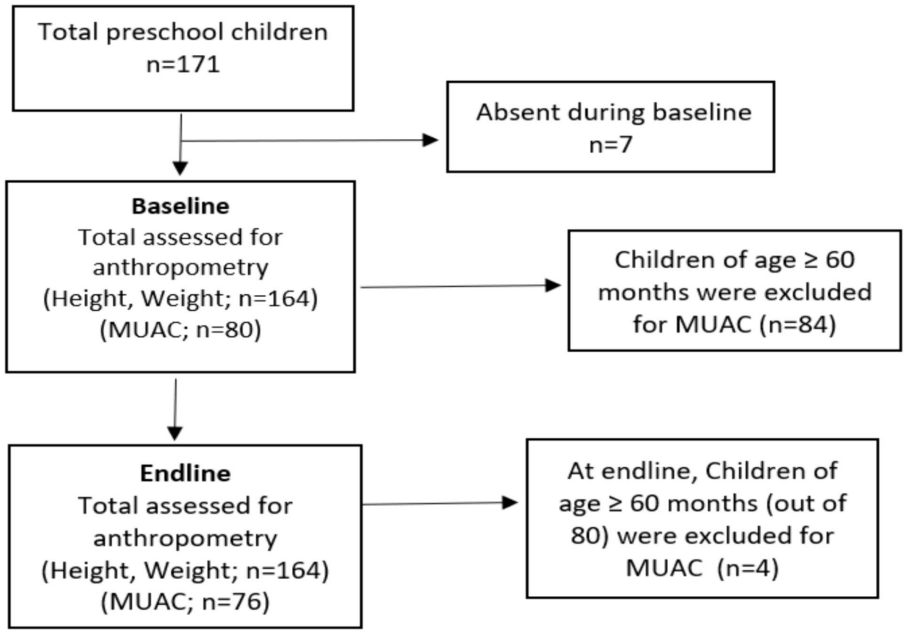

FIGURE 2
Details of anthropometric assessment for preschool children.

Monitoring and compliance measures

The Co-Principal Investigator (CO-PI) actively participated in the data collection process, training sessions, and consultative workshops. Collaboratively, an activity calendar was developed with schools, and mutually agreed timelines were established. Monitoring of NFSI-specific activities is overseen by the head teacher, utilizing engagement and communication channels to foster accountability. A WhatsApp group was created for the school community to share activity photos and brief reports. As part of this initiative, a school nutrition policy was drafted and integrated into the school handbook, ensuring the systematic inclusion of NFSI-related activities in the school's annual activity calendar. Consultation meetings at the end line provided opportunities for feedback solicitation and progress assessment, allowing for discussions on areas requiring additional support.

Ethical consideration

The study protocol was approved by the Ethical Review Committee (ERC) of Aga Khan University—AKU Ref #2021–6,622-20068 (Supplementary Annexure 3). In addition, signed informed consent was obtained from study participants (parents/caregivers), providing clear and concise details about the study purpose, risks, and benefits of participation (Supplementary Annexure 4).

Results

Characteristics of children

Among the 164 eligible children, 92 (56.1%) were boys, and, 80 children (48.8%) were aged below 60 months. During the endline assessment, 76 out of 80 were eligible for MUAC, as four children exceeded the age eligibility criteria for MUAC measurement.

Assessment of pre-school preparedness for NFSI

During the baseline consultation with the school community, only 10 ($n = 10$) out of 26 indicators were marked as "Yes" (score of 10 points). Four indicators were deemed not applicable in the context of the school setting. In the end-line assessment, a total of 22 ($n = 22$) indicators were marked as "Yes" which shows that almost all the applicable areas were addressed through this intervention and the end-line assessment indicates an improvement in school preparedness toward NFSI (Table 1).

Pre-post assessment of knowledge among parents of preschool children

The training program focused on key aspects of the health and nutrition-promoting curriculum tailored for parents and caregivers of preschool children. Of the 164 eligible parents invited, 84 individuals (51.2%) participated in the one-day session. Four participants did not submit pre- or post-test and were excluded from the analysis,

At baseline, the mean test score was 12.6 ± 4.92 (50.4%) significantly improving to $19.8/25 \pm 3.03$ (79.1%) at endline p value <0.001 (refer to Table 2). This reflects a substantial increase of 7.2 points in the knowledge of parents/caregivers on health and nutrition promoting manual post-training. Further analysis reveals a greater mean score increase among caregivers of male children (8.3 points) compared to female caregivers (5.2 points). However, the mean difference is negligible across age groups. The overall mean change in

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TABLE 1 Pre-and-post assessment of preschool readiness based on activities outlined under the NFSI checklist.

		Baseline			End line			Comments
Code	Essential criteria	Yes	No	N/A	Yes	No	N/A	
1	Having a written nutrition-friendly school policy							
1.1	Development of a written Nutrition-friendly Schools' Policy that addresses all five points described in this framework, and includes elements described in 1.2–1.5		X		X			A draft policy was developed and submitted to the Head of Programs and presented to the AKDN sister organization for review and officiation
1.2	Rationale		X		X			
1.3	Objectives: with timelines and clear milestones		X		X			
1.4	Action plan: Outline the whole-school approach contributing to healthy living.		X		X			The proposed plan has been submitted to the school (embedded with a draft policy document).
1.5	Monitoring and evaluation plan for the Nutrition-Friendly Schools' Policy.		X		X			Embedded in the draft policy document
2	Enhancing awareness and capacity building of the school community							
2.1	Dissemination of the Nutrition-friendly Schools' Policy			X			X	Not applicable. The policy document was handed over and discussed with the core team based in Islamabad. Endorsement, dissemination, and adoption will be as per AKESP policy
2.2	Activities for families and community, community involvement, and outreach in the area of nutrition and health-related issues.		X		X			Activities include awareness sessions (training) for parents on thematic areas outlined in Health & Nutrition promoting behavior, periodic health assessment of children, creating referral linkages, counseling of parents identified with malnutrition, engaging children utilizing Nutrition theme classroom, Nutrition month celebrated, and parents were engaged on weekly message (WhatsApp group message). daily WhatsApp message to caregivers on parenting messages (key family care practices). Activities proposed to be aligned with an action plan that mainly includes awareness sessions for parents on thematic areas outlined in Health & Nutrition promoting behavior, periodic health assessment of children, and creating referral linkages.
2.3	School staff training in nutrition and health-related issues.		X		X			School community were trained in nutrition and health-related issues.
3	Developing a nutrition and health-promoting school curriculum							
3.1	Culturally appropriate and effective nutrition education.		X		X			
3.2	Age, sex, and culturally appropriate physical education curriculum.	X			X			
3.3	Healthy Living and life-skills Education Curriculum	X			X			
3.4	Regular monitoring of school curriculum relevant to NFSI, and evaluation of the impact of how well the education meets the objectives.			X			X	Not applicable, beyond the scope of school SoP/policy
4	Creating a supportive school environment							

(Continued)

TABLE 1 (Continued)

		Baseline			End line			Comments
Code	Essential criteria	Yes	No	N/A	Yes	No	N/A	
4.1	School meals, food vendors, and snack bars (if present) promote healthy eating.			X			X	Not applicable, beyond the scope of school SoP/policy.
4.2	Positive messaging toward nutrition and active living.		X		X			Day-wise (weekdays) rolling out of 22 key family care practices (parenting package) in April 2022 Rolled out weekly Health Diet and Health Eating messages on account of National Nutrition Month (in March 2022). Copies of essential material (NNS-2018), Dietary needs of children with 0–8 years, and parenting package have been provided to the school and placed over the Nutrition Theme classroom continuing to roll out positive messages.
4.3	Absence of marketing of foods and beverages at school	X			X			
4.4	Access to an adequate eating place if the school provides food and/or beverages to the children	X			X			
4.5	Adequate school cooking facilities			X			X	Not applicable, beyond the scope of school SoP/ policy.
4.6	Access to safe drinking water.	X			X			
4.7	Promotion of safe hygiene and sanitary behavior.	X			X			Safe hygiene and sanitary behaviors are already practiced however through NFSI these areas were further reinforced through sessions with parents and the school community.
4.8	Availability of clean and separate toilets, for boys and girls.	X			X			
4.9	Opportunity for all age groups to access space and school sporting facilities for physical activity within and outside of the curriculum.	X			X			
4.10	Affirmative action against bullying, stigmatization, and discrimination.	X			X			
4.11	School staff as role models in encouraging healthy eating and healthy lifestyles.	X			X			
5	Providing supportive school nutrition and health services							
5.1	Regular monitoring of children's growth development.		X		X			Incorporated into a policy document, the school community has received orientation on the growth monitoring of children, focusing on Height, Weight, and Mid-Upper Arm Circumference (MUAC). Additionally, Aga Khan Health Services, Pakistan (AKHS, P) health staff actively participate as volunteers, extending their support for the periodic monitoring, which is conducted semi-annually. Essential supplies, including MUAC tapes, weight machines, and height tapes, have been distributed to each campus. The intervention period saw the implementation of quarterly screenings, a total of two rounds, to comprehensively assess the growth and health of the children.
5.2	The effective feedback system for parents and children on findings of the regular monitoring.		X		X			Incorporated in a policy document, moreover, referral contacts with AKHS, P has been established and AKHS, P staff nurse were also involved in the anthropometric assessment.

(Continued)

TABLE 1 (Continued)

Code	Essential criteria	Baseline			End line			Comments
		Yes	No	N/A	Yes	No	N/A	
5.3	Supportive school health service, including a referral system.		X		X			Linkages with Aga Khan Health Service, Pakistan (AKHS, P) health facilities have been developed and in addition to the school community, AKSH, P staff were engaged as volunteers to support the assessment component. AKHS, P facility will serve as a referral point to ensure a continuum of care.
Total score		10	12	04	22	00	04	

WHO/UNICEF/FAO. (2021). Nutrition-Friendly School Initiative. Part I: Conceptual framework. Part II: Self-appraisal tool. Geneva, Switzerland: World Health Organization (13).

knowledge score and changes across age and gender groups are statistically significant ($p < 0.001$) (Table 2).

TABLE 2 Knowledge score of parent/caregiver at baseline and end-line.

Indicators	Mean value/ score	Mean difference	*p*-value (95% CI)
Overall knowledge scores in points (out of 25) of caregivers			
Pretest	12.6	7.2	$p < 0.001$ (95% CI: 6.19, 8.15)
Post-test	19.8		
Knowledge scores among children aged under 5 years			
Pretest	11.5	8.4	$p < 0.001$ (95% CI: 5.47, 9.63)
Post-test	19.1		
Knowledge scores among caregivers of children aged 5 years and above			
Pretest	11.0	8.1	$p < 0.001$ (95% CI: 6.41, 9.94)
Post-test	19.1		
Knowledge scores among caregivers of female children			
Pretest	14.8	5.2	$p < 0.001$ (95% CI: 3.36, 6.91)
Post-test	20.0		
Knowledge scores among caregivers of male children			
Pretest	12.4	8.3	$p < 0.001$ (95% CI: 5.27, 11.2)
Post-test	20.7		

Pre-post anthropometric assessment of preschool children

Anthropometric findings show increase variations in MUAC, weight, and height, with mean increase of 0.27 cm, 0.36 kg, and 0.62 cm, respectively. Among 24–-month-olds participants, boys had a slightly higher mean MUAC increase (0.28 cm) than girls (0.25 cm). Similarly, weight difference was greater in children aged 5 years and above (0.43 kg) than those under 5 years (0.28 kg). However, boys had slightly higher weight differences than girls (0.39 kg vs. 0.33 kg). Overall, mean MUAC changes across genders were statistically significant ($p < 0.001$).

Height differences were negligible between genders and age groups. The mean change in height-for-age Z-score (HAZ) is 0.22, indicating height improvement. HAZ changes were higher in <5-year-olds compared to ≥5-year-olds, with slightly higher differences in girls (0.63) than boys (0.61). Changes were statistically significant across age groups and genders ($p < 0.001$).

Weight-for-age Z-scores (WAZ) also showed a statistically significant mean change (0.06), with overall statistical significance ($p = 0.002$), particularly in <5-year-olds and girls ($p < 0.01$ and 0.013, respectively), but not in ≥5-year-olds ($p > 0.05$).

Weight-for-height Z-score (WHZ) or Body Mass Index-for-Age Z-score (BAZ) had a mean change of 0.11, higher in ≥5-year-olds and boys (0.14). Changes were statistically significant in these groups (*p*-value ≤0.01), but not in <5-year-olds and girls ($p > 0.05$) (Table 3).

The prevalence of stunting, underweight, wasting, and overweight/obesity was 7.3, 10.4, 7.9, and 4.3%, respectively (Table 4). At the end-line assessment, stunting and overweight/obesity prevalence remained unchanged. However, reductions in underweight (from 10.4 to 7.3%) and wasting (from 7.9 to 6.1%) were observed.

Discussion

This study assessed the preparedness of selected rural preschools in Sindh for adopting the NFSI to prevent all forms of malnutrition among preschool children by creating a nutrition-friendly preschool environment. The study findings demonstrated progress in transforming selected preschool sites into nutrition-friendly settings, with preparedness scores improving from 10 to 22 points. This improvement resulted from collaborative efforts with school management, including developing a nutrition policy, creating a health and nutrition manual, establishing nutrition screening mechanisms, implementing learn-with-fun approaches through nutrition theme corners, training sessions for mothers, engaging parents in awareness campaigns, and orienting the school community.

The UNICEF-supported NFSI program in Gaza and the West Bank aimed to establish healthy dietary and physical activity habits and improve the nutritional status of school-age children. Implemented through local NGOs, the program supported the Ministry of Education and the Ministry of Health in promoting nutrition and healthy lifestyles. The intervention package elevated school nutrition to a national priority and increased the commitment of Palestinian authorities to future scalable interventions (19).

TABLE 3 Anthropometric measurements of children at baseline and end-line.

Variables	Overall		Age adjusted				Gender adjusted			
			Under 5 years		Above 5 years		Boys		Girls	
	Difference in mean (95% CI)	*P*-value	Difference in mean (95% CI)	*P*-value	Difference in mean (95% CI)	*P*-value	Difference in mean (95% CI)	*P*-value	Difference in mean (95% CI)	*P*-value
MUAC (cm) for Children 24–59 m	0.27 (0.22, 0.31)	<0.001	0.27 (0.22, 0.31)	<0.001	n/a	n/a	0.28 (0.23, 0.33)	<0.001	0.25 (0.18, 0.31)	<0.001
Weight (Kg) for Children 24–84 m	0.36 (0.28, 0.45)	<0.001	0.28 (0.17, 0.4)	<0.001	0.43 (0.31, 0.56)	<0.001	0.39 (0.27, 0.51)	<0.001	0.33 (0.20, 0.45)	<0.001
Height (cm) for children 24–84 m	0.62 (0.57, 0.68)	<0.001	0.62 (0.54, 0.7)	<0.001	0.63 (0.55, 0.71)	<0.001	0.61 (0.53, 0.68)	<0.001	0.63 (0.55, 0.71)	<0.001
Height-for-age z-score (HAZ)	0.22 (0.2, 0.23)	<0.001	0.27 (0.24, 0.29)	<0.001	0.17 (0.15, 0.19)	<0.001	0.21 (0.19, 0.23)	<0.001	0.22 (0.19, 0.25)	<0.001
Weight-for-age z-score (WAZ)	0.06 (0.02, 0.10)	0.002	0.11 (0.05, 0.17)	<0.001	0.02 (−0.03, 0.03)	0.449	0.04 (0.001, 0.09)	0.053	0.08 (0.02, 0.14)	0.013
Weight-for-Height z-score (WHZ/BHZ)	0.11 (0.05, 0.13)	<0.001	0.008 (0.001, 0.17)	0.052	0.14 (0.06, 0.22)	<0.001	0.14 (0.06, 0.22)	<0.001	0.08 (0.008, 0.16)	0.076

TABLE 4 Change in HAZ, WAZ, and WHZ among children at baseline and end line.

Indicators	Stunted (%)		Underweight (%)		Wasting (%)		Overweight/Obesity (%)	
	HAZ-score ≤ -2SD		WAZ-score ≤ -2SD		WHZ-score ≤ -2SD		WHZ-score > +2SD	
	Baseline	End line	Baseline	End line	Baseline	End line	Baseline	End line
Total malnourished identified ($n = 164$)	12(7.3%)	12(7.3%)	17(10.4%)	12(7.3%)	13(7.9%)	10(6.1%)	7(4.3%)	7(4. 3%)
Child (<5 years of age) ($n = 77$)	1(1.3%)	1(1.3%)	4(5,2%)	1(1.3%)	4(5.2%)	4(5.2%)	3(3.9%)	4(3.9%)
Child (> 5 years of age) ($n = 87$)	11(12.6%)	11(12.6%)	13(14.9%)	11(12.6%)	9(10.3%)	6(9.9%)	4(4.6%)	3(3.4%)
# of boys ($n = 92$)	7(7.6%)	7(7.6%)	9(7.6%)	7(7.6%)	10(10.9%)	8(8.7%)	5(5.4%)	4(4.3%)
# of girls ($n = 72$)	5(6.9%)	5(12.5%)	8(13.9%)	5(6.9%)	3(4.2%)	2(2.8%)	2(2.8%)	3(4.1%)
Moderate (z-score ≤ -2SD and > -3SD) or (z-score > +2SD and < +3SD)	11(6.7%)	11(6.7%)	16(10.4%)	12(7.3%)	12(7.3%)	10(6.1%)	4(2.4%)	4(2.4%)
Severe (z-score < -3SD)	1(0.6%)	1(0.6%)	1(1.2%)	0	1(0.6%)	0	3(1.8%)	3(1.8%)

Anthropometric analysis indicated a higher prevalence of underweight and wasting compared to stunting, with children aged 5 years and above exhibiting a greater burden across all categories of malnutrition (except overweight/obesity). Boys exhibited a higher prevalence than girls in stunting, underweight, wasting, and overweight. The intervention notably reduced underweight and wasting burdens by

29 and 23%, respectively. A similar pattern of malnutrition was observed in a cross-sectional study of school children aged 6–15 years in rural Bengaluru, South India (20), emphasizing the need for targeted interventions to alleviate malnutrition burdens among preschool-age children. Hence, NFSI shows promise in mitigating and preventing various forms of malnutrition.

This study showed a 28.7% improvement in parental knowledge after a training session. From 50.4 to 79.1%. This highlights the role of schools in educating parents about health and nutrition, promoting healthier childhoods. A similar study in Taguig City, Philippines, reported a 22.2% increase in maternal knowledge of nutritious meal preparation (21). Similarly, in Pakistan, a nutrition education intervention in Tando Jam and Quetta for children aged 6 months to 8 years showed significant improvements. In Tando Jam, 36% of children, and in Quetta, 32% of children, improved to normal nutritional status. Meal frequency increased significantly (Tando Jam: $p \leq 0.001$, Quetta: $p \leq 0.025$), along with the intake of high-starch foods, vegetables, and fruits in Tando Jam ($p \leq 0.001$). These results underscore the impact of nutrition education on children's health and nutrition (22).

Through this initiative, three additional outputs were achieved: (i) drafting of the school nutrition policy; (ii) updating of the health and nutrition promoting behavior manual; and (iii) establishment of nutrition-themed classrooms across all three campuses. Ensuring the sustainability of such initiatives is crucial. The school nutrition policy will serve as a roadmap, aiding in the planning of annual calendars by incorporating activities outlined in the policy. Adequate budget allocation is essential to ensure the quality and effectiveness of these initiatives. Furthermore, the school nutrition manual provides an opportunity to address and prevent health issues by educating parents about nutritional needs and healthy behaviors. The inclusion of a parenting component enhances the manual's value.

This initiative not only benefited parents/caregivers in improving the knowledge of health and nutrition promoting behavior but also benefited schools in building an enabling environment for promoting the overall health and nutritional well-being of children. It also strengthened the capacity of schools to address the health and nutritional problems of the children, their families, and communities, acting both within and beyond the classroom. Finally, it enabled schools to become accredited as "Nutrition-Friendly Schools," enhancing the schools' reputations for making an effective investment in the future generation.

The observed improvement in outcome indicators is attributed to the essential nature of interventions in rural settings. These improvements are further facilitated by the adaptability of school leadership in allocating resources for innovative interventions and strict adherence to monitoring and compliance measures. Additionally, the school's capabilities, particularly in delivering a well-defined pre-primary curriculum by teachers trained in early childhood development, may have played a significant role. Moreover, increased parental involvement has raised awareness, resulting in improved childcare practices.

Future NFSI implementation in LMICs should extend beyond public sector school settings to include school-age and adolescent children (5–19 years). The intervention should not solely focus on creating an enabling environment but should also integrate school meal and supplementation programs through multi-sectoral collaboration. This endeavor requires sustainable funding, robust monitoring and evaluation, and integration with complementary programs. It must address social determinants such as poverty and gender inequality. Community engagement should inform culturally appropriate interventions encompassing nutrition education, healthy food environments, WASH facilities, and whole-school policies. Coordinated efforts across education, health, agriculture, and local governments are crucial for creating an enabling environment that promotes good nutrition and overall child development.

Study limitations and strengths

Study limitations include the lack of a control group for this study; therefore, it may limit the internal validity of the study. Without a control group, it is challenging to rule out alternative explanations for observed changes, confounders, or biases (i.e., gender, age predominately). However, to overcome this limitation, internal validity was strengthened when techniques of varying strength were used instead of randomization, including pre- and post-assessment of outcomes. Secondly, the study setting includes private schools only, and therefore the public schools might have different outcomes. Among the strengths, this study used mixed methods research, combining quantitative and qualitative data to optimize the strengths and mitigate the weaknesses of the standalone approach. Notably, this study is pioneering, being the first of its kind to explore NFSI implementation feasibility in rural Sindh. Lastly, it has generated a school nutrition policy, serving as a foundational document to inform national school nutrition policy.

Conclusion

The NFSI implementation has tremendously improved preschool preparedness toward achieving nutrition-friendly schools. Furthermore, this initiative has significantly improved the knowledge of parents/caregivers on health and nutrition promoting behaviors. This study has engaged the private sector in addressing the nutrition burden and promoting healthy nutrition subsequently opening avenues for future public-private partnerships in alleviating the triple burden of malnutrition.

This study holds the potential for replication in public schools and could pave the way for a school accreditation program, certifying schools as Nutrition-friendly. This move aims to set minimum quality standards for implementing NFSI, as an imperative for holistic child development from an early age. The nutrition policy developed under this initiative has the potential to scale up and inform the development of a National School Nutrition Policy. Future studies in diverse settings, encompassing rural and urban areas as well as private and public schools, are warranted to comprehensively assess the real impact of this intervention.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Aga Khan University, Ethics Review Committee. The studies were conducted in

accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

AS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. RN: Writing – review & editing. PP: Writing – review & editing, Methodology. SS: Writing – review & editing. RK: Writing – review & editing, Funding acquisition, Project administration, Resources, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2024.1395883/full#supplementary-material

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Management of undernutrition during preconception and pregnancy in an urban setting in North India

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Introduction: The prevalence of underweight in women of reproductive age (WRA) in South Asia remains unacceptably high. Underweight women suffer from lowered immunity, infertility, and a risk of developing non-communicable diseases. In pregnancy, undernutrition results in poor neonatal and maternal outcomes. We present the findings and the management strategy of undernutrition in the preconception and pregnancy phase intervention group in the WING study in low- to lower-middle-income neighborhoods of North India.

Methods: We analyzed data from the Women and Infants Integrated Interventions for Growth Study (WINGS) intervention group. In this individually randomized factorial design trial, 13,500 women were enrolled from low to middle-income neighborhoods of Delhi: 6,722 women in the preconception group and 2,640 from the pregnancy group. Food supplements in the form of locally prepared snacks were given to provide necessary calories and protein requirements as per the Body mass index (BMI) during the preconception period and each trimester of pregnancy. The snacks (sweet or savory) and milk or egg as a source of high-quality protein were delivered at home, and intakes were observed. Individual tracking and close monthly monitoring were done for compliance, besides screening and treatment of infections.

Results: The enrolled women's mean (SD) age was 24.2 (3.1) years. Approximately 35% of women had a height of $<$150 cm, and 50% had schooling $>$12 years. 17% of women in preconception and 14 % in pregnancy intervention groups were Underweight. Approximately two-thirds of underweight women improved 9–12 months after management in the preconception group, and the same proportion improved 4 weeks after management during pregnancy. The proportion of women with inadequate weight gain (IWG) during pregnancy was higher in women who were underweight during preconception.

Discussion: A comprehensive approach to managing undernutrition with high-quality energy-dense food supplementation substantially improved weight gain in women during preconception and pregnancy.

Clinical trial registration: http://ctri.nic.in/Clinicaltrials/pmaindet2.php?trialid=19339%26EncHid=%26userName=societyforappliedstudies, identifier: Clinical Trial Registry India #CTRI/2017/06/008908.

KEYWORDS

undernutrition, pregnancy, preconception, BMI, inadequate weight gain

Introduction

The world's sociocultural, environmental, and economic conditions significantly impact a woman's health, and her biology presents unique challenges. This is particularly evident in low- to middle-income countries (LMICs), where issues of food security, along with social and cultural norms, often restrict a woman's ability to improve her diet (1). Being underweight among women of reproductive age continues to be a significant public health concern; a recent study reported the prevalence of underweight women in LMICs at 15%, with a particularly high prevalence of 28% in South Asia, contributing to an economic burden of 2.5–3.8% of the country's GDP (2–4). While the global prevalence of underweight women decreased by 2%, from 12% in 2000 to 10% in 2016, and most regions saw a decline, South Asia experienced the most substantial decrease (from 27% to 22%) (5).

The prevalence of undernutrition among women of reproductive age in India has declined by 45% over the past decade, from 35.5% in 2005–2006 to 18.7% in 2019–2020). However, according to the National Family Health Survey 2019–2021(NFHS 5), 1 in 5 women are still underweight (6). In neighboring states like Haryana and Uttar Pradesh, the figures remain similar, with Haryana reporting 11.4%−17% and Uttar Pradesh 14%−21%.

Underweight women are a particularly vulnerable group, facing numerous health challenges, including anemia, micronutrient deficiencies, and lowered immunity, which increases their susceptibility to infections such as tuberculosis and reproductive tract infections, as well as infertility and a heightened risk of non-communicable diseases (5). Maternal undernutrition has far-reaching consequences, perpetuating an intergenerational cycle of undernutrition through epigenetic changes and leading to poor obstetric outcomes such as low birth weight (LBW), preterm birth, small for gestational age (SGA) infants, stunting, developmental delays, and increased maternal morbidity and mortality (7).

Barker's hypothesis posits that intrauterine fetal nutrition during pregnancy influences the risk of developing adult diseases and disorders by inducing changes in the DNA. The Developmental Origins of Health and Disease (DOHAD) framework identifies the period around conception as critical in mediating parental influences on the next generation's health, particularly by affecting gamete health and embryogenesis before pregnancy is even diagnosed (8–10). While it is acknowledged that being underweight during pregnancy is a serious issue that requires attention, the preconception period is equally crucial. This phase offers a significant window of opportunity to address health and nutrition deficits before pregnancy, highlighting the need for a pragmatic, life-course approach that provides a continuum of care from preconception through pregnancy.

Abbreviations: BMI, Body Mass Index; FGD, Focus group discussions; ICDS, Integrated Child Development Scheme; IOM, Institute of Medicine; IWG, Inadequate weight gain; LMIC, Low- and middle-income countries; LBW, Low birth weight; NFHS, National Family Health Survey; SGA, Small for gestational age; WRA, Women of reproductive age; DOHAD, Developmental origins of health and Disease.

Based on the above principles, we designed and implemented a comprehensive community-based nutritional intervention as part of the Women and Infants Integrated Interventions for Growth Study (WINGS). This intervention was delivered at home, aiming to provide the recommended caloric and protein intake during the preconception period and the additional caloric needs required during the second and third trimesters of pregnancy (11). While clinical settings often rely on qualitative descriptions and quantitative measures of undernutrition, body size is more commonly used in community settings due to its ease of measurement and effectiveness as a screening tool for nutritional status and health. Therefore, BMI was used to indicate undernutrition (12). Pregnant women with inadequate weight gain during pregnancy were identified and managed according to Institute of Medicine (IOM) guidelines (13, 14).

Currently, there is no comprehensive preconception nutrition intervention program for women of reproductive age in India, except for the weekly prophylactic iron and folic acid supplementation and biannual deworming for anemia (15). For pregnant women, the Integrated Child Development Services (ICDS) provide supplementary nutrition through micronutrient-fortified food, energy-dense food, or take-home rations, which offer approximately 600 calories and 15–20 gm of protein (16). However, this food supplementation is not individualized according to trimester-specific requirements or BMI.

The objective of this study is to present the management strategy for addressing undernutrition during preconception and pregnancy in the intervention groups of the WING study, as well as to report the outcomes and improvements achieved through this approach.

Methods

Study design and participants

Data were analyzed from the preconception and pregnancy phase intervention groups of the WING study. We are not presenting the RCT results in this manuscript.

To provide a brief overview, the WING study involved the recruitment of 13,500 women aged 18–30 years who met the eligibility criteria (married, with no or one child, and desiring a second child; exclusions included plans to move out of the study area or delivery outside of Delhi). These women were identified and recruited through a door-to-door survey conducted in Delhi's lower and lower-middle socioeconomic neighborhoods. Upon providing written consent, the women were enrolled and underwent the first randomization to either receive a package of integrated preconception interventions or routine care. They were followed until pregnancy was confirmed or up to 18 months post-enrollment. After pregnancy confirmation via ultrasonography, a second randomization was performed (following additional written consent), assigning pregnant women to either enhanced pregnancy and early childhood care interventions or routine care, continuing until the child reached two years of age. The study commenced on July 17, 2017, and concluded in August 2021. The study's setting, methods and initial results have been published previously (11).

For this study, "Improved" during the preconception phase was defined as a shift to the next higher or normal BMI category (e.g., from <16 kg/m^2 to 16–18.49 kg/m^2 or from 16–18.49 kg/m^2 to ≥ 18.5 kg/m^2). Adequate weight gain during pregnancy, starting from the second and third trimesters, was defined according to BMI categories as follows: 0.44–0.58 kg/w for underweight women, 0.35–0.50 kg/week for normal-weight women, 0.23–0.33 kg/week for overweight women, and 0.17–0.27 kg/week for obese women (14).

Food supplements

Energy-dense snacks were prepared using locally sourced, high-quality raw ingredients (such as cereal, pulses, soya, oil, sugar, salt, milk powder, and peanut butter). Study nutritionists carefully designed the recipes to provide the specific calorie needs required to address undernutrition during the preconception and pregnancy phases. The snacks were culturally acceptable and ready to eat, including savory biscuits and cookies (mathis, namak para), puffed soya granules, and a dry sweet mixture (panjeeri). These snacks were pretested in the community and attractively labeled as "diet for women" or "diet for pregnant women."

In addition to the snacks, fresh eggs were procured daily, boiled, and provided to the participants. Milk (180 ml) was commercially available, prepacked, and treated at an ultra-high temperature (UHT), with a shelf life of 90 days. Hot-cooked meals were also prepared using broken wheat (dalia), sprouted lentils, and gram flour, with variations in the menu each day. Extra snack packets were made available to the women if they reported sharing the snacks with others.

Delivery and monitoring

All supplements were delivered to the participants' homes. Locally residing community workers delivered eggs, milk, and hot-cooked meals 6 days a week to the participants through neighborhood depots. The consumption of these supplements was closely observed and documented. If a participant was unavailable during the delivery, repeat visits were made to ensure she received her supplements.

Each participant was assigned a trained accredited social health activist (ASHA)-like worker, referred to as a "Sangini." These Sanginis made home visits to counsel the women on the study's nutritional interventions, observe supplement intake when possible, deliver and replenish the weekly supply of snacks, and monitor weight gain. They also conducted compliance checks and organized referrals to hospitals or outreach clinic as needed.

The weight of each participant was recorded and updated in real time using an electronic tracker for individual monitoring. To ensure accuracy, weighing machines were calibrated monthly.

Management of underweight during preconception

The nutrition intervention was designed to supplement the participants' regular diet, aiming to improve their general health and ensure that they entered pregnancy in a nutritionally replete state. To address the protein energy deficit, additional food was provided in the form of energy-dense snacks (either sweet or savory), along with milk or egg as sources of high-quality protein.

Anthropometric measurements (height and weight) were taken at home during enrollment using standardized equipment. Height was measured with a Seca 213 stadiometer, and clothed weight was recorded using a Salter 9509 weighing scale. These measurements were repeated every 3 months until pregnancy was confirmed or for up to 18 months if pregnancy did not occur. Women were classified based on their BMI into normal weight (BMI 18.5–24.99 kg/m^2), moderately underweight (BMI 16–18.49 kg/m^2), and severely underweight (BMI < 16 kg/m^2) (17).

Weight gain of <500 g/month during the preconception period was defined as inadequate weight gain (IWG). For underweight women, monthly weight measurements were continued until improvement was observed.

For women with a BMI of <21 kg/m^2, one egg or 180 ml of milk, providing 70 kcal and 6 g protein, was given to all women 6 days a week to improve diet quality. We chose a cut-off BMI of <21 kg/m^2 as it represented the median BMI in this community.

Additionally, women with moderate undernutrition received snacks providing 500 kcal and 6–8 g of protein 7 days a week, while those with severe undernutrition received double the quantity −1,000 kcal with 12–15 g of protein. Women with severe undernutrition were also referred to the study clinic for a detailed medical and nutritional assessment. Food supplements were continued until a normal BMI was achieved, and the modified was adjusted based on changes in the BMI category.

Multiple micronutrient (MMN) tablets, providing half to three-fourths of the recommended dietary allowance (RDA) of various micronutrients, were administered three times a week. Iron folic acid (IFA) tablets were given once weekly for anemia prophylaxis (containing 100 mg elemental iron, 1,500 mcg folic acid, and 15 mcg Vit B12). For mild/moderate anemia (Hb 8 ≤ 12 gm/dl), daily Autrin was given for 3 months. Women with severe anemia (Hb < 8 gm/dl) were referred to a collaborating hospital for investigation and treatment.

Blood samples were collected, and a detailed health questionnaire was administered to screen for anemia and infections. Women with inadequate weight gain (IWG) were referred to the outreach study clinic for infection screening (e.g., RTI/STI, tuberculosis, urinary infections, and dental infections) and management of other medical issues (seasonal fever, chronic diseases, and gastrointestinal ailments). They also received nutritionist advice and counseling. Medical referrals were facilitated to the collaborative hospital for further management. A psychosocial assessment was conducted to identify barriers to compliance, such as depression or other interpersonal and family issues.

Management of undernutrition in pregnant women

Assuming an average weight gain of 12 kg during pregnancy, the estimated additional calorie requirements were 280 kcal plus 8 g of protein in the second trimester and 470 kcal plus 27 g of protein in the third trimester. Nutrient-dense snacks and milk were provided as sources of high-quality protein to meet these requirements (18). A comprehensive antenatal care (ANC) approach was implemented, ensuring a minimum of eight ANC checks, necessary investigations, and registration at a collaborative hospital. Psychosocial assessment was conducted using the Patient Health Questionnaire 9 (PHQ-9).

Women received daily supplementation of multiple micronutrient supplements (MMS, ~1RDA) throughout pregnancy. Starting from the second trimester, they were also provided with twice-daily calcium (500 mg) plus Vitamin D tablets and iron-folic acid (IFA) based on their hemoglobin status. Weight measurements were taken at pregnancy confirmation (in the first trimester) and were repeated monthly until 32 weeks, biweekly until 36 weeks, and weekly until delivery.

All women with a BMI of <25 kg/m² received daily food supplements in the form of snacks, provided 7 days a week, and milk (70 kcal plus 6 g protein) 6 days a week throughout pregnancy. Additionally, women with a BMI of <18.5 kg/m^2 were given a hot cooked meal, providing 500 kcal plus 20 g protein as their first meal of the day, 6 days a week, until delivery. Inadequate weight gain during pregnancy was defined using the following cut-offs: <0.44 kg/week for underweight women (BMI < 18.5 kg/m^2), <0.35 kg/week for normal-weight women (BMI ≥ 18.5 to 24.99 kg/m^2), <0.23 kg/week for overweight women (BMI 25 to 29.99 kg/m²), and <0.17 kg/week for obese women (BMI > 30 kg/m²) (12). Women identified as having inadequate weight gain (IWG) were also given an additional hot cooked meal (500 kcal plus 20 g of protein) six days a week until delivery. Study workers conducted twice-weekly home visits to ensure compliance and monitor recovery. Referrals to study clinics were made as needed. Nutritional counseling and focused group discussions with the women and their families were conducted to address dietary challenges and promote behavior change communication.

Statistical analysis

Sociodemographic characteristics were reported as mean (SD) or proportions, as appropriate. We calculated the proportion of underweight women who improved, as well as the mean (SD) and median (IQR) weight change every 3 months during the preconception period. We also calculated the proportion of inadequate gestational weight gain in each trimester and the proportion of women who responded to management after 4 weeks. During preconception, "Improved" was defined as a shift to the next higher or normal category of BMI: from <16 kg/m^2 to 16 to kg/m^2, and from 16–18.49 kg/m^2 to ≥18.5 kg/m^2. Adequate weight gain during pregnancy, starting from the second and third trimesters, was defined as 0.44–0.58 kg/w for underweight women, 0.35–0.50 kg/w for normal-weight women, 0.23–0.33 kg/w for overweight women, and 0.17–0.27 kg/w for obese women (14).

TABLE 1 Baseline characteristics of women of reproductive age at enrollment and pregnant women at second randomization.

Characteristics	WRA (n = 6,722)	Pregnancy (n = 2,460)
Age, years; mean (SD)	24.2 (3.1)	24.5 (3.1)
Height, cm; mean (SD)	152.2 (5.7)	152.4 (5.7)
Height <150 cm	2,340 (34.8)	846 (34.4)
BMI category (kg/m^2)		
≥25 (overweight and obese)	1,798 (26.8)	595 (24.2)
18.5 to 24.99 (normal)	3,774 (56.1)	1,498 (60.9)
16 to 18.49 (moderately underweight)	1,004 (14.9)	328 (13.33)
<16 (severely underweight)	146 (2.2)	39 (1.5)
Hindu	5,540 (82.4)	2,028 (82.4)
No Schooling	336 (5.0)	110 (4.5)
Joint or extended family*	3,922 (58.6)	1,636 (66.5)
Schooling of ≥12 yr.	3,286 (49.1)	1,250 (50.8)
Homemaker	6,328 (94.6)	2,342 (95.2)
Family with below poverty line card	129 (1.9)	84 (3.4)
Family covered by health scheme/health insurance	555 (8.3)	(10.6)

*Adult relatives other than the enrolled woman's husband and children living together in a household.

Results

The sociodemographic characteristics of the 6,722 women of reproductive age (WRA) and 2,460 pregnant women are depicted in Table 1. As per the study design, the cohort of pregnant women was randomized equally into preconception intervention and control groups. The average age was 24 years. About a third of the study population (34.8%) was short stature (<150 cm). Half of the women had more than 12 years of schooling. The majority (~95%) were homemakers, and more than half lived in joint families. Approximately 17% of women of reproductive age (WRA) and 14% of pregnant women were underweight.

In this study, a joint or extended family was defined as a household where adult relatives other than the enrolled woman's husband and children lived together.

Figure 1 illustrates the prevalence of undernutrition among women of reproductive age (WRA) for one year following enrollment. At the time of enrollment, 17% of women were underweight, with 2.2% classified as severely underweight (BMI of <16 kg/m^2) and 14.9% as moderately underweight (BMI 16–18 kg/m^2). After 12 months, the proportion of severely underweight women decreased to 0.9%, and more than half of the moderately underweight women showed improvement.

The women with a BMI of ≥18.5 kg/m^2 at enrolment gained on an average 900 g to 1.5 kg during the follow-up period.

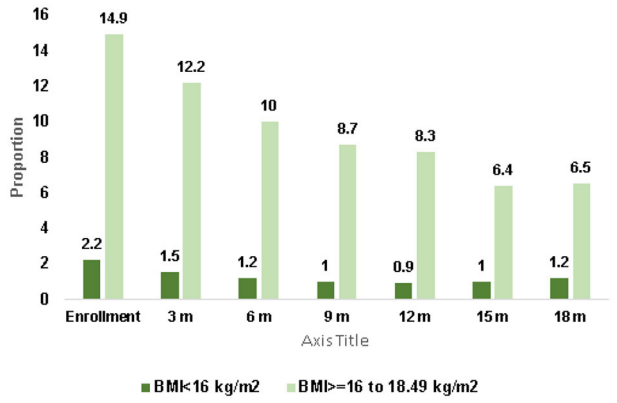

FIGURE 1
Trend in prevalence of undernutrition in women of reproductive age over 12 months $N = 6,722$.

Table 2 shows the response to the management of underweight WRA. Among the severely underweight women, 46% showed improvement after three months, with a mean (SD) weight gain of 1.7 kg (2.4), moving to a higher BMI category (BMI 16–18.49 kg/m^2). By the end of 9–12 months, 68% of these women showed improvement, with a mean (SD) weight gain of 3.5 kg (3.9). For moderately underweight women, 33% showed improvement after three months, with a mean (SD) weight gain of 1.3 kg (1.7). By 9–12 months, 53% had improved, with a mean (SD) weight gain of 2.8 kg (2.9).

Table 3 shows the proportion of pregnant women with IWG, assessed according to the IOM criteria.

The data reveal that the proportion of women with IWG increased as pregnancy progressed but was prevalent in women with pre-existing undernutrition. Among women with a prepregnancy BMI of <18.5 kg/m^2, 29% had IWG at 24 weeks, 36% at 28 weeks, and 47% at 32 weeks of gestation. In comparison, women with a normal prepregnancy BMI (18.5–24.9 kg/m^2) had IWG rates of 25% at 24 weeks, 30% at 28 weeks, and 35% at 32 weeks of gestation. Overall, the proportion of women with IWG reached 33% at 32 weeks of gestation. The average weight gain from the confirmation of pregnancy until 35–36 weeks was 8.8 kg.

Table 4 shows the response to the management of IWG during pregnancy. It shows that 68% of women with IWG at 20–24 weeks of gestation achieved adequate weight gain at 24–28 weeks. Similarly, 62% of pregnant women with IWG at 28–32 weeks and 64% women at 28–32 weeks showed gestational weight gain in the following 4 weeks.

Discussion

In this study, of the 6,722 women in the preconception group, 1,150 women (17%) were underweight, with 1,004 women being moderately underweight and 146 women being severely underweight. Approximately two-thirds of severely undernourished women and half of those who were mildly to moderately undernourished women showed improvement over 12 months of management during the preconception period.

The prevalence of inadequate weight gain ranged from 24 to 33% during early, mid, and late pregnancy, peaking in late pregnancy. This was notably higher among women with a preconception BMI of <18.5 kg/m^2. The data effectively demonstrate that approximately two-thirds of pregnant women with inadequate gestational weight gain achieved adequate weight gain after 4 weeks of management. As pregnancy progresses, the energy intake required to support maternal and fetal metabolism (energy expenditure), fetal growth, and energy storage increase (energy storage) increases (19). Underweight women, therefore, are most vulnerable during the third trimester, where this demand peaks, as evidenced in our study. The continuation of conditions that result in undernutrition during the preconception period impedes adequate gestational weight gain, highlighting the need for early detection and management. The International Federation of Obstetricians and Gynecologists (FIGO) recommends estimating BMI at every opportunity of interaction with non-pregnant women of reproductive age and providing appropriate counseling to identify women at nutritional risk early (20).

Most LMICs do not include preconception screening strategies in their national health guidelines, and the significance of preconception nutrition for women of reproductive age is often overlooked. A desk review of studies conducted over the last decade in South Asian countries to gather evidence on nutritional strategies emphasized the need for early pregnancy registration to screen for severe undernutrition (21).

A recent analysis of the ICDS scheme found only a 57.8% of pregnant and lactating women utilized the service (22). Factors such a taste preferences, inaccessibility, service disruption, and sharing of food supplements were cited barriers to utilization. In this study, we addressed these challenges by tailoring interventions to individual needs and delivering them at home to enhance compliance. A similar (pilot) maternal nutrition project implemented in West Bengal, India, aimed to strengthen the existing government food supplementation program in Anganwadi centers for pregnant mothers by assessing and monitoring BMI, providing home counseling, and spot feeding of cooked food, resulting in improved outcomes (23).

The key strengths of our approach included a comprehensive strategy to address undernutrition at the community level, regular monitoring and screening for IWG, home delivery of pretested, culturally acceptable food supplements, tailored calorie and protein supplementation, observed intake, treatment of infections, and consistent follow-up. Height and weight assessments were standardized and subjected to quality checks.

Implementing this strategy posed several challenges, including ensuring consistent quality at every stage of preparation, maintaining adequate supplies, and ensuring timely delivery. A large team was necessary for these tasks, which could present a programmatic challenge in scaling up the intervention. During the COVID-19 lockdown periods—from 24th March to 18th May 2020 (55 days), and from 1st April to 1st June 2021 (61 days)—the delivery of food supplements to some areas was disrupted, necessitating the discontinuation of hot cooked meals and the provision of precooked snacks instead. This may have affected

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TABLE 2 Response to management of undernutrition in women of reproductive age.

Severe undernutrition (BMI <16 kg/m) at enrolment ($n = 47$)	Enrollment to 3 m	3 to 6 m	6 to 9 m	9 to 12 m	12 to 15 m	15 to 18 m
Moved to a higher category (BMI 16 to 18.49 kg/m^2)	46.8%	53.2%	57.5%	68.1%	59.6%	59.1%
Change in weight (kg)						
Mean (SD)	1.7 (2.4)	2.6 (2.9)	3 (3.3)	3.5 (3.9)	3.6 (4.3)	4.2 (5.4)
Median (IQR)	1.3 (0.4 to 2.5)	1.8 (0.8 to 4.1)	2.2 (0.6 to 5.5)	2.2 (1.4 to 5.5)	3.0 (1.1 to 6.6)	3.4 (0.3 to 7.4)
Moderate undernutrition (BMI 16 to 18.49 kg/m) at enrolment ($n = 332$)	**Enrollment to 3 m**	**3 to 6 m**	**6 to 9 m**	**9 to 12 m**	**12 to 15 m**	**15 to 18 m**
Moved to higher category (BMI > 18.49 kg/m^2)	33.1%	41.9%	49.1%	53.3%	59.3%	61.6%
Change in weight (kg)						
Mean (SD)	1.3 (1.7)	1.9 (2.1)	2.5 (2.7)	2.8 (2.9)	3.4 (3.3)	3.6 (3.4)
Median (IQR)	1.0 (0.1 to 2.6)	1.8 (0.4 to 3.4)	2.3 (0.7 to 4.0)	2.4 (1 to 4.4)	2.9 (1.1 to 5.2)	3.3 (1.4 to 5.3)

TABLE 3 Inadequate weight gain in pregnancy.

Period of gestation (weeks)	All	Baseline BMI		
		<18.5 kg/m	18.5–24.9 kg/m	≥25 kg/m
		$n = 290$	$n = 1,125$	$n = 457$
Early pregnancy (16–20 weeks ($n = 1,872$)	229.3%	31.7%	31.1%	23.2%
		$n = 306$	$n = 1,159$	$n = 466$
Early pregnancy (20–24 weeks ($n = 1,931$)	23.7%	28.8%	24.5%	18.2%
		$n = 309$	$n = 1,181$	$n = 481$
Mid pregnancy (>24–28 weeks) ($n = 1,971$)	27.8%	35.9%	29.6%	18.1%
		$n = 286$	$n = 1,192$	$n = 473$
Late pregnancy (> 28–32 weeks) ($n = 1,951$)	32.7%	46.5%	35.2%	18.2%

some outcomes. Additionally, managing costs within the study budget was challenging. We also had to address issues related to women sharing snacks with their families, especially children, and frequently substituting their regular diet with the additional food provided.

An in-depth qualitative analysis of the causes of undernutrition would have provided more nuanced insights, but this was a limitation in our statistical analysis. We acknowledge that while BMI is not the ideal measure of weight status and undernutrition, it remains an invaluable screening tool for community trials (12).

This study has tremendous public health implications. Preconception care, particularly the nutritional assessment of women of reproductive age, represents a major unmet need in India and South Asia. Our findings highlight the absence of preconception nutrition programs, even though India has robust guidelines and programs targeting child undernutrition, including support for pregnant and lactating women. However, the pre-pregnancy phase in women of reproductive age remains largely unaddressed. Poshan Abhiyan, launched in 2018, adopts an integrated approach but lacks a specific preconception component beyond anemia prevention (23). Overall, in the WING trial, the integrated interventions led to a 24% reduction in low birth weights and a 51% reduction in stunting at 24 months of age

TABLE 4 Response to management of inadequate weight gain in pregnancy.

Period of gestation (weeks)	Women with inadequate weight gain *n* (%)	Adequate weight gain in the next 4 weeks
Early pregnancy (16 to 20 weeks), $n = 1,872$	548 (29.3)	73.9%
Early pregnancy (20 to 24 weeks), $n = 1,931$	457 (23.7)	68.1%
Mid pregnancy (>24 to 28 weeks), $n = 1,971$	547 (27.8)	61.5%
Late pregnancy (>28–32 weeks), $n = 1,951$	638 (32.7)	63.9%

compared to the control group. The interventions also yielded improved maternal outcomes, including higher hemoglobin concentration, better gestational weight gain, and reduced risks of reproductive tract infections, anemia, and pregnancy-induced hypertension.

Programmatic implications

Currently, preconception and early pregnancy screening for underweight women is not part of any national program in India. There is a need for education and advocacy on proper nutrition, using IEC material by grassroots workers to promote social and behavioral change. Early pregnancy screening for underweight women and consistent reporting by health workers whenever women of reproductive age are examined could be effective in addressing this issue. Family planning programs could incorporate BMI as a screening tool for undernutrition in women of reproductive age when identifying eligible couples, and subsequently include them in ICDS programs. The existing ICDS program could be adapted to provide trimester-specific food supplements during pregnancy. Conducting an implementation research project to study the feasibility of these interventions would be a positive step forward.

Conclusion

The promotion of preconception nutrition is critical and requires greater focus, as undernutrition needs to be managed before pregnancy, often requiring 9–12 months for improvement. Our study shows that supplementation with high-quality, energy-dense food, coupled with close monitoring, individual tracking for compliance, screening, and treatment of infections and other morbidities, as well as observed intake, significantly improved the nutritional status of women during preconception and pregnancy.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The trial has being conducted according to the guidelines outlined in the Declaration of Helsinki and is approved by the Ethics Committees of the Society for Applied Studies, New Delhi (SAS/ERC/LG/2017); the Vardhman Mahavir Medical College and Safdarjung Hospital (IEC/SJH/VMMC/PROJECT-2017/694), New Delhi; and the WHO, Geneva (ERC.0002934). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

ND: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. RC: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. ST: Data curation, Formal analysis, Methodology, Writing – review & editing. MS: Investigation, Supervision, Writing – review & editing. JK: Investigation, Supervision, Writing – review & editing. PM: Data curation, Investigation, Methodology, Resources, Writing – review & editing. RD: Investigation, Methodology, Resources, Supervision, Writing – review & editing. NB: Conceptualization, Investigation, Methodology, Resources, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1405247/full#supplementary-material

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Impact of a virtual antenatal intervention for improved diet and iron intake in Kapilvastu district, Nepal - the VALID randomized controlled trial

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Introduction: Counseling, together with iron and folic acid supplements, can improve hemoglobin levels in pregnant women, but few interventions have tested a virtual method of delivering counseling. We hypothesized that a virtual counseling intervention delivered via a mobile device (mHealth) would prevent and treat anemia, compared with routine antenatal care (ANC).

Methods: Virtual antenatal intervention for improved diet and iron intake (VALID) was a non-blinded parallel group two-arm, individually randomized superiority trial (1:1 allocation). Participants were pregnant women who were married, aged 13–49 years, able to answer questions, 12–28 weeks' gestation and living in Kapilvastu district, Nepal. Women were randomized to receive routine ANC (control arm), or ANC plus a virtual antenatal intervention of two problem-solving counseling sessions via video call. The primary outcome was iron folic acid (IFA) tablet compliance (consumption on 12 or more days of the previous 14 days). Secondary outcomes were dietary diversity, promoted food consumption, iron bioavailability enhancement, and knowledge of iron-rich foods. Primary logistic regression analysis was by intention-to-treat, adjusting for baseline values.

Results: We enrolled 319 pregnant women (161 control, 158 intervention) from 23 January 2022 to 6 May 2022 and analyzed outcomes in 144 control and 127 intervention women. Compliance with IFA increased in both arms. In the intervention arm, compliance increased by 29.7 percentage points (pp) (49.0–78.7%) and 19.8 pp. in the control arm (53.8–73.6%). Despite the more significant increase in the intervention arm, we found no intervention effect upon IFA compliance (adjusted odds ratio [aOR] 1.33; 95% confidence interval [CI]: 0.75, 2.35; $p = 0.334$), dietary diversity, or ANC visits. The intervention increased knowledge of iron-rich foods (coefficient 0.96; 95% CI: 0.50, 1.41; $p < 0.001$), consumption of promoted foods (aOR: 1.81; 95% CI: 1.08, 3.02; $p = 0.023$), behavior to enhance iron bioavailability (aOR: 4.41; 95% CI: 1.23, 15.83; $p = 0.023$), and coronavirus disease 2019 (COVID-19) knowledge (aOR: 4.06; 95% CI: 1.56, 10.54; $p = 0.004$). The total intervention cost was US$35,193, and the cost per pregnant woman receiving two virtual counseling sessions was US$277.

Conclusion: Virtual counseling can improve antenatal health behaviors, such as the consumption of promoted foods and methods to enhance bioavailability. Improved IFA consumption and ANC attendance may require additional family/community support.

Clinical trial registration: https://www.isrctn.com/ISRCTN17842200, identifier ISRCTN17842200.

KEYWORDS

anemia, pregnancy, antenatal, virtual counseling intervention, iron intake, diet, Nepal, iron and folic acid

Introduction

Anemia in pregnancy is an intractable problem worldwide (1–3). Severe anemia causes more maternal deaths in South Asia than in any other region (4) and it is doubtful that South Asian countries will meet global targets to reduce anemia by 50% by 2025 (5). In Nepal in 2016, 46% of pregnant women were anemic (hemoglobin [Hb] concentration < 110 g/L) (6), almost unchanged from the 2011 estimate of 48% (7).

Women are recommended to take iron and folic acid (IFA) supplements during pregnancy to reduce the risk of anemia, iron deficiency, and low birth weight (8) and improve child survival (9). However, despite Nepal implementing a routine IFA supplementation program from the second trimester of pregnancy, anemia levels remain alarmingly high, particularly in the Terai (plains) region (6) where thinness and poor diet adversely affect women's health (10, 11).

Behavior change interventions can play a role in promoting access and adherence to IFA supplementation and improving other determinants of anemia. In Nepal, gender-inequitable intrahousehold dynamics affect access to IFA (12), iron-rich food (10) and ANC (13), suggesting the importance of addressing the family context in reducing anemia (14). Patrilineal marriage practices often result in women moving to the home of their husbands after marriage, where they are lowest in the family hierarchy. They are usually expected to cook for the extended family under the supervision of their mother-in-law, who controls what is cooked and the quantity of food cooked. Cultural norms around maintaining ritual purity of food and the low position of daughters-in-law in the household mean that the cook (usually the daughter-in-law) serves the food and then eats after others have eaten. Women of childbearing age are often expected to be satisfied with eating less and are considered to have lower nutritional needs compared with the men of the family, who tend to work outside the household (15, 16).

Compared with IFA alone, an intervention combining IFA with one short counseling session and provision of an information brochure on anemia was associated with higher hemoglobin concentrations in pregnant women (17). Another nutritional counseling intervention with dietary assessment and menu planning increased hemoglobin concentrations slightly more than general education about hygiene and sanitation, rest/exercise, and danger signs in pregnancy (18).

Significant barriers limit access to ANC and behavior change interventions, such as travel costs and human resource constraints (13). mHealth interventions, defined as *the use of mobile phones and other wireless technology in medical care*, may help to overcome some of these barriers by providing services virtually, notably as mobile phone ownership and network coverage have expanded rapidly across the globe. The potential of mHealth interventions became increasingly apparent during the COVID-19 pandemic, which made providing ANC and face-to-face engagement with health workers difficult. In Nepal, repeated lockdowns, fear of visiting health facilities, and discrimination against frontline workers (19) posed barriers to women's access to ANC and IFA (20).

Virtually delivered mHealth interventions have so far shown mixed effects on antenatal health behaviors, perhaps because they have had limited participatory elements. We identified nine virtual mHealth interventions aiming to improve food and/or nutrient intakes in pregnancy in low- or middle-income countries (LMICs) from two systematic reviews (21, 22) and our systematic search update (summary in Supplementary Annex 1). All used didactic, information-based models and thus were not tailored to women's contexts, and most were asynchronously delivered with automated content, which limited their interactivity with participants. Seven of the nine interventions involved reminders to take supplements or attend ANC via SMS, voice messages, or phone calls (23–29); the other two provided educational material via SMS (30) or a smartphone application (31). Impacts were varied, with some showing improvements in adherence to iron tablets (23, 26), ANC (24, 26), diets (30, 31), and Hb (26, 29), while others showed no impact on iron adherence (25, 27, 29) and Hb concentration (23, 25, 28).

The evidence suggests that the virtual mHealth interventions show promise to improve IFA compliance, dietary intakes in pregnancy, and ANC access. However, the interventions tested so far have not been interactive or tailored to women's contexts and have not included participatory design elements, which we know can have significant impacts on intervention effectiveness and equity of coverage (32, 33) and therefore could improve mHealth effectiveness.

Research is needed to develop and test innovative methods to increase IFA intake and improve dietary quality in Nepal, particularly among hard-to-reach groups. Therefore, we did the "virtual antenatal intervention for improved diet and iron intake" (VALID) individually randomized controlled trial testing the effectiveness of an mHealth dialogical "virtual counseling" intervention delivered via video calls with pregnant women and their families living in Kapilvastu district, Lumbini Province in the Terai. We hypothesized that providing counseling twice in mid-pregnancy would increase compliance to IFA tablets, compared with ANC alone. Although initiating IFA during preconception or in early pregnancy may be beneficial (34), mid-pregnancy was selected as a pragmatic intervention point in this study for three reasons. First, women in Nepal tend only to reveal their pregnancies after the first trimester is complete. Second, compliance with IFA is

more challenging to attain in early pregnancy due to nausea during this period. Third, at the time of designing the intervention, IFA was usually only provided free of cost by government health facilities after 16–20 weeks' gestation to achieve a minimum of 180 days of consumption over the pregnancy.

The primary objective was to assess whether the intervention, in addition to usual government services, increased women's compliance to IFA supplementation compared with access only to usual government services. As a secondary objective, we assessed impacts on dietary knowledge and practices, access to ANC, and knowledge of COVID-19. We conducted a concurrent process evaluation to understand the intervention's effects.

Methods

Trial design

The trial was a non-blinded parallel group two-arm individually randomized superiority trial with 1:1 allocation. In the control arm, women had access to routine ANC. There were no essential changes to methods after trial commencement or from the published protocol (35).

Setting

The trial was implemented in 54 rural population clusters of southern Kapilvastu district in the Nepal Terai, bordering the state of Uttar Pradesh in India. Anemia prevalence is high (45%), and IFA in pregnancy is suboptimal: 43% took at least the recommended dose of 180 IFA tablets, 33% took 60–179 tablets, and 24% took <60 tablets (3). IFA is supplied free of charge at primary health services and outreach clinics. Discrimination against young married women is common in the plains of Nepal, and harmful gender norms and intrahousehold hierarchies are significant drivers of women's poor health and nutrition in this context (10, 12, 14, 15, 36). In Nepal overall, in 2022, 80% of women and 92% of men owned any mobile phone, with 60 and 74%, respectively, owning a smartphone. In rural Lumbini province, 52% of women and 70% of men owned a smartphone, so mobile phone access is high (37). However, since only 61% of rural women in Lumbini province can read a whole sentence (37), their capacity to use smartphones may be limited.

The trial protocol is available as a published paper (35).

Trial registration

Trial registry name: ISRCTN; registration number: ISRCTN 17842200; registration date: 13 January 2022. URL: https://doi.org/10.1186/ISRCTN17842200.

ISRCTN collects all items from the World Health Organization Trial Registration Data Set.

Participants

Pregnant women were eligible for the baseline survey if they were aged 13–49 years, could respond to questions, and resided in a study cluster. Additional inclusion criteria for enrolment in the trial included the following: 12–28 weeks' gestation (estimated from the recall of the last menstrual period or expected date of delivery given by a health worker), no plan to leave the country, and no other pregnant woman in her household already enrolled in the trial. Interviewers identified pregnant women with help from Female Community Health Volunteers, confirmed eligibility, and took written consent.

Randomization and masking

Health Research and Social Development Forum (HERD) Data Manager implemented stratified block randomization using the "blockrand" package in "R" with four strata defined by the combinations of (i) any IFA consumed in the last 14 days at baseline and (ii) first pregnancy or not. Allocations were sealed into sequentially numbered opaque envelopes, transported to the field office, stored securely, and opened by the monitoring and evaluation manager when interviewers called to ask a participant's allocation at the end of the baseline interview. After the interviewers had assigned each respondent to a study arm, they visited each pregnant women in the intervention arm to distribute a mobile device. Blinding of trial staff and participants was impossible as they were aware of who was receiving virtual counselling. The details of data management are provided in the trial protocol (35).

Procedures

After enrolment, researchers delivered a mobile device with a sim card and a data package worth 399 Nepalese rupees (~USD 3) to intervention arm participants. They trained them to use the device. Enrolled women were assigned to one of ten trained counselors who were auxiliary nurse midwives or graduates with >4 years of community-based health intervention experience. Counselors telephoned women to schedule sessions via Zoom at 12–28 weeks' gestation, and a second session ≥2 weeks later.

The intervention encouraged women and their families to take action to improve dietary practices, IFA compliance, and access to ANC. Using stories and dialogue to trigger reflection and action, counselors supported them in thinking critically about the causes of anemia in pregnancy in their household and community. Stories directly addressed issues identified from formative research (14). After the first session, participants made action plans to address relevant issues for their families. In the second session, action plans were reviewed/discussed, and a second plan was made. At the end of each session, we sent the action plan and some standardized "take-home" messages about dietary guidance, ANC and IFA uptake, and COVID-19 symptoms and prevention to the device via WhatsApp. After the second counseling session, researchers collected the mobile devices. Participants were free to seek concomitant care during pregnancy, irrespective of the trial allocation.

Researchers measured participants' recall of outcomes and pregnancy symptoms/problems at enrolment (12–28 weeks' gestation) and endline (at least 49 days later). At baseline, they collected women's age, gravida, medical history, date of the last menstrual period, and

other socioeconomic and demographic data. The data collection tools were programmed onto Android mobile devices in Nepali and English using the CommCare electronic data collection platform. These had in-built jump sequences and value limits to prevent data entry outside plausible ranges. Interviewers followed standard procedures for 24 h dietary recall measurements, and IFA recalls to increase accuracy and minimize the interobserver difference.

Outcomes

The primary outcome was consumption of IFA on ≥12 of the preceding 14 days. Secondary outcomes were dietary diversity score, consumption of promoted foods, practice of iron bioavailability enhancement, knowledge of iron-rich foods, and number of ANC visits. Exploratory outcomes included understanding why blood tests were needed, knowledge of COVID-19, and timing of ANC. Outcomes were generally derived from multiple questions to generate a count or a binary indicator (Table 1).

Counselors and interviewers recorded adverse events and informed field managers. COVID-19 infections were tracked among participants by prospectively filling in COVID-19 symptoms forms before interactions but were not reported as adverse events.

Statistical analysis

Our target sample size was 150 participants in each arm (300). We undertook power calculations for two scenarios, where the control arm prevalence of the primary outcome (consuming IFA on at least 12 of the preceding 14 days) was either (a) 67% or (b) 50%. Assuming a 10% loss to follow-up in each arm, the sample size gives 80% power to detect a 15 percentage points increase in the primary outcome in scenario (a) and a 16.7 pp. increase in scenario (b).

Our primary analysis was by intention-to-treat (i.e., "as randomized") following a prespecified Statistical Analysis Plan approved by the Trial Steering Committee (Supplementary Annex 2). All confidence intervals were 95% and two-sided. Statistical tests were two-tailed at the 5% significance level. Analyses of the primary outcome and other binary outcomes were based on logistic regression, leading to adjusted odds ratios (aORs) and 95% CI. We also expressed the intervention effect as an adjusted difference with 95% CI based on marginalization, that is, the difference in predicted outcome prevalence from our regression model between allocating all participants to intervention and all to control. We used linear regression with robust standard errors for count outcomes.

To report data completeness, we considered the primary outcome to be missing where the woman was unavailable, moved away, or withdrew consent but to be not applicable if she had a miscarriage, abortion, or stillbirth. We do not impute any missing values of the primary outcome, as the strongest predictor of the outcome is IFA compliance at baseline, which we have included as a covariate in our regression models.

The analysis of the primary outcome (IFA consumed on ≥12 out of the previous 14 days) was adjusted for the same outcome as reported at baseline and gravida (0, 1+) because these are the design factors that together defined the randomization strata. Another "fully adjusted analysis" adjusted for further factors that we expected to affect the outcome are education, age of the pregnant woman, and gestational age at the endline interview. This was considered a secondary analysis because, despite potentially addressing any residual imbalance between arms, adjustment for many factors may reduce precision. Analysis of secondary outcomes followed the same approach. Both the primary and fully adjusted analyses additionally adjusted for the baseline value of the outcome (if measured at baseline). For count outcomes, the baseline values (where available) were adjusted as a linear term.

A second analyst checked the code used to derive the primary outcome and all adjustment factors in the primary analysis. Preliminary analysis of distribution shape in a dataset without trial arm informed choice of regression method for count outcomes. We examined covariate standard errors to check for collinearity between covariates and model stability. Analyses were conducted using Stata version 17.

We undertook subgroup analyses of the primary outcome, presenting effect measures in women who had and had not, consumed IFA on ≥12 of the previous 14 days at baseline. We also tested the interaction between this factor and the arm. No interim analyses were planned or conducted.

We collected process evaluation data using mixed methods to describe the delivery of the intervention and fidelity to plans, to understand the context and mechanisms of how the intervention worked or failed. The detailed process evaluation results are presented elsewhere (38).

We estimated the costs of designing and implementing the intervention from a program provider perspective. We collected cost data from HERD international accounts, staff time use surveys, and interviews. The time horizon for the analysis was 14 months, which was divided into 7 months of startup and 5 months of implementation. All costs were presented in 2022 US$, using the exchange rates of 131.5 for Nepal and 1.2 for the United Kingdom. Detailed cost analysis will be published separately.

Patient and public involvement statement

Our study was designed during the acute COVID-19 pandemic, so lockdowns and restrictions on community engagement activities limited our capacity to engage patients and the public in the design of the intervention. However, the virtual counseling intervention was adapted from that designed for a previous trial in the same study population which was stalled due to the pandemic (35). In this study, we undertook extensive public involvement through meetings with municipality leaders and collected extensive formative qualitative data from potential participants in the trial, which informed the content and design of the counseling (12, 14).

Results

Participant flow (Consolidated Standards of Reporting Trials [CONSORT] diagram) is illustrated in Figure 1. Enrolment ran from 14 January 2022 to 23 February 2022. The counseling sessions ran from 23 January 2022 to 6 May 2022, and the follow-up ranged from 9 March 2022 to 7 June 2022. The trial ended when all women who consented and could be located had been followed up. 319 pregnant women enrolled, 161 in control, and 158 in intervention arms.

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TABLE 1 Virtual antenatal intervention for improved diet and iron intake (VALID) trial outcome measures.

VALID trial outcomes	Recorded also at baseline[b]	Recall period	Definition	Variable type	Effect measure to compare arms
Primary outcome					
Compliance with recommended iron and folic acid tablet (IFA) intake	Yes	14 days	IFA consumed on 12 or more days out of the previous 14 days (i.e., on at least 80% of days)	Binary	Odds ratio and difference in proportion[a]
Secondary outcomes					
Dietary diversity	Yes	24 h	Count of the number of food groups consumed in the previous 24 h preceding the endline interview, assessed using the list-based method, out of 10 food groups	Count (0–10)	Difference in mean
Consumption of intervention-promoted foods	Yes	24 h	Any consumption of green leafy vegetables, meat, or fish	Binary	Odds ratio and difference in proportion[a]
Practicing one or more methods to enhance bioavailability	Yes	7 days	Recalled one or more of the following: using lemon or other vitamin C-rich foods with meals, eating sprouted grains or pulses, avoiding tea/coffee 1 h on either side of meals, or spreading meat-eating over two eating occasions rather than one	Binary	Odds ratio and difference in proportion[a]
Knowledge of iron-rich foods	No	N/A	Count of iron-rich food groups correctly recalled	Count (0–9)	Difference in mean
ANC visits	No	Baseline to endline	Antenatal care (ANC) visits between enrolment and endline interview	Count (0–4)	Difference in mean
Exploratory outcomes					
Understanding of why blood tests are taken at antenatal check-ups.	Yes	N/A	The proportion of those women who had a blood test at ANC who could correctly explain one or more reasons for having a blood test	Binary	Odds ratio and difference in proportion[a]
Knowledge of COVID-19 symptoms, precautions, and vulnerability	No	N/A	The proportion of women who could correctly identify at least one vulnerable group, at least three coronavirus disease 2019 (COVID-19) control/prevention measures, and at least three COVID-19 symptoms	Binary	Odds ratio and difference in proportion[a]
ANC visits at the right time for her gestational age	Yes	Pregnancy to date	Whether the woman had her ANC visits at 2, 4, 6, and 8 months or not	Binary	% by arm (no effect measure)

[a]Formal testing is linked to the odds ratio, but the effect is also expressed as a difference in proportion.
[b]Items recorded at baseline are adjusted for in analyses.

We obtained IFA compliance for 158 and 155 women at baseline and for 144 control and 127 intervention women at endline, 89.4 and 80.4% of enrolled, respectively.

Miscarriage or abortion amounted to 7 pregnancies in control and 12 in intervention. No stillbirths were recorded. Excluding pregnancy losses, loss to follow-up was 10 (6.2%) in control and 19 (12.0%) in intervention arms. Reasons for losses are detailed in the participant flow diagram but were mostly due to migration, delivering the baby, and, in the case of intervention, withdrawal of consent. No maternal deaths were reported.

Characteristics of those lost to follow-up (or who experienced pregnancy loss) versus those retained by the study arm are provided in Supplementary Annex 3. More multiparous and more illiterate women were lost in the intervention arm than in the control arm.

Baseline characteristics are summarized by the arm in Table 2 and were mostly well balanced between arms. Participants were mainly of Madheshi ethnicity from "Middle Madheshi," Muslim or Dalit groups. Around two-thirds of the household heads were farmers with landholdings <2 hectares, whereas one in five households was landless. Half (51%) of women could read, and less than one quarter were educated to secondary level or above. Over half of the respondents had smartphone access, but 28% had no phone access, and others used push-button phones. Gestational age at enrolment was a median of 18.4 weeks (IQR: 14.9, 22.6) in the control and

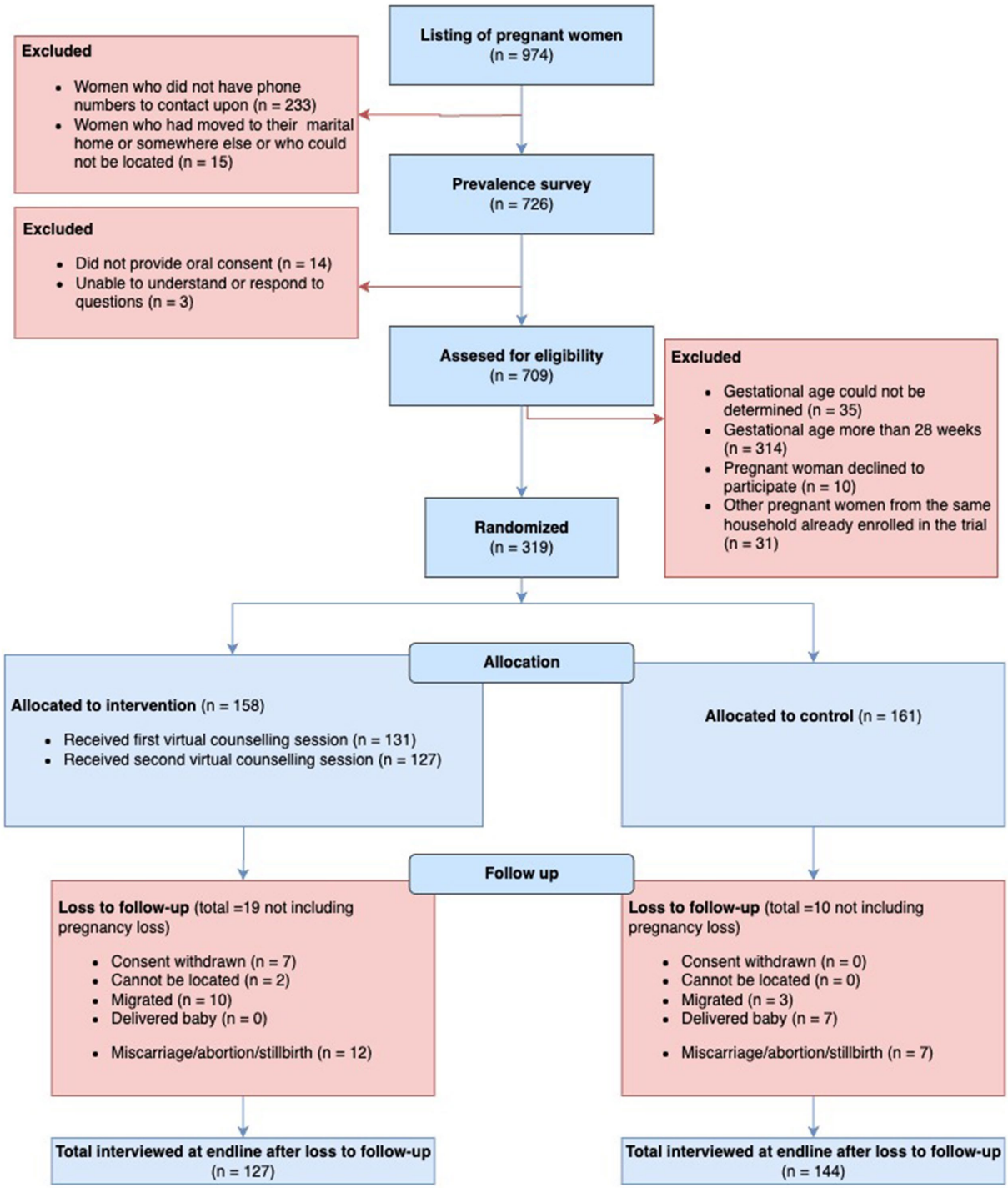

FIGURE 1
The consolidated standards of reporting trials (CONSORT) flowchart of trial recruitment and retention.

17.5 weeks (IQR: 14.1, 23.4) in the intervention arm. The baseline–endline gap was a median of 55 (IQR: 51, 61) days and did not differ by arm.

Implementation went as planned and followed prespecified protocols (35, 38). A total of 131 women received the first counseling session, and 126 received the second. The median gap between the two sessions was 18 days (IQR: 16, 21). Women were median 21.3 (IQR: 17.3, 24.7) and 23.8 (IQR 20.2, 27.4) weeks' gestation at first and second counseling, respectively.

Outcomes at baseline and endline are described in Table 3, and Table 4 gives minimally adjusted (primary analysis) regression results. Fully adjusted regression results are shown in Table 5. In the text, we provide ORs and coefficients from the primary analyses.

TABLE 2 Characteristics of women enrolled in the trial by arm.

Characteristic	Control			Intervention			Total		
	N	Frequency	%	*N*	Frequency	%	*N*	Frequency	%
Caste									
Dalit	161	31	19.3	158	24	15.2	319	55	17.2
Janajati		4	2.5		1	0.6		5	1.6
Muslim		44	27.3		48	30.4		92	28.8
Middle Madheshi		78	48.4		81	51.3		159	49.8
Brahmin/Chettri		4	2.5		4	2.5		8	2.5
Primary source of household income									
Farming	161	101	62.7	158	108	68.4	319	209	65.5
Animal husbandry		3	1.9		2	1.3		5	1.6
Skilled labor		11	6.8		13	8.2		24	7.5
Unskilled labor		28	17.4		16	10.1		44	13.8
Job/business/other		7	4.3		10	6.3		17	5.3
Remittances		11	6.8		9	5.7		20	6.3
Gravida									
Primigravida	161	35	21.7	158	34	21.5	319	69	21.6
1 previous pregnancy		44	27.3		44	27.8		88	27.6
2 previous pregnancies		39	24.2		24	15.2		63	19.7
3+ previous pregnancies		43	26.7		56	35.4		99	31.0
Pregnant woman's education									
No schooling	161	51	31.7	158	61	38.6	319	112	35.1
Primary to grade 8		69	42.9		61	38.6		130	40.8
Secondary grade 9 and above		41	25.5		36	22.8		77	24.1
Pregnant woman's literacy									
Cannot read (ref)	161	71	44.1	158	84	53.2	319	155	48.6
Reads with difficulty or easily		90	55.9		74	46.8		164	51.4

(Continued)

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TABLE 2 (Continued)

Characteristic	Control			Intervention			Total		
	N	Frequency	%	*N*	Frequency	%	*N*	Frequency	%
Pregnant woman's access to a phone									
No phone access	161	49	30.4	158	42	26.6	319	91	28.5
Owns or accesses a push-button phone	161	63	39.1	158	64	40.5	319	127	39.8
Owns or accesses a smartphone	161	90	55.9	158	83	52.5	319	173	54.2
Woman's knowledge of using the internet									
No knowledge	161	70	43.5	158	66	41.8	319	136	42.6
Some/little experience		66	41.0		72	45.6		138	43.3
Experienced		25	15.5		20	12.7		45	14.1
Continuous variables	*N*	Mean	SD	*N*	Mean	SD	*N*	Mean	SD
Household size	161	8.8	4.9	158	8.8	5.1	319	8.8	5.0
Total number of children (alive)	161	1.5	1.3	158	1.6	1.6	319	1.6	1.5
Age of pregnant woman	161	25.2	4.0	158	25.7	4.8	319	25.5	4.4
Age at marriage	161	18.4	2.4	158	18.3	2.4	319	18.3	2.4
Age at first pregnancy	161	20.4	2.1	158	20.3	2.7	319	20.4	2.4
Age of first menstruation	161	13.5	1.3	158	13.6	1.3	319	13.6	1.3
Continuous variables	*N*	Median	IQR	*N*	Median	IQR	*N*	Median	IQR
Gestational age at enrolment (baseline)	161	18.4	14.9, 22.6	156	17.5	14.1, 23.4	317	18.0	14.4, 22.9
Gestational age at follow-up (endline)	157	26.1	23.1, 30.4	124	26.1	23.3, 30.8	281	26.1	23.1, 30.7

IQR, interquartile range; SD, standard deviation.

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There was no effect of the intervention on IFA compliance (odds ration [OR]: 1.33; 95% CI: 0.75, 2.35; $p = 0.334$). Compliance increased from 53.8 to 73.6% (an increase of 19.8 pp) in the control arm and from 49.0 to 78.7% (29.7 pp) in the intervention arm (Table 3). Figure 2 illustrates the number of days of IFA consumption in the last 14 days by the arm at baseline and endline and displays a strong bimodal distribution. At both baseline and endline, women either mostly complied with daily consumption or did not consume IFA at all. At the endline, a small number of women reported missing a few days of consumption, whereas at baseline, almost all women either recalled 0 or 14 days of consumption.

Among secondary outcomes, we found no apparent intervention effect on dietary diversity score or number of ANC visits. We found that the intervention increased dietary knowledge and improved nutritional practices. Women in the intervention arm could name one more iron-rich food on average than those in control (control mean 2.4; intervention mean 3.4 foods; coefficient 0.96; 95% CI: 0.50, 1 0.41; $p < 0.001$). The proportion of women consuming intervention-promoted foods was higher in the intervention than control, aOR: 1.81; 95% CI: 1.08, 3.02; $p = 0.023$. The odds of practicing iron bioavailability enhancement (squeezing lemon on food, avoiding tea wholly or within 1 h of mealtimes, or spreading meat eating out between two eating occasions rather than one) was also higher (aOR: 4.41; 95% CI: 1.23, 15.83; $p = 0.023$).

Among exploratory outcomes, we found that knowledge of COVID-19 increased (aOR: 4.06; 95% CI: 1.56, 10.54; $p = 0.004$). The proportion who could recall three COVID-19 symptoms, three precautions, and one COVID-19 vulnerable group was higher at the endline in the intervention (15%) than in the control participants (4.2%). Understanding of the reasons for blood tests at ANC did not differ. The proportion of women who had their ANC visits at the right time (i.e., at 2, 4, 6, and 8 months) was 30.6% in the control and 26.8% in the intervention arm.

Ancillary analyses are given in Table 5. We did not find a differential effect of the intervention on IFA compliance between women who were or were not complying with IFA supplements at baseline.

Table 6 shows reported reasons why women did not take IFA and women's recall of action plans. The main reasons were lack of time to visit health facilities and side effects. Approximately 80% of women receiving the counseling session recalled making an action plan. The most common actions were drinking adequate water, going for ANC, and consuming IFA tablets. Half of the women made action plans to improve their consumption of vitamin C and iron-rich foods after the first counseling session. Some planned actions related to pregnancy problems that were not dietary (e.g., back pain and leg cramps).

A virtual intervention may be more cost-effective than a face-to-face intervention because of the time and travel costs saved. We could not undertake a cost-effectiveness analysis because of the lack of significant difference in compliance between arms, but the calculated total cost of the intervention was US$35,193, and cost efficiency or costs per pregnant woman receiving two virtual counseling sessions was US$277. However, at scale and under routine, non-research condition costs would potentially be lower.

Discussion

The VALID mHealth virtual counseling intervention did not improve IFA compliance, dietary diversity, or number of ANC visits relative to the control. However, women's knowledge and consumption of intervention-promoted iron-rich foods and behaviors to enhance iron bioavailability were significantly higher in the intervention arm compared to the control. Although the increase in the proportion complying with 12 or more days of consumption out of 14 was higher in the intervention than in the control arm, the odds of compliance did not differ between arms. Given the intervention did not increase IFA compliance, ANC, or dietary diversity, it is unlikely that the changes in consumption of iron-rich and iron-bioavailability-enhancing foods alone would have led to improved anemia levels for pregnant women in the intervention arm.

The cost of the intervention was US$277 per participant covered. However, if scaled up, costs would be lower due to economies of scale. To our knowledge, there is no published cost data on community-based implementations of mHealth virtual antenatal counseling tools in LMICs. In addition, comparing the costs of this virtual antenatal counseling intervention with other mHealth counseling tools is challenging because of differences in the type of intervention (e.g., virtual counseling meetings or SMS and call reminders), scale, and cost approach. Research from high-income settings suggests that satisfaction levels are similar between face-to-face and virtual counseling, but face-to-face counseling is usually of a longer duration (39). Given the modest effects seen, it is questionable whether it would be justified to undertake a repeat trial of the same intervention with a larger sample size powered to detect a smaller difference between arms.

Although the intervention did not improve IFA compliance, compliance improved in both arms over time. For those who did not take IFA, a primary reason cited by participants in both study arms was not having time to go to the health facility to get IFA tablets. Convenient access, family support to accompany pregnant women to ANC, and the ability to take time out from their responsibilities are necessary to enable women to get IFA tablets (38). Formative data showed a lack of trust in government health services by husbands in particular (12). This may have restricted women's access to IFA since women's intrahousehold status is often low, and they may not have been able to negotiate with the family to visit the health facility. Women living far from a health facility, those from poor or marginalized families, or those living in conservative families may benefit from virtual counseling, especially if supplemented with targeted support from Female Community Health Volunteers (FCHVs). FCHVs could help to identify particularly vulnerable women in prepregnancy and then make home visits to deliver IFA which may improve compliance (40).

Despite attempting to engage family members in the intervention to accompany women to ANC, improve their access to iron-rich foods, and comply with IFA, this was difficult because of the different working patterns of men and women and the small screen limitations. This lack of family engagement may have affected women's access to IFA, thereby contributing to a lack of intervention impact on compliance. Hence, the future interventions could benefit from providing additional behavior change content that can be accessed at a time that is convenient for the whole family (e.g., videos, group chats, or SMS content), and/or by engaging with communities to address harmful gender norms (41, 42), and engaging with families face-to-face to problem-solve (38). Our approach might have been enhanced by a concomitant provision of asynchronously delivered content (43), and/or by community-focused interventions such as participatory learning and action (PLA) groups. PLA groups have been successful at increasing

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TABLE 3 Outcomes at baseline and endline.

	Baseline						Endline					
Outcomes	Control			Intervention			Control			Intervention		
Primary outcome	*N*	Frequency	%	*N*	Frequency	%	*N*	Frequency	%	*N*	Frequency	%
Compliance with recommended iron and folic acid tablet (IFA) intake on 12+ out of 14 days	158	85	53.8%	155	76	49.0%	144	106	73.6%	127	100	78.7%
Secondary outcomes	*N*	Mean	SD	*N*	Mean	SD	*N*	Mean	SD	*N*	Mean	SD
Dietary diversity of pregnant women in last 24 h (10 groups)	158	5	1.7	154	4.7	1.7	144	4.7	1.5	127	4.9	1.5
Knowledge of iron-rich foods (maximum 9 foods)	0	na		0	na		144	2.4	1.8	127	3.4	1.9
ANC visits between baseline and endline	0	na		0	na		144	1.2	0.7	127	1.2	0.7
Binary secondary outcomes	*N*	Frequency	%	*N*	Frequency	%	*N*	Frequency	%	*N*	Frequency	%
Consumption of intervention-promoted foods in the last 24 h	158	121	76.6%	154	106	68.8%	144	79	54.9%	127	85	66.9%
Practicing one or more methods to enhance iron bioavailability in the last 7 days	158	138	87.3%	154	135	87.7%	144	130	90.3%	127	124	97.6%
Exploratory outcomes	*N*	Frequency	%	*N*	Frequency	%	*N*	Frequency	%	*N*	Frequency	%
Knows > = 1 reason for getting a blood test (out of all those who had a blood test)	27	21	78.0%	22	13	59.0%	51	34	67.0%	47	37	79.0%
Reasons cited for blood tests												
To check for anemia	27	20	74.0%	22	13	59.0%	51	32	63.0%	47	34	72.0%
To check for blood-borne diseases (HIV, hepatitis)	27	8	30.0%	22	4	18.0%	51	24	47.0%	47	22	47.0%
To check for syphilis	27	4	15.0%	22	3	14.0%	51	24	47.0%	47	19	40.0%

(Continued)

TABLE 3 (Continued)

	Baseline						Endline					
Outcomes	Control			Intervention			Control			Intervention		
To check blood sugar levels	27	7	26.0%	22	3	14.0%	51	19	37.0%	47	18	38.0%
To see if the blood of the mother and baby are compatible (rhesus factor)	27	2	7.0%	22	2	9.0%	51	1	2.0%	47	4	9.0%
To conduct thyroid (TSH) tests	27	0	0.0%	22	0	0.0%	51	4	8.0%	47	5	11.0%
Knowledge of COVID-19: 3 symptoms, 3 precautions, and 1 vulnerable group	0	na		0	na		144	6	4.2%	127	19	15.0%
ANC visits at the right time for her gestational age	158	28	17.7%	154	37	24.0%	144	44	30.6%	127	34	26.8%

ANC, antenatal care; IQR, interquartile range; na, not applicable; SD, standard deviation; TSH, thyroid stimulating hormone.

dietary diversity for pregnant women and children in rural India (44, 45) and for pregnant women in Nepal (46). Unfortunately, this was not feasible in the context of COVID-19. Health systems strengthening to improve the supply and distribution of IFA and quality of ANC, plus community engagement may help to increase trust in ANC and create an enabling environment to address anemia, especially if harmful gender and social norms can be tackled at the community level (12, 14, 38, 47).

In contrast to Galloway's review, which found that 10% of women reported that they stopped taking IFA due to side effects (48), at the endline, we found that ~3% of respondents (and 27–31% of non-compliant women) cited side effects as their reason for not taking IFA. Although counselors were trained on strategies to manage side effects, this could receive more focus in future interventions. There is potential to include targeted advice about addressing side-effects of IFA in Ministry of Health revisions to the ANC guidance.

Our results also showed conflicting impacts on diets. While dietary diversity did not change, consumption of iron-rich food (meat, fish, or green leafy vegetables) increased among women in the intervention arm compared to the control. The lack of effect on overall dietary diversity may be explained by the substitution of foods, for instance, if meat is substituted for other vegetable-based foods. Additionally, households may have "channeled" meat to pregnant women, as was found in a trial of PLA women's groups in Nepal, which demonstrated increased odds of pregnant women consuming more animal–source foods than their household head in intervention relative to control areas (46).

Women were also more likely to enact behaviors to increase the bioavailability of iron in food in the intervention arm. Process evaluation data showed that the advice not to drink tea within 1 h of meals and to combine green leaves and pulses with sources of vitamin C (e.g., lemon) during meals was novel and interesting for women and that these actions were within their control (38). Similarly, knowledge of COVID-19 symptoms, precautions, and vulnerability, was significantly higher at endline in intervention (15%) than in control (4.2%). This may also be because the information was new and relevant. Innovative, practical, and low-cost strategies for pregnant women and their families are necessary to maintain family and community focus on preventing anemia.

Women appeared to be less able to change ANC (and IFA) access which depended on others' support. Some advice, which was sent via WhatsApp messages, was well received. This suggests that the platform of intervention delivery should be one that is most familiar and easy to use for women and their families. mHealth messaging to remind women about dietary and supplement intake during their pregnancy (30, 31, 49) combined with participatory problem-solving with families and communities might enable women to access ANC and IFA.

Meaning of the study: possible explanations and implications for clinicians and policymakers

Our trial of an mHealth virtual counseling intervention showed limited benefits to IFA compliance and dietary intake in pregnancy in a region of Nepal with a high burden of anemia where women have low literacy levels and limited access to mobile devices. Unreliable/inaccessible mobile phone networks and lack of confidence in the use of mobile devices impeded the implementation of our intervention, and some women did not have the agency to move to areas with better reception or to speak freely in front of family members (38). Moreover, engaging family members was difficult because they were often away

TABLE 4 Intervention effect on a) the primary, secondary and exploratory outcomes and b) the primary outcome by baseline compliance.

(a) Intervention effect on the primary and secondary outcomes	Adjusted for baseline IFA and gravida								
Primary outcome	Odds ratio	Lower 95% CI	Upper 95% CI	*p*	*n*	Marginalized difference in proportion	Lower 95% CI	Upper 95% CI	*n* for marginal effect
Compliance with recommended iron and folic acid tablet (IFA) intake	1.33	0.75	2.35	0.334	271	0.05	−0.05	0.15	299
	Adjusted for baseline outcome value (where available), baseline IFA and gravida								
Secondary outcomes (counts)	Coefficient (difference)	Lower 95% CI	Upper 95% CI	*p*	*n*				
Dietary diversity	0.19	−0.15	0.54	0.272	271				
Knowledge of iron-rich foods	0.96	0.50	1.42	<0.001	271				
ANC visits between baseline and endline	0.02	−0.15	0.20	0.81	271				
Binary secondary outcomes	Odds ratio	Lower 95% CI	Upper 95% CI	*p*	*n*	Marginalized difference in proportion	Lower 95% CI	Upper 95% CI	*n* for marginal effect
Consumption of intervention-promoted foods	1.81	1.08	3.02	0.023	271	0.13	0.02	0.24	298
Practicing one or more methods to enhance iron bioavailability, including avoiding tea close to meals	4.41	1.23	15.83	0.023	271	0.08	0.01	0.16	298
Exploratory outcomes	Odds ratio	Lower 95% CI	Upper 95% CI	*p*	*n*	Marginalized difference in proportion	Lower 95% CI	Upper 95% CI	*n* for marginal effect
Understanding of why blood tests are taken at antenatal check-ups (among those who had blood tests)	1.93	0.27	13.93	0.513	35	0.11	−0.22	0.44	48
Knowledge of COVID-19 symptoms, precautions, and vulnerability	4.06	1.56	10.54	0.004	271	0.11	0.03	0.20	299

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TABLE 4 (Continued)

(b) Intervention effect on the primary outcome by baseline compliance	Adjusted for gravida									
Disaggregated analyses for women complying and not complying at baseline	Odds ratio	Lower 95% CI	Upper 95% CI	*p*	*n*	Marginalized difference in proportion	Lower 95% CI	Upper 95% CI	*n* for marginal effect	*p*-value for interaction between IFA compliance at baseline and study arm[a]
Women taking IFA on 12/14 days at baseline	0.84	0.37	1.90	0.675	147	−0.03	−0.16	0.10	159	0.14
Women not taking IFA on 12/14 days at baseline	2.04	0.90	4.64	0.088	124	0.14	−0.01	0.29	140	

[a]Interaction between IFA compliance at baseline and study arm based on the model adjusting for gravida only.
ANC, antenatal care; COVID-19, coronavirus disease 2019; CI, confidence interval; IFA, iron folic acid.

from home during the day, and/or engaging via the small screen of the tablet was challenging (38). Our findings are generalizable to other areas of South Asia where women may have access to smartphones but have limited skills in how to use them and low levels of agency. The intervention might have more application in contexts where there is better mobile coverage, women routinely use smartphones for video calls, and women's families are enabled to support them.

Our mHealth virtual counseling intervention did not improve IFA compliance, dietary diversity, or ANC access but did improve pregnant women's dietary knowledge and some dietary practices. This may be due to a lack of access to IFA, the need for family and community support, and the side effects of IFA.

Strengths and weaknesses of the study

Our study implemented a highly contextualized intervention, which was informed by detailed, mixed-methods research with potential participants, and used a rigorous randomized controlled trial design to evaluate impact. We achieved high fidelity in implementation despite the logistical challenges of scheduling and delivering a synchronously delivered, novel mHealth virtual counseling approach and achieved satisfactory levels of follow-up despite COVID-19 restrictions still being in place during implementation. We implemented a detailed and rigorous process evaluation to understand the effect of our intervention which has been reported elsewhere (38). Our study is among the first to report the costs of an mHealth virtual counseling intervention in LMICs.

Our study has some limitations. Due to the government IFA provision beginning in the fourth month of pregnancy, we were not able to begin our intervention in early or prepregnancy despite this being a potentially good approach. Our outcomes were all self-reported, which is subject to respondent bias. For example, most women recalled taking IFA daily or not at all, but this could be subject to bias in recall. We could not measure hemoglobin due to COVID-19 physical contact restrictions. Due to COVID-19, our timeline for intervention was limited. The short time gap between counseling sessions and the primary outcome measurement meant the intervention had limited time to affect behaviors. Given that IFA compliance over a 14-day period was >70% in both study arms at the endline future studies should be powered for modest impacts and could target starting IFA earlier in pregnancy.

Dialogical counseling encouraged women to strategize with the counselors, but engaging family members proved difficult (38). Counselors had to make multiple phone calls to pregnant women to arrange virtual counseling sessions (38) which increased the cost and decreased the feasibility of the intervention. Some women required multiple visits from researchers to learn to use the mobile device, which made the intervention logistically challenging (38). Frustrations with these intervention processes may have led to a higher loss of follow-up in the intervention group than in the control.

Unanswered questions and future research

Given the modest effects seen, future studies should test integrated complex interventions at the health system, community, family, and

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individual levels to promote problem-solving and develop enabling environments to address maternal anemia. Health system strengthening could improve IFA supply and distribution, and enhanced community engagement and gender transformative interventions are required to address community barriers to ANC and IFA compliance. Given the relatively high short-term compliance in both intervention and control arms, future work could investigate whether compliance is sustained throughout pregnancy and, if not, how to maintain it. The intervention was done mid-pregnancy. It is conceivable that beginning counseling periconceptually or during

TABLE 5 Fully adjusted analyses of (a) intervention effect on the primary, secondary, and exploratory outcomes, and (b) intervention effect on the primary outcome by baseline compliance.

(a) Intervention effect on outcomes	Adjusted for baseline IFA, gravida, education, age of pregnant woman, gestational age at follow-up								
Primary outcome	Odds ratio	Lower 95% CI	Upper 95% CI	*p*	*n*	Marginalized difference in proportion	Lower 95% CI	Upper 95% CI	*n* for marginal effect
Compliance with recommended iron and folic acid tablet (IFA) intake	1.31	0.73	2.35	0.372	265	0.05	−0.06	0.15	277
	Adjusted for baseline outcome (where available), baseline IFA, gravida, education, age of pregnant woman, gestational age at follow-up								
Secondary outcomes (counts)	Coefficient (difference)	Lower 95% CI	Upper 95% CI	*p*	*n*				
Dietary diversity	0.21	−0.14	0.56	0.24	265				
Knowledge of iron-rich foods	1.06	0.59	1.52	<0.001	265				
ANC visits between baseline and endline	0.04	−0.13	0.21	0.648	265				
Binary secondary outcomes	Odds ratio	Lower 95% CI	Upper 95% CI	*p*	*n*	Marginalized difference in proportion	Lower 95% CI	Upper 95% CI	*n* for marginal effect
Consumption of intervention-promoted foods	1.91	1.13	3.22	0.015	265	0.15	0.03	0.26	277
Practicing one or more method to enhance bioavailability including avoiding tea close to meals	4.59	1.26	16.74	0.021	265	0.09	0.01	0.17	277
Exploratory outcomes	Odds ratio	Lower 95% CI	Upper 95% CI	*p*	*n*	Marginalized difference in proportion	Lower 95% CI	Upper 95% CI	*n* for marginal effect
Understanding of why blood tests are taken at antenatal check-ups (among those who had blood tests)	3.20	0.35	29.21	0.302	35	0.18	−0.13	0.50	48
Knowledge of COVID-19 symptoms, precautions and vulnerability	4.25	1.61	11.27	0.004	265	0.11	0.04	0.19	277

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TABLE 5 (Continued)

(b) Intervention effect on the primary outcome by baseline compliance	Adjusted for baseline IFA, gravida, education, age of pregnant woman, gestational age at follow-up									
Disaggregated analyses for women complying and not complying at baseline	Odds ratio	Lower 95% CI	Upper 95% CI	*p*	*n*	Marginalized difference in proportion	Lower 95% CI	Upper 95% CI	*n* for marginal effect	*p*-value for interaction between IFA compliance at baseline and study arm[a]
Women taking IFA on 12/14 days at baseline	0.93	0.40	2.18	0.871	144	−0.01	−0.14	0.12	149	0.225
Women not taking IFA on 12/14 days at baseline	1.78	0.77	4.12	0.179	121	0.11	−0.05	0.27	128	

[a]Interaction between IFA compliance at baseline and study arm based on a model adjusted for gravida, education, age of pregnant woman, and gestational age at enrolment.
ANC, antenatal care; COVID-19, coronavirus disease 2019; CI, confidence interval; IFA, iron folic acid.

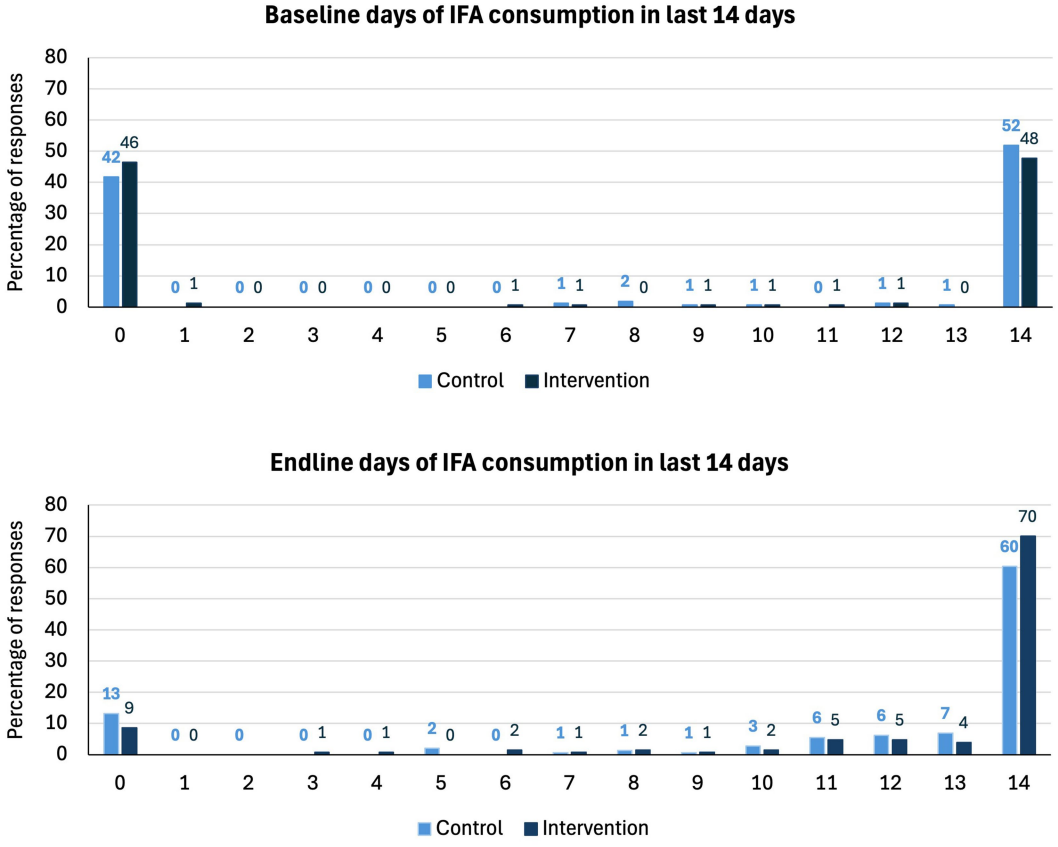

FIGURE 2
Bar chart of the number of days of IFA consumption in the last 14 days by arm at baseline and endline by trial arm.

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TABLE 6 Reasons for not taking iron and recall of action plans cited by pregnant women.

Reasons for not taking IFA cited by the woman	Control baseline *n* = 66		Control endline *n* = 22		Intervention baseline *n* = 71		Intervention endline *n* = 13	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Didn't have time to go to health facility	14	21	11	50	10	14	5	38
Last time I took iron tablets in pregnancy I got side effects	2	3	6	27	3	4	4	31
The woman ran out of iron tablets	0	0	1	5	1	1	1	8
Doctor advised not to take IFA	0	0	0	0	0	0	1	8
There was no problem so did not see the need for IFA	0	0	0	0	0	0	1	8
Went to parental home	0	0	0	0	0	0	1	8
Did not take IFA due to Ramadan	0	0	1	5	0	0	1	8
Planning to take later in pregnancy but it is not time to take them yet	45	68	1	5	51	72	0	0
Health post ran out of IFA/did not provide IFA, or health worker unavailable	3	5	2	9	2	3	0	0
Not interested in taking iron tablets	0	0	0	0	2	3	0	0
Didn't know the importance of (IFA)	0	0	1	5	0	0	0	0

Recall of action plans by women in the intervention arm who could remember making an action plan	Recall of first virtual counseling *n* = 102		Recall of second virtual counseling *n* = 96	
Following advice related to dietary and/or IFA intake:	Frequency	%	Frequency	%
Drinking adequate water	86	84	81	84
Getting ANC check-up	80	78	79	82
Regular consumption of IFA tablets	71	70	76	79
Importance of Vitamin C and consumption of iron-rich foods	54	53	69	72

(Continued)

TABLE 6 (Continued)

Recall of action plans by women in the intervention arm who could remember making an action plan	Recall of first virtual counseling $n = 102$		Recall of second virtual counseling $n = 96$	
Dealing with weakness during pregnancy	23	23	25	26
Dealing with gastritis (indigestion) during pregnancy	25	25	23	24
Dealing with loss of appetite during pregnancy	10	10	12	13
What to do when I dislike certain foods	9	9	6	6
Reducing or stopping tea drinking	13	13	5	5
Eat larger servings and more often	0	0	2	2
Taking lemon	2	2	1	1
Soak pulses (Bengal gram)	1	1	1	1
Others (eat beetroot/pickles with meals/take sag and dairy)	0	0	3	3
Take calcium supplements/deworming	0	0	2	2
Dealing with piles	1	1	0	0
Actions related to other problems experienced by pregnant women	Frequency	%	Frequency	%
Dealing with back pain during pregnancy	13	13	14	15
Leg cramps/pain during pregnancy	6	6	10	10
Avoid lifting/carrying heavy loads	9	9	4	4
Get an ultrasound	0	0	3	3

ANC, antenatal care; COVID-19, coronavirus disease 2019; IFA, iron folic acid.

early pregnancy might enhance the effect. Since the anemia burden persists in Nepal despite relatively high IFA compliance, future studies need to identify other potential biological drivers of anemia in this setting.

Conclusion

The VALID trial is the first randomized controlled trial to test the impact of two dialogical counseling sessions delivered via video call on a mobile device loaned to pregnant women in the rural plains of Nepal. The intervention improved knowledge and consumption of promoted iron-rich foods, adoption of dietary behaviors to increase iron bioavailability, and knowledge of COVID-19 symptoms, precautions, and vulnerability. There was no significant increase in compliance with IFA, dietary diversity, or the number of ANC visits between baseline and endline in the intervention, compared with the control arm, which received routine ANC.

Our research shows that virtual counseling with women alone can improve some health behaviors but is not sufficient to bring changes in behaviors that are contextually driven and often rely on family support in this context. Virtual (video call) counseling informed by formative research is a useful supplement to ANC to improve knowledge among pregnant women about how to increase the bioavailability of iron and iron-rich foods and could be included in multicomponent interventions to address anemia in pregnancy.

Future interventions to address drivers of anemia in pregnancy could supplement virtual counseling with asynchronously delivered mHealth approaches, home visits among hard-to-reach groups, and gender-transformative community-focused interventions.

Data availability statement

The datasets presented in this study can be found in the UCL research data repository. Deidentified individual participant data that underlie the findings in this article (and data dictionaries) can be found here: https://doi.org/10.5522/04/27077962.v1.

Ethics statement

This study involving human participants was approved by Nepal Health Research Council (570/2021) and UCL research ethics committee (14301/001). The study was conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants themselves and, in the case of minors, by participants' legal guardians/next of kin.

Author contributions

NS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration,

Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. SaB: Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. SG: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Visualization, Writing – review & editing. SS: Investigation, Project administration, Supervision, Writing – review & editing. JM: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. BT: Investigation, Supervision, Writing – review & editing. BB: Investigation, Supervision, Writing – review & editing. SY: Investigation, Writing – review & editing. AA: Conceptualization, Project administration, Supervision, Writing – review & editing. AC: Conceptualization, Formal analysis, Methodology, Writing – review & editing. HH-B: Conceptualization, Methodology, Writing – review & editing. HH-F: Conceptualization, Methodology, Writing – review & editing. RP: Investigation, Writing – review & editing. SuB: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – review & editing. SH: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2024.1464967/full#supplementary-material

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Changing maternal and child nutrition practices through integrating social and behavior change interventions in community-based self-help and support groups: literature review from Bangladesh, India, and Vietnam

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Introduction: Self-help groups (SHGs) and Support Groups (SGs) are increasingly recognized as effective mechanisms for improving maternal and young child nutrition due to their decentralized, community-based structures. While numerous studies have evaluated the outcomes and impact of SHGs and SGs on nutrition practices, there remains a gap in the literature. To address this, we conducted a literature review to examine the role of SHGs and SGs in improving health and nutrition outcomes, focusing on marginalized women, especially pregnant and lactating women (PLW), in India, Bangladesh, and Vietnam, with an emphasis on programs supported by the international non-governmental initiative, Alive & Thrive.

Methods and materials: We conducted a literature review to assess various models, summarizing findings from 34 documents, including research studies, evaluation reports, program materials, strategies, annual reports, work plans, and toolkits. Relevant information from these documents was extracted using predetermined forms.

Results: In India, the models used SHGs with 10–20 women, federated into larger village and district organizations. Bangladesh and Vietnam SGs have similar structures but with local leaders and committees playing key roles. In all three countries, interventions aimed to improve health and nutrition practices through social behavior change (SBC) interventions, including peer-to-peer learning, interpersonal communication, home visits, and community meetings. Outcomes of the interventions showed that SHG members had increased knowledge of breastfeeding, complementary feeding, and improved dietary diversity compared to non-SHG participants. Interventions helped improve infant and young child feeding practices. Common challenges included sustaining

the SHGs, ensuring adequate participation, socio-cultural barriers, and logistical difficulties in reaching PLW in remote areas. Limited time for health topics during SHG meetings and the dissolution of older SHGs were also significant issues.

Conclusion: SHG and SG models demonstrate success in improving health and nutrition outcomes but face challenges in scale, sustainability, and participation. Integrating nutrition-focused SBC interventions into SHGs and SGs requires significant capacity building for technical and counseling skills. Ensuring comprehensive coverage and robust quality assessment during community-based rollouts is essential. To sustain these interventions, it is crucial to prevent group dissolution, allow time for maturation, and secure strong stakeholder engagement and political support.

KEYWORDS

breastfeeding, community-based interventions, complementary feeding, maternal nutrition, self-help groups, social and behavior change, support groups

1 Introduction

The intergenerational effects and socio-economic costs of undernutrition are well known (1–5). Undernourished women face higher risks of mortality and conditions like anemia, which negatively impact future generations (6, 7). Poor diets, disease, food insecurity, inadequate care, and socio-cultural factors are key causes of undernutrition (8, 9). Women in low and middle-income countries (LMICs), especially in Asia, often face inadequate dietary diversity and low food consumption (10–13). Their diets, especially in low-income settings, are largely based on starches, lacking in nutrient-rich foods (14, 15).

Undernourished children under five face higher risks of disease, lower cognitive ability, and reduced productivity as adults. Children in LMICs in Asia suffer from poor dietary diversity and suboptimal breastfeeding, leading to growth faltering and stunting (16–21). While breastfeeding rates have improved in Bangladesh, India, and Vietnam, early initiation of breastfeeding remains low (22). Various factors like income, education, gender norms, and exposure to nutrition counseling influence breastfeeding practices and overall diet quality for women and children (8, 23–29).

Household behaviors like food distribution, eating preferences, hygiene, education, lack of safe drinking water and health service uptake also contribute to undernutrition (30–35). Social behavior change (SBC) interventions have shown positive results in addressing these issues by influencing behaviors at household, community, and policy levels (31–35). Governments and partners are focusing on strengthening community outreach and capacity building to address these behavioral causes (36–39).

Self-Help Groups (SHGs) and Support Groups (SGs) have emerged as platforms for socio-economic empowerment in low-income communities, especially among women (40–43). There is increasing evidence of their potential to improve health and nutrition outcomes, particularly maternal and infant nutrition (44–49). This paper synthesizes information from models integrating SBC into SHGs and SGs in India, Bangladesh, and Vietnam, focusing on the design, platforms, and challenges.

In India, Jeevika, started by the Bihar government with support from the World Bank in 2006, evolved to include health and nutrition interventions. Rajiv Gandhi Mahila Vikas Pariyojana (RGMVP) in Uttar Pradesh, launched in 2012, also integrated nutrition into its women's empowerment program. Both the programs were initially meant to link SHGs with financial institutions and eventually evolved to include SBC interventions on health and nutrition. In Bangladesh, the Livelihood Improvement of Urban Poor Communities Project (LIUPCP), implemented from 2017 to 2022, organized poor urban communities to address climate resilience and livelihoods along with health and nutrition. Vietnam's Infant Young Child Feeding (IYCF) SG model, developed by Alive & Thrive from 2011 to 2014, focused on reaching ethnic communities in remote areas with maternal and child nutrition information.

While numerous studies have evaluated the outcomes and impact of SHGs and SGs on nutrition practices, there is a lack of comprehensive reviews examining their role in improving health and nutrition outcomes for marginalized women in Asia. To fill in the literature gap, we conducted this literature review to examine the role of SHGs and SGs in improving health and nutrition outcomes, focusing on marginalized women, especially pregnant and lactating women (PLW), in India, Bangladesh, and Vietnam, with an emphasis on programs supported by a non-governmental initiative, Alive & Thrive.

2 Methods and materials

2.1 Selection of models

The criteria for the selection of models for this review included: (a) implemented in South or Southeast Asia; (b) integrated nutrition services with SHGs or SGs; (c) use of SBC interventions targeting improvement in maternal and child nutrition; (d) involvement of Alive & Thrive either as a technical partner, implementor, or supporting the development partners or governments in any capacity. We have not published any review protocol for this study.

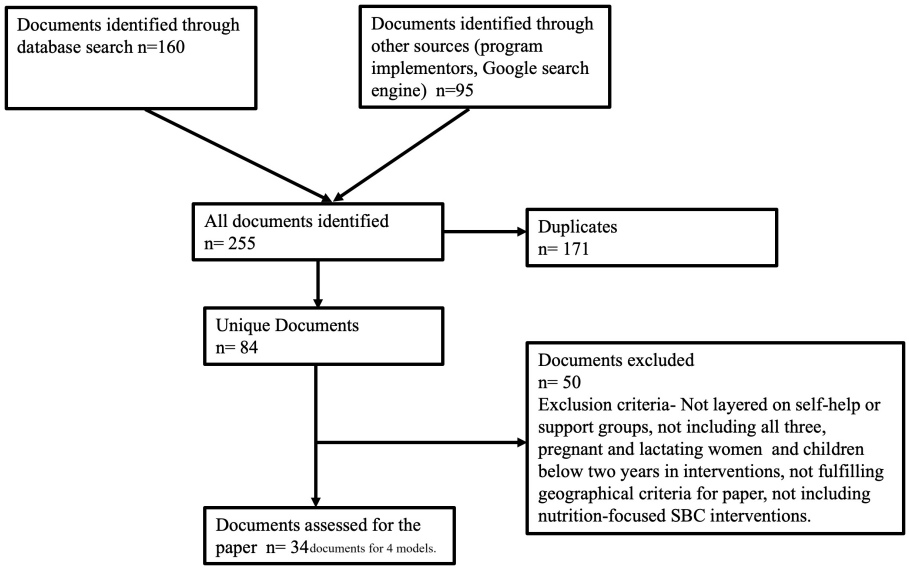

FIGURE 1
Prisma diagram.

2.2 Literature selection

We reviewed the literature to extract information on the selected models and understand how SBC interventions were integrated into the SHGs and SGs. Based on the researchers' language proficiency, we limited our search to English-language documents. The documents included research studies, evaluation reports, program materials, strategies, annual reports, work plans, and toolkits. We placed no restrictions on the publication year. We searched for documents and conducted literature review using three different methods denoted by PRISMA (Figure 1). These included a database search (PUBMED) to select studies on the models using specific key phrases, gathering program materials solicited through program implementors and technical partners, and undertaking a keyword search using Google's search engine to access gray literature and online program materials relevant to the models. We used the same keywords to search through the database and search engine to maintain consistency. We chose the keywords based on the topic, context and models (as defined by the selection criteria). The abstracts obtained through PUBMED were reviewed and selected for further review. The selected literature underwent another round of assessment against the mentioned criteria for a final selection. The documents collected through means other than database search was also assessed for relevance before being admitted for full-length review. The search keywords included following phrases "SHGs in LMICs," "Health and nutrition integration with SHGs," Self-Help Groups in India," "Self-Help Groups in Bangladesh," "Support Groups in Vietnam," "Support Groups for IYCF," "Jeevika," Rajiv Gandhi Vikas Pariyojana," "Livelihood improvement for urban poor communities in Bangladesh," "Support Group Models for Nutrition," "Nutrition social and behavior change."

2.3 Data items, charting process and synthesis

The whole team discussed the development of key contents for the information extraction forms. The extraction forms include information on methods, platforms, contents, and stakeholders for the Social and Behavior Change Communication (SBC) interventions; program coverage, targeting, and delivery metrics for the training of facilitators who delivered the interventions; framework for integrated program implementation and support; and intervention outcomes.

The lead author extracted information from the selected materials using the defined checklists. Results from the extraction were summarized in tables. The tables, figures, and results were circulated to all authors for review to ensure completeness and accuracy before finalization.

Synthesis of findings were drafted and finalized based on the discussion among all authors.

3 Results

Starting with 255 identified documents (Figure 1), the lead author reviewed and excluded 171 due to duplication, and an additional 50 because they did not focus on SHGs or SGs, targeted different groups, did not include SBC interventions, or were from regions outside Asia. The list then was circulated to other co-authors to check for completeness. The documents included for synthesis were research studies in peer-reviewed journals and on other platforms ($n = 9$), evaluations and outcome studies ($n = 5$), and program materials such as program briefs and outcome documents ($n = 5$), strategies ($n = 4$), work plans ($n = 2$), annual reports ($n = 5$), and toolkits ($n = 4$).

TABLE 1 Methods and platforms used for social and behavior change communication (SBC) interventions.

	Jeevika (India)	RGMVP (India)	LIUCPC (Bangladesh)	IYCF SG (Vietnam)
Duration of the intervention (start and end date)	Pilot: 2012–2016 Implementation: 2016–2023	2011–2018	2018–2024	November 2011–November 2014
Methods and platforms used for social and behavior change communication	IPC: SHG meetings, home visits	IPC: SHG meetings, home visits	IPC: PG meetings, home visits, mothers' SGs	IPC: SG meetings with specific topics based on the need of target groups
	Mid-media: wall stickers, posters	Mid-media: rallies, oath-taking, songs in local dialect, wall writing	Mid-media: wall stickers, community events, pamphlets and posters	Mid-media: posters, pamphlets, counseling cards
	Mass-media: a 15-episode drama series aired on YouTube, a digital tool, video shows	Mass-media: video shows	Mass-media: television commercials	Community engagement: involving participants for peer-to-peer support, sharing experiences with each other, food demonstrations, breastfeeding demonstrations
	Community engagement: Cooking and feeding demonstrations, special nutrition drives, involving community members in spreading messages	Community engagement: Quizzes in local dialects, night meetings, special nutrition drives, involving community members in spreading messages	Community engagement: Participation of community members in spreading messages, special drives, developing women and nutrition-friendly business corners, nutrition drives on selected days promoting health and nutrition	Strengthening existing government structures: Working with existing village/commune and primary health centers to strengthen service provision, monitoring and evaluation, and discussions on challenges and course corrections
	Strengthening existing government structures: Community-based events and village health and sanitation day, distribution and production of take-home ration	Strengthening existing government structures: Community-based events and village health and sanitation day	Advocacy: Local governments and organizations providing nutrition services in urban slums, MoHFW	Advocacy: Village heads, local government structures, policymakers at the national level
	Advocacy: With village communities at the local level, local government structures, policymakers	Advocacy: With village communities and village heads, local government structures		
SBC interventions and platforms	Discussions during SHG meetings, line listing of PLW for targeted counseling, targeted home visits for interpersonal counseling, community events, rewards and recognition, support for government instituted CBEs, production and supply of THR, community mobilization for VHSND	Discussions at SHG meetings, counseling through home visits, community, community events, recognition and rewards, nutrition drives and campaigns on maternal and child nutrition, support for government-instituted CBEs	Individual counseling, nutrition education of group members, community mobilization, home visits	Categorizing PLW in three diverse groups, SG meetings, Individual and group counseling, cooking demonstrations, asking each SG member to recall messages from the previous meeting
Key thematic areas for messaging	Antenatal & postnatal care, dietary diversity for PLW, EIBF, EBF, age-appropriate and timely complementary feeding, IFA & Vitamin A supplementation, Integration Child Development Services & other government entitlements for pregnant women and children, kitchen gardens, hygiene practices, handwashing, health risk fund for SHG members	Antenatal & postnatal care, Maternal nutrition during pregnancy & lactation period, EIBF, EBF, debunking myths around breastfeeding, ANC	Antenatal and postnatal care, husband's role during ANC, dietary diversity for PLW, dietary diversity for other primary group members, EIBF, EBF, complementary feeding, dietary diversity for children between 6 and 24 months, not feeding children processed and junk food, handwashing, hygiene, safe drinking water, and sanitation, and support needed by PLW for following recommended practices	Dietary diversity/nutrition adequacy for PLW, EIBF, EBF, breastfeeding techniques, complementary feeding, dietary diversity for children, causes and effects of child malnutrition, significance of breastfeeding, complementary feeding, family & community support required by women for recommended practices
Key actors in nutrition and health service delivery	Nutrition resource persons, MRPs (core block and district staff of Jeevika, community mobilizers, village health sub-committee members, block health, nutrition, and sanitation integrator)	RGVMP staff, community resource persons (Swasthya Sakhi), community leaders from SHGs and federated groups	Socio-Economic and Nutrition Facilitator from LIUPCP, nutrition experts, leaders of primary and federated groups	Community-based workers, commune health staff & provincial and district health staff, members of SGs

(Continued)

TABLE 1 (Continued)

	Jeevika (India)	RGMVP (India)	LIUCPC (Bangladesh)	IYCF SG (Vietnam)
Nature of non-SBC interventions	Kitchen garden, livestock rearing, sanitation, livelihood development	Kitchen gardens, sanitation, livelihood development	Conditional cash and food transfer	–
			Nutrition voucher support for adolescent girls	
			Screening of children for malnutrition and referral	
Key departments (convergence) and engagement	Health, ICDS, Lohiya Swacch Bharat Abhiyan agriculture and animal husbandry departments, public distribution system	Health and integrated child development services, agricultural departments	City council, city-level health and nutrition service providers, organizations working on providing sanitation, housing, and other services	Provincial departments of health and reproductive health centers, district health center/commune health center

SBC, Social and Behavior Change; IPC, Interpersonal communication; SG, Support Groups; SHGs, Self Help Groups; MoHFW, Ministry of Health and Family Welfare; PLW, Pregnant and Lactating Women; EIBF, Early Initiation of Breastfeeding; EBF, Exclusive Breastfeeding; IFA, Iron and Folic Acid; ANC, Antenatal Care; MRPs, Master Resource Persons; LIUPCP, Livelihood Improvement of Urban Poor Communities Project; RGMVP, Rajiv Gandhi Mahila Vikas Pariyojana.

3.1 Structure and evolution of SHGs and SGs

Table 1 shows that Jeevika's structure includes SHGs with 10–12 members from poor, marginalized households, federated into village organizations and larger clusters. SHGs focus on financial savings, intra-group lending, and linking with banks (50). In 2016, Jeevika reached over seven million households, expanding to more than 10 million (51). Health and nutrition interventions were introduced in 2013, supported by community mobilizers who facilitated SHG meetings and health-related activities. Dedicated nutrition resource persons and Master Resource Persons provided capacity building at the village level, with district-level managers overseeing health, nutrition, and sanitation programs (52).

RGMVP SHGs also followed a community-centric approach, comprising 10–20 women from marginalized groups. The women were trained for 6 months and then federated into larger organizations. RGMVP focused on socio-economic empowerment through financial inclusion, banking, livelihood, and health services. Nutrition services were introduced through trained mobilizers, with additional focus on maternal and child nutrition (Table 1).

In Bangladesh, the LIUPCP model features three levels of structure. Primary groups of 15–20 members, mostly women, form community development committees, which are further grouped into clusters. These committees focus on nutrition discussions led by designated facilitators (Table 1).

Vietnam's IYCF SG model differs by drawing members from existing village structures. Facilitators, including village health workers and Women's Union members, lead groups focused on breastfeeding, complementary feeding, and community support, targeting pregnant women, mothers, and caregivers in rural areas.

3.2 Design of nutrition and health-specific SBC interventions

Table 1 also shows that the SBC interventions targeted pregnant women, mothers of children up to 23 months, families, and caregivers. All four models undertook a stakeholder mapping exercise and designed the SBC interventions around the individual, community, program, and policy levels (Figure 2). The three SHG models used a mix of interpersonal communication (IPC), mass media, mid-media, and digital approaches, while the IYCF SG model relied mainly on IPC and on-site demonstrations, using tools like counseling cards and mother-child booklets. SHG contact points included home visits, community events, and nutrition drives, while IYCF SGs focused on village meetings (Table 1).

Coordination with government departments was essential across the SHG and SG models, incorporating SBC, non-SBC nutrition, and nutrition-sensitive interventions. Common methods included storytelling, cooking demonstrations, and peer-to-peer support (Table 1).

Jeevika introduced innovative tools like Samvad Kunji, a digital media tool with QR codes, and food group stickers to monitor dietary diversity. RGMVP used visual maps to help women visualize concerns and plan actions (Table 1). Both programs aimed to shift social norms around maternal nutrition, involving families and communities in the process (53–58).

3.3 Coverage and adequacy

Table 2 shows that all models aimed to reach pregnant and lactating women (PLW) and key influencers through SBC interventions. Since not all PLW were SHG members, Jeevika used a two-step approach, identifying PLW within SHG households through members and then reaching them via home visits and community events (53, 54). RGMVP used village maps to track PLW and their needs, combining this with joint home visits. LIUPCP employed similar methods, while the Vietnam IYCF SG model involved village heads to boost community participation and attendance (54, 58, 59).

In 2022, Jeevika targeted 1.82 million mother-child dyads, reaching 45% of PLW in Bihar. LIUPCP in Bangladesh reached over 1.39 million dyads, and Vietnam's IYCF SGs covered 33,000 PLW across nine provinces (53, 54, 58). All models used multiple touchpoints, including weekly and monthly meetings, home visits, and community events to deliver consistent nutrition messages.

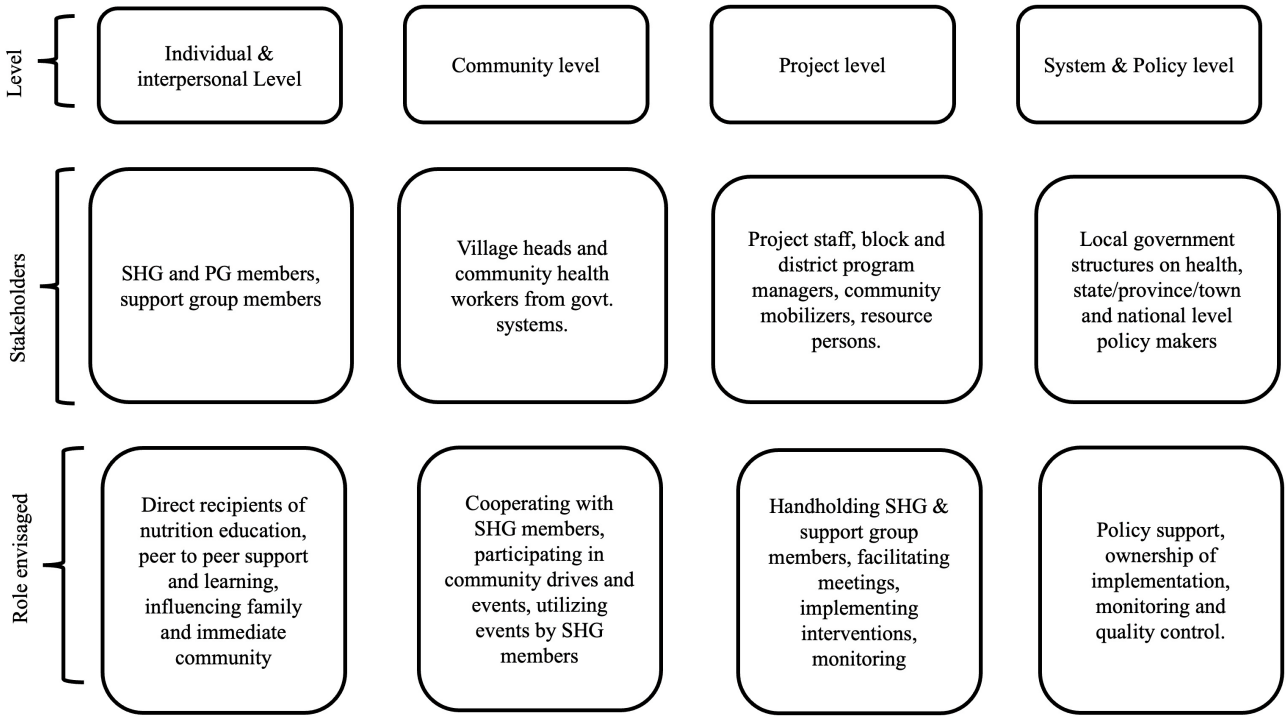

FIGURE 2
Different levels of stakeholders.

For example, Jeevika reached each mother 16 times over 6 months, while Vietnam's IYCF model had monthly meetings and occasional community gatherings.

Community mobilization and raising awareness of government nutrition services were central to all models. SHGs played a key role in encouraging participation and promoting nutrition interventions in collaboration with government programs. LIUPCP also organized urban communities to demand services through town federations, while Vietnam's IYCF SG model coordinated efforts with local health systems (61, 62).

3.4 Processes and pathways

Table 3 shows that the models integrated SBC interventions into SHGs and SGs due to their strong outreach and mobilization platforms. SHGs target individuals and households in marginalized communities, making them suitable for health and nutrition-focused SBC efforts. In India, SHGs targeted rural poor populations, while in Bangladesh and Vietnam, urban poor and ethnic minorities in remote areas were reached. Prior evidence, local contexts, and formative studies guided the design of interventions, with models like Jeevika using socio-ecological and human-centered design approaches (Table 3).

Capacity building was key across all four models, employing a cascade training approach (53–58). Jeevika and RGMVP developed detailed training modules for community mobilizers, nutrition resource persons, and master resource persons (MRPs), combining classroom teaching with participatory methods like role plays and group discussions. By 2017, Jeevika trained 1,500 MRPs, 7,000 nutrition resource persons, and 80,000 community mobilizers, while RGMVP trained over 124,000 community resource persons (Table 3). LIUPCP and Vietnam's IYCF SGs also emphasized training facilitators to lead SBC efforts (62–64).

The models differed in support structures, with Jeevika having a clear ongoing support framework, including post-training assistance and monitoring. Supportive supervision was strong in the Vietnam IYCF SG and present in Jeevika and LIUPCP for nutrition components. Monitoring structures for health and nutrition were clearly defined in most models, except for RGMVP, which tracked improvements during IYCF campaigns. Quality assessment in Jeevika included mobile data collection and feedback mechanisms, while RGMVP tracked knowledge retention and practices in nutrition-focused campaigns (Table 3).

3.5 Outcomes, sustainability and scale-up

Table 4 shows that the primary goals of SHGs and SGs were to raise awareness of optimal maternal nutrition, IYCF practices, and government schemes, while improving health and nutrition among mother-child dyads. Outcomes showed that SHG members in Jeevika and LIUPCP had higher knowledge of breastfeeding and complementary feeding than non-members. RGMVP's nutrition campaigns also increased awareness, and Vietnam's IYCF SGs had better outcomes on breastfeeding knowledge. SHG families had higher rates of early breastfeeding initiation and exclusive breastfeeding. Jeevika improved dietary

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TABLE 2 Program coverage, targeting, and delivery metrics for the training of facilitators who delivered the interventions by country.

	Jeevika (India)	RGMVP (India)	LIUCPC (Bangladesh)	IYCF SG (Vietnam)
Coverage				
Number of SHG members and SG facilitators trained	1.02 million (2016–2023)	Over 10,000 (2011–2017)	139,060 (2018–March 2024)	1,500 (2011–2014)
Total number of PLW who received counseling	13.9 million (between 2016 and 2022)	NA	30,838	30,000
Targeted all relevant program participants (PW, LM with children below 24 months)	Y	Y	Y	Y
Additional direct program participants if any	N	Y	Y	N
Levels targeted				
Individual level	Y	Y	Y	Y
Community level	Y	Y	Y	Y
System/policy level	Y	Y	Y	Y
Inclusion non-SBC nutrition interventions	Y	Y	Y	N
Use of platforms				
Dedicated training of key actors for delivering nutrition interventions	Y	Y	Y	Y
Two or more platforms used	Y	Y	Y	Y
Three or more interactions with eligible participants from the first trimester of pregnancy till the child became 23 months old	Y	Y	N	Y
Periodic nutrition drives and special campaigns	Y	Y	Y	N
Convergence/coordination with other platforms for service delivery	Y	Y	Y	Y
Delivery				
Type of IEC/SBC materials used				
Print	Y	Y	Y	Y
Audio-visual	Y	Y	Y	N
Digital	Y	N	N	N
Measures to maintain message consistency (common materials developed; training provided to all concerned members)	Y	Y	Y	Y
BCC materials available to beneficiaries after visits/interventions	Y	Y	Y	Y

SHG, Self Help Group; SG, Support Group; PLW, Pregnant and lactating women; PW, Pregnant women; LM, Lactating mothers; FM, Family members; Y, Yes; N, No; NA, Information not available among reviewed literature; SBC, Social and Behavior Change; IEC, Information, Education and Communication; BCC, Behavior Change Communication.

diversity, while RGMVP showed better exclusive breastfeeding rates and increased consumption of Iron Folic Acid (IFA) (60, 64–70).

Sustainability and scale-up showed mixed results. Jeevika expanded from 101 blocks to 300 blocks in Bihar, supported by the state government and the World Bank (70). It contributed to India's National Rural Livelihood Mission (NRLM), integrating food, nutrition, and health initiatives. RGMVP, active in 49 districts at its peak, saw a decline after donor support ended in 2018, though learnings informed future models (Table 4).

LIUPCP in Bangladesh, ending in 2024, proposed multisectoral coordination for sustained nutrition efforts, with some cities already operating independently. Vietnam's IYCF SG model scaled up successfully, covering 267 villages in nine provinces, supported by local government and partners like Save the Children and World Vision (Table 4). The model adapted to local investments for long-term sustainability (71–73).

3.6 Challenges

SHGs faced critical challenges including adequacy, sustainability, and quality assessment. Jeevika, RGMVP, and LIUPCP, initially focused on livelihood, poverty reduction, and financial inclusion, were not designed for health and nutrition

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TABLE 3 Framework for integrated program implementation and support.

	Jeevika (India)	RGMVP (India)	LIUCPC (Bangladesh)	IYCF SG (Vietnam)
Design				
Rationale for Integration	Nutrition is recognized as a driver for socio-economic and physical wellbeing; common factors between the underlying principles of integrated nutrition interventions and Jeevika; similarities between demographic profiles of target groups; similar overall goals; capacity for outreach; providing agency for women	There are similarities between the demographic profiles of target groups; existing structures and capacity for outreach; similar overall goals; recognition of nutrition as a driver for socio-economic and physical wellbeing; and providing agency for women	Similarities between demographic profiles of target groups; structures for outreach; increased risk of malnutrition due to growing inflation among urban poor; recognition of health and nutrition as a determinant of MPI; lack of health and nutrition services for urban poor; providing agency for women	Providing access to IYCF information for communities in hard-to-reach areas in their own localities; low prevalence of recommended IYCF practices among ethnic minorities; existence of healthcare systems and human resource with some existing knowledge on maternal and child nutrition providing agency to women; contextualizing interventions to local social norms and practices; create an enabling environment for breastfeeding
Evidence	Learnings from Parivartan (change); an initiative by PCI focused on comprehending the dynamics; processes; and effectiveness of BCC interventions in RMNCHN and sanitation interventions in community-based SHGs	Experiences from Society for Elimination of Rural Poverty; Andhra Pradesh on building institutions supported by poor communities	Learnings from the Urban Partnerships for Poverty Reduction project that demonstrated integration of nutrition services with poverty reduction program	Findings from two formative research studies conducted by A&T with support from a technical advisory committee with key stakeholders from UNICEF and the National Institute of Nutrition (NIN) and formative research on trials of improved practices with support from NIN and Ha Noi Medical University and existing studies
	Findings from previous assessment studies in Bihar: Study on IYCF; maternal nutrition; and hygiene practices conducted by A&T in collaboration with PCI; UNICEF; Care; Jeevika Bihar and other existing studies	Findings from formative research and trials of improved maternal nutrition; IYCF; and household sanitation and Hygiene practices in Uttar Pradesh conducted by A&T and other existing studies	Nutrition Survey to assess nutrition status and the prevailing knowledge; practices and nutritional status of children in poor settlements in City Corporations by and Municipalities by UNDP	
			City-Level Nutrition Context Assessment Narayanganj 2019 conducted jointly by A&T and UNDP; Study on understanding opportunities and challenges of delivering MIYCN services in urban areas and MNCH at facilities in Dhaka conducted by A&T and ICDDR; B	
Approach	Socioecological model; human-centered design approach	Socio-ecological model	Socio-ecological model	Behavior change communication combined with supportive supervision and strategic use of data
	Key considerations: evidence; fit with local contexts; gaps and opportunities across various levels for behavior change; existing structures of Jeevika; frequency of interaction; exposure; community participation; and multisectoral approach	Key considerations: local contexts; gaps; existing structures of RGMVP; community participation; and multisectoral approach	Key considerations: evidence; culturally sensitive; local contexts; opportunities across levels; primary and secondary causes of undernutrition; gender sensitivity; promotion of nutrition-focused budgeting; multisectoral approach; and role of local government	Key considerations: access to IYCF information; hard-to-reach areas; cultural sensitivity; localization of interventions; drivers of inadequate IYCF behaviors; social sphere of influence; linkages with existing women unions; village-level structures; and government health systems; the role of local government
Integration				
Training	Cadres: Community mobilizers; block HNS nodal HNS; members of village health sub-committee	Cadres: Community health volunteer (one from each SHG) called as Swasthya Sakhi; Meeting Sakhis and members of village organization	Cadres: Socio-economic nutrition facilitator community organizers; local government institutions (municipality and city corporation staff)	Cadres: Community-based workers acting as IYCF facilitators; district trainers

(Continued)

TABLE 3 (Continued)

	Jeevika (India)	RGMVP (India)	LIUCPC (Bangladesh)	IYCF SG (Vietnam)
	Materials developed: 20 sessions in 5 modules on health; nutrition; and sanitation covering technical and practical aspects	Materials developed: Modules on newborn and maternal health care; maternal; infant and young child nutrition	Materials developed: Modules on nutrition for field staff along with SBC components; training module on multisectoral urban nutrition to support CLMNCC	Materials developed: 2 training manuals-SG trainer manual and trainee manual
	Approach: cascade	Approach: cascade	Approach: cascade	Approach: cascade
	Mode: Use of classroom interactions; real-life examples; and supplementary materials	Mode: Classrooms; workshops; skits	Modes: classroom teaching	Modes: Classroom interactions; supplementary materials (21 counseling cards)
	Training partners: Jeevika technical support program (JTSP) led by PCI	Training partners: National Institute of Rural Development; Andhra Pradesh; A&T; India; PCI	UNDP's training partners: A&T; Bangladesh	Training partners: save the children
On-ground handholding support	Block HNS nodal person support community mobilizers and SHGs	–	–	Support by village heads
Supervision	MRPs; area and cluster coordinators as well as PCI staff members provided supervision over CMs			IYCF group facilitators were supervised by commune/district health center staff for every meeting; further the District Secretary supervises facilitators every 2 months; A&T staff also provides supervision. All supervisors across levels and staff members used a supportive supervision checklist
Monitoring	Mechanisms: Jeevika decision support system; monthly review meetings by block program managers	–	Mechanisms: Inclusion of MIYCN behavior indicators in LIUPCP project monitoring tool; decentralized review of implementation by community development committees and community development committee clusters	Mechanisms: Multilevel monitoring beginning from data collection by facilitators; proceeding to CHC level; district level; and province level with final reporting to A&T and NIN; Hanoi
	Use: Review of capacity building of MRPs; CMs; orientation of SHGs; mobilization for CBEs and households for kitchen gardens; occurrence of BCC interventions; occurrence of desired behaviors		Use: Review of SENF's performance; the orientation of PGs; the occurrence of planned BCC activities; and the occurrence of desired behavior	Use: Review of occurrence of activities; the occurrence of behaviors; household visits; need for improvement and challenges

RGMVP, Rajiv Gandhi Mahila Vikas Pariyojana; LIUPCP, Livelihood Improvement of Urban Poor Communities Project; IYCF, Infant and Young Child Feeding; BCC, Behavior Change Communication; PCI, Project Concern International; MIYCN, Maternal, Infant and Young Child Nutrition, Maternal Newborn and Child Health; ICDDR, International Center for Diarrheal Disease Research; SHG, Self Help Groups; SG, Support Group; SBC, Social and Behavior Change; CLMNCC, City-Level Multisectoral Nutrition Coordination Committee; JTSP, Jeevika Technical Support Unit; MRPs, Master Resource Persons; CBEs, Community Based Events.

interventions, requiring significant capacity building and new components, increasing the workload for community mobilizers.

SHGs had gaps in time allocation and meeting frequency. Jeevika's groups met weekly for about 30 min on health topics aside from training, while RGMVP had monthly meetings with similar time for health discussions. Meeting frequency varied, especially during harvest season. In Vietnam, IYCF SG meetings occurred monthly for PLW and bimonthly for others, with messages reviewed at subsequent meetings.

Sustaining SHGs proved challenging, with dissolutions reported for Jeevika and RGMVP, impacting HNS component implementation. Low meeting participation also hindered SBC interventions. Most women in Jeevika, RGMVP, and LIUPCP were not of reproductive age, leading to reliance on home visits and community events to reach PLW, which saw low attendance in some cases. Jeevika's assessment revealed some CMs lacked necessary skills, leading to refresher training.

The Vietnam IYCF SG model faces socio-cultural and economic barriers, with traditional practices and limited resources affecting adherence to recommended feeding practices. Remote areas struggle with healthcare access, and post-support from Alive & Thrive, reduced funding led to decreased meeting frequency. While a sustainability plan is in place, not all communities can fund activities beyond national program support.

3.7 Summary of findings

SHGs and SGs are recognized as effective community-based models for improving maternal and child nutrition. This literature review, focusing on India, Bangladesh, and Vietnam, explores their role in enhancing health and nutrition outcomes, particularly for PLW from marginalized communities. Drawing from 34

TABLE 4 Outcomes as cited in various assessment studies.

Documents reviewed	Reported results/findings
Jeevika (India)	
(1) Association of BCC Module Roll-Out in SHG meetings with changes in complementary feeding and dietary diversity among children (6–23 months): Evidence from Jeevika in Rural Bihar, India 300 children (6–23 months), pre- and post-intervention from 60 village organizations Source: PCI (2017)	(1) Adequate dietary diversity for children (eating from at least four food groups out of 7) Pre-intervention: 19% Post-intervention: 49% among SHG members and 28% among non-SHG members. The exposed group had an odds ratio of 3.81 (95% CI: 2.03, 7.15) for consuming a diverse diet compared to the pre-intervention group Higher knowledge of CF: Pre-intervention (48%) and post-intervention (81%), with 91% of the post-intervention respondents being from exposed groups
(2) Study by CARE, 2018 100 JTSP blocks districts in Bihar Vs. Non-JTSP blocks of 11 districts Source: CARE (2018)	(2) Timely initiation of breastfeeding JTSP Blocks: 83%, Non-JTSP blocks: 79% Skin to Skin care JTSP Blocks: 76%, Non-JTSP blocks: 66% Delayed Bathing JTSP Blocks: 62%, Non-JTSP blocks: 55% Initiation of Complementary Feeding JTSP Blocks: 91%, Non-JTSP blocks: 87% MDD JTSP: Blocks: 30%, Non-JTSP blocks: 28% Minimum meal frequency JTSP Blocks: 75%, Non-JTSP blocks: 61%
(3) Endline survey (2023) by Bihar Transformative Development Project (BTDP) 300 Blocks of 32 districts in Bihar Source: BTDP	(3) Children (6–23 months) from targeted SHGs with MDD Baseline: 8%, Midline:23%, Endline: 53% Women from targeted SHGs reporting MDD Baseline: 9%, Midline: 13%, Endline: 54%
(4) Engaging women's groups to improve nutrition: Findings from an evaluation of the JEEViKA multisectoral convergence pilot in Saharsa, Bihar 2246 households from 24 Gram Panchayats of Saharsa district in Bihar (IFPRI's endline survey) Source: IFPRI	(4) 10.3 percentage point (pp) increase in women reporting consuming 5 out of 10 food groups, a 36.3 pp increase in CF practices, an increased number of IFA tablets consumed, and a 2.8 pp increase in the likelihood of women consuming Calcium tablets in treatment arms (all values are in comparison of non-treatment arm) No improvements in the average Body Mass Index (BMI) of women and anthropometric measurements of children, knowledge of services provided by the FLWs (4.7 pp increase over endline comparison mean), knowledge on child feeding (6.6 pp increase over endline comparison mean), knowledge of dietary diversity (4.9 pp increase over endline comparison mean), knowledge on kitchen gardens (2.3 pp increase over endline comparison mean)
RGMVP (India)	
(1) Increasing knowledge of home-based maternal and newborn care using self-help groups: Evidence from rural Uttar Pradesh, India SHG women from two administrative blocks of Jhansi district in UP with 25 and 23 GPs, respectively, Baseline 803 participants and endline 470 women Source: Population Council Data	(1) A significant net effect (DID analysis: Net effect 17.4, $p < 0.05$) was observed in knowledge on consuming a minimum of 100 IFA tablets and maternal health in the treatment arm, no significant net effect on knowledge on EIBF, though there were some significant improvements of knowledge on newborn health
(2) CORT Pre and Post survey of one-month educational campaign from a selected block of 41 districts in Uttar Pradesh Participants 419 women baseline (July–August 2018), 506 endline (November 2018). Participants: married women who had given birth to a child within 12 months preceding the survey and/or were currently pregnant. Source: CORT and RGMVP (2018)	(2) 11 pp increase among women at endline on MDD, significant increase ($p < 0.01$) in the knowledge on ANC and services for pregnant women, marginal increase in the number of women consuming IFA tablets
(3) Evaluation of exclusive breastfeeding campaign Participants: 480 (240 SHG + 240 non-SHG) baseline and endline: same as baseline Source: POP Council (2018)	(3) The percentage of mothers practicing exclusive breastfeeding increased from 26.6% to 65.6% (SHG members) and from 29.5% to 58.5% (non-SHG members) Knowledge of exclusive breastfeeding increased among both SHG and non-SHG members, but there was no significant difference between the two groups. SHG members with correct knowledge of early initiation of breastfeeding were more (47.3%—82.4% among SHG members, 75.5% from 47.3% among non-SHG members)
LIUPCP (Bangladesh)	
(1) Bi-annual progress report of LIUPCP (October 2022–March 2023) Source: UNDP	(1) 25,796 PLW received nutrition grants, 25,796 Children aged 7–24 months received nutrition 95.2% of PLW grantees consumed protein in the last 7 days. 96.2% of children (7–23 months) grantees consumed protein in the last 24 h (children)

(Continued)

TABLE 4 (Continued)

Documents reviewed	Reported results/findings
(2) Outcome document of nutrition-specific and nutrition-sensitive interventions and policy advocacy by UNDP Source: UNDP	(2) 81.2% percent of lactating mothers have improved knowledge and skills related to infant and young child feeding practices. 68.9% of targeted (1,000 days) households have improved complementary feeding practices
IYCF SG (Vietnam)	
(1) Study by A&T for effectiveness and cost. Participants: 551 mothers of children aged 0–23 months in intervention and 559 in comparison communes from intervention districts in three regions of Vietnam. Source: A&T	(1) Statistically higher ($p < 0.05$) recommended breastfeeding practices ($p < 0.05$) in the intervention communes than in comparison communes (early initiation of breastfeeding (70.6% vs. 58.3%), exclusive breastfeeding under 6 months (62.8% vs. 13.1%), and no bottle feeding (78.0% vs. 60.0%). Mothers in the intervention communes more often fed their children minimum dietary diversity (81.0% vs. 73.0%, $p = 0.09$) and minimum acceptable diet (70.6% vs. 58.3%, $p = 0.06$).
(2) Save the Children Study (2017). 376 samples with 149 intervention households and 227 comparison households from 37 villages in 5 communes. Source: Save the Children	(2) On average, the participants from intervention villages scored 6.0 (out of 10) on the breastfeeding knowledge scale, compared to an average score of 5.3 among the comparison group. On average, mothers from the intervention group scored 4.9 (out of 10) on the complementary feeding knowledge scale, compared to an average score of 4.3 among comparison group mothers. This difference was statistically significant at the 10% level More intervention mothers correctly answered at least half of the questions (79% vs. 67%) and 80 percent of the questions (22% vs. 15%). Appropriate complementary feeding (CF), we found convincing evidence that the project had a positive impact. The intervention group scored significantly higher in CF knowledge compared to the matched comparison group (average score of 4.9 vs. 4.3). A significantly higher proportion of the intervention mothers (58%) was also found to be correctly answering at least half of the questions compared to the mothers from comparison villages (44%)

RGMVP, Rajiv Gandhi Mahila Vikas Pariyojana; LIUPCP, Livelihood Improvement of Urban Poor Communities Project; IYCF, Infant and Young Child Feeding; BCC, Behavior Change Communication; PCI, Project Concern International; MIYCN, Maternal, Infant and Young Child Nutrition, Maternal Newborn and Child Health; ICDDR, International Center for Diarrheal Disease Research; SHG, Self Help Groups; SG, Support Group; SBC, Social and Behavior Change; CLMNCC, City-Level Multisectoral Nutrition Coordination Committee; JTSP, Jeevika Technical Support Unit; MRPs, Master Resource Persons; CBEs, Community Based Events.

documents, the review highlights that SHGs in these countries use decentralized, peer-driven approaches to deliver social behavior change interventions like peer learning, interpersonal communication, and community events. These interventions have improved knowledge of breastfeeding, complementary feeding, and dietary diversity among SHG members. However, challenges such as sustaining group participation, overcoming socio-cultural barriers, and logistical difficulties remain significant.

Sustainability and fidelity issues arose from low participation, irregular meetings, and capacity gaps. Economic barriers, traditional practices, and reduced support also hindered activity sustainability, despite plans in place.

4 Discussion

Our synthesis shows that while integrating SBC interventions for MIYCN into SHGs and SGs produces encouraging outcomes, key lessons must be learned about designing and implementing these interventions, especially with regard to long-term sustainability and scalability. With the growing focus of global funding bodies and national governments on community-led and localized development, SHGs and SGs gain further significance as platforms embedded within communities (74). Recently, development partners and funding organizations have provided evidence supporting demand-driven capacity building, institutionalizing feedback and accountability within communities, and making monitoring, learning, and evaluation more participatory for successful community-led development (75, 76).

The integration processes must feature intensive capacity building for SHGs, SG meeting facilitators, and community mobilizers. Earlier studies have also highlighted the need for capacity building in community-based interventions to empower communities and place their voices at the center of solving the challenges that affect them (77–79). Our synthesis showed that the models focused on developing training materials that combine technical information with soft skills to maintain consistency in delivering training and orienting key actors to build their knowledge and counseling skills. Implementing agencies collaborated with technical partners, which significantly aided this process.

A significant challenge in implementing MIYCN-focused interventions is that although SHGs provide a suitable platform, their reach is not always direct. While PLW are members of SHG households, they are not necessarily direct members of SHGs themselves. Therefore, identifying ways to reach PLW and their influencers during the design phase is essential. Strategies such as listing identified PLW, conducting home visits, organizing open-to-all community events, and hosting nutrition drives or campaign-like events were some of the pathways used by the reviewed models to ensure coverage of all target groups. A previous systematic review on behavioral change interventions to improve maternal and child nutrition in sub-Saharan Africa also shows positive impacts of interventions based on behavior change theory, counseling, and communication (79). These interventions improved infant and child nutrition outcomes by

reducing wasting, underweight, and stunting, and enhancing dietary diversity and total food consumption, as well as maternal psychological outcomes. Additionally, this study shows that interventions incorporating the Behavior Change Wheel functions (incentivization, persuasion, and environmental restructuring) were most effective (79).

Beyond reach, the time allocated for nutrition discussions in SHGs and the frequency of meetings are equally crucial, as SHG members are expected to amplify nutrition messages beyond the group. There are encouraging examples of intensity when we consider the frequency of interactions with PLW. These groups, particularly those that followed a layered approach with multiple interventions, enabled multiple contact points with target groups. Studies from various countries have emphasized the benefits of multiple contact points for improving MIYCN outcomes (79, 80), which was made possible through SHGs. SGs dedicated to PLW do not face this challenge. However, SG models must work with influencers to ensure attendance at meetings and secure buy-in from existing health structures to guarantee the availability of facilitators and government ownership.

Our review also showed that engaging influencers at the policy level is essential to position maternal and child nutrition as critical for both health and economic productivity outcomes and to garner support for community institutions. This finding aligns with previous studies that deem advocacy at the policy level crucial for the success of health and nutrition interventions (81–83). Political will and policy-level support played a significant role in sustaining the Jeevika model. The scale-up and successful adaptation of CLMNCC under the LIUPCP program in Bangladesh, as well as the implementation of the Vietnam IYCF SG, demonstrated the substantial role of policy advocacy in ensuring effective program implementation, monitoring, and review through existing government systems.

This study has limitations. This scoping review focuses on four known Alive &Thrive programs and the processes and outcomes reported in the selected documents. Therefore, this review might not capture information from other programs and interventions, making it an internal organizational review, which could theoretically cause bias toward positive outcomes. Although we were not able to address such biases, to our knowledge, there are no other similar interventions at the project sites, and the majority of documents used for this study were peer-reviewed publications and published reports. A previous study indicates that behavior change communication might not be sufficient (79). Since we are not able to evaluate background information beyond the intervention, the effect could be the result of other interventions in the same community, such as food supplementation, cash transfers, mass communications, or general improvements in socioeconomic status (79). Further research is needed to better understand the influence of different aspects of these models and to identify which attributes are most associated with impact.

Additionally, we acknowledge that this was a scoping review rather than a systematic review, and we could not use search engines other than PubMed. Embase, Web of Science, and Scopus which are subscription-based databases that were not permitted by the donor due to their associated costs. Our search in the Cochrane Library did not yield any relevant literature reviews. Also, due to resource constraints, we could only arrange for one author within our organization to perform article screening and data extraction, and no formal software or tools were used to manage the process or evaluate the quality of documents. Given that the findings were reviewed by authors who have worked with these programs from the beginning, we anticipate that key literature and information have been captured.

In conclusion, SHG-based models have demonstrated success in improving health and nutrition outcomes but face challenges related to scale, sustainability, and participation. To address these challenges, it is essential to strengthen these models by maintaining rigorous and intense implementation, providing high-quality capacity building, conducting regular assessments, securing policy support, and ensuring sustained political commitment. Additionally, SHG models should be closely monitored and documented to bolster advocacy, generate political will, and foster ownership. The findings from this study can be utilized by policymakers, project managers, scholars, health workers, and frontline workers in designing, planning, implementing, and evaluating relevant intervention models in low-resource settings of lower-middle-income countries.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

AV: Formal analysis, Writing – original draft, Writing – review & editing. TN: Formal analysis, Writing – review & editing. AP: Writing – original draft. NP: Writing – review & editing. AH: Writing – review & editing. PZ: Writing – review & editing. ZM: Writing – review & editing. SG: Writing – original draft, Writing – review & editing. RM: Writing – review & editing. TF: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Nutrition status of nulliparous married women (15–24 years) in South Asia: trends, predictors, and program implications

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Introduction: Preconception nutrition, the nutritional status of women before pregnancy, is crucial for maternal and child health. Interventions focusing on preconception nutrition can help break the intergenerational cycle of malnutrition by improving the health and nutritional status of women before pregnancy. This study investigated the recent trends and patterns in the nutritional status of nulliparous adolescents and young women across six countries in South Asia: Bangladesh, India, Maldives, Nepal, Pakistan, and Sri Lanka.

Methods: This study utilized the cross-sectional data from the Demographic and Health Survey (DHS) conducted between 2010 and 2022 for six South Asian countries. A total sample of 20,024 nulliparous married women aged 15–24 years was analyzed to estimate the pooled prevalence for various anthropometric outcomes. Annual changes in the prevalence of the outcome indicators were presented for each country. Predictors of thinness and overweight were analyzed using logistic regression models.

Results: Based on the latest rounds of DHS for respective countries, the pooled weighted prevalence of thinness was 24.4%, overweight was 24.8%, and short height was 11.3%. The prevalence of underweight ranged from 14.6% in Pakistan (DHS 2018) to 25.9% in India (DHS 2021). The least reduction in the prevalence of underweight was observed in India at 2.8% and Nepal at 0.7%. Based on the latest surveys, the mean BMI among women aged 15–24 years was the highest in Maldives (24.1, 95% CI: 23.4, 24.8) and Pakistan (22.9, 95% CI: 22.2, 23.5) and the lowest in India (20.9, 95% CI: 20.9, 21.0) and Nepal (20.8, 95% CI: 20.4, 21.2). The pooled prevalence of thinness and short height was high in rural areas (26.2 and 11.8%), among less educated (28.1 and 14.5%), and bottom 40% wealth quintile groups (29.8 and 15.8%). Compared to young women (20–24 years), adolescent girls were 39% more likely to be underweight (OR: 1.39; 95% CI: 1.25, 1.54).

Conclusion: The findings highlight the need to broaden the scope of policies and programs designed for pregnant and lactating women so that nulliparous married women can be screened frequently for their anthropometric progress. Given the uneven distribution of the burden, it is recommended to implement comprehensive nutrition packages to reach all population subgroups across the regions.

KEYWORDS

nulliparous women, thinness, severe thinness, overweight, nutrition, South Asia

1 Introduction

The dietary practices and nutritional status of women in the preconception stage is a critical determinant of maternal and child health outcomes. Substantial evidence shows that children born to women who are undernourished—particularly those who are thin and short—are more likely to be born prematurely and experience low birth weight and intrauterine growth retardation (1–4). High levels of undernutrition among women during the preconception phase are a key factor contributing to the high burden of stunting (5, 6). Women of reproductive age (WRA) and adolescent girls are physiologically susceptible to undernutrition and micronutrient deficiencies due to the increased nutrient requirements for menstruation, pregnancy, and lactation. It is well known that undernutrition among women of reproductive age groups continues to be a public health challenge for most of the countries in South Asia (7–10). Interventions initiated post-conception, such as enhancing maternal diet and micronutrient intake, might enhance maternal nutrition but may have limited influence on newborn health results (11). Given the substantial influence on the well-being of both mothers and children, it is imperative to advocate for and prioritize interventions that focus on enhancing the nutrition of nulliparous women. Nulliparous women (women who have never given birth) represent a unique group within the reproductive age group (15–49 years) with distinct health needs. As the nulliparous women prepare for potential first pregnancies, ensuring adequate intake of key nutrients like folic acid and iron is essential to support healthy maternal and fetal outcomes. Since many young women may not be planning for pregnancy, they are often unaware of their specific nutritional requirements, increasing the risk of deficiencies (4). Additionally, lifestyle factors like poor diet or unhealthy habits further emphasize the importance of targeted interventions to ensure young women are well-prepared for healthy pregnancies in the future (4).

Despite a decrease in the incidence of underweight in WRA from 14.6% in 1975 to 9.7% in 2014, there are still significant burdens across Africa and Asia, with a rate of 24% in South Asia (12). As of 2022, 50% of women in the reproductive age group are anemic in South Asia, while approximately a quarter are thin (7, 13). Even within South Asia, the prevalence of malnutrition varies considerably. While India accounts for the large share of the undernutrition burden, the prevalence of overweight is high across Bangladesh and Maldives (7). Over the last two decades, there has been some progress in reducing the burden of undernutrition. However, the prevalence of overweight and obesity is increasing drastically across the world (7, 9). Consequently, regions including South Asia are now experiencing a double burden of malnutrition (7). Evidence suggests mothers who are obese are likely to suffer from pre-eclampsia and gestational diabetes (1, 11).

While both the high burden of undernutrition and overweight/obesity are of concern, most of the nutrition programs are primarily focused on delivering services to pregnant and lactating women. Recent studies have demonstrated that addressing preconception risk factors, such as undernutrition or obesity, is crucial for reducing adverse health outcomes during pregnancy and in newborns (14–16). For instance, research has shown that poor nutritional status in the preconception stage is associated with higher risks of preterm birth, low birth weight, and intrauterine growth restriction (16). Furthermore, evidence supports the role of maternal preconception health in influencing long-term child development and reducing the intergenerational cycle of malnutrition (15). The focus on addressing preconception nutrition needs is lacking despite an increase in spending on nutrition initiatives. In recent years, various governments and policymakers have recognized the nutrition needs of women in the preconception stage to break the intergenerational cycle of malnutrition.

This study aims to investigate the trends and patterns in the nutritional status of nulliparous women across six countries in South Asia: Bangladesh, India, Maldives, Nepal, Pakistan, and Sri Lanka. The key objectives of this study are to (1) present prevalence of thinness, severe thinness, overweight (including obesity), and short stature among married nulliparous adolescents (15–19 years) and nulliparous young women (20–24 years) for each country in South Asia; (2) estimate the average annual rate of reduction and the annual rate of increase within countries of South Asia using data for two time periods; and (3) identify the predictors of underweight and overweight for adolescents and young women, and to understand the strength of association with the specific predictors across countries over time.

2 Materials and methods

The study utilized data from the nationally representative Demographic Health Survey (DHS). DHS provides information on anthropometric outcomes as well as the socio-economic characteristics of the women. For this study, we included six out of eight South Asian countries: Bangladesh, India, Maldives, Nepal, Pakistan, and Sri Lanka. Data for two time periods were considered for each country: Bangladesh (2018 and 2022), India (2016 and 2021), Maldives (2009 and 2017), Nepal (2016 and 2022), and Pakistan (2013 and 2018). Data for Sri Lanka was available only for 2016 limiting the analysis of trends and patterns over time. Data for height and weight were not collected for Afghanistan and Bhutan.

The analysis is based on a total of 20,024 married nulliparous women aged 15–24 years (adolescents—7,188 and young women—12,836), obtained from the latest rounds of DHS for each country (Table 1). Most of the sample was from India (18,388), followed by Bangladesh (503) and Sri Lanka (391).

2.1 Primary outcome indicators of nutritional status

Three indicators of nutritional status were created based on the Asia Pacific cut-off for BMI: thinness (BMI $< 18.5\,kg/m^2$), severe thinness (BMI $< 16\,kg/m^2$), and Overweight, including obesity (BMI $\geq 23\,kg/m^2$) and short stature (less than 145 cm). BMI was calculated by dividing the person's weight in kilograms by the square of their height in meters. The variable was then categorized into the different BMI ranges. *Z*-scores for adolescents were calculated using World Health Organization (WHO) reference standards. Growth standards specified by WHO were used to determine the anthropometric outcomes for adolescents by comparing the calculated *z*-score with the median z-score: thinness (BAZ < -2 SD), severe thinness (BAZ < -3 SD) and obesity (BAZ $> +1$ SD).

Pooled prevalence was estimated after adjusting the sampling weight. A weight was created for each country by dividing the

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TABLE 1 Analytical sample and sample size used in the study.

			Out of 15–49 years		After applying exclusion criteria		
		Women 15–49 years	Adolescents (15–19 years)	Young adults (20–24 years)	Adolescents (15–19 years)	Young adults (20–24 years)	Total sample
Bangladesh	DHS 2018	20,127	1,951	3,154	648	400	1,048
	DHS 2022	30,078	2,449	4,851	328	175	503
India	DHS 2016	699,686	124,878	122,955	9,072	13,443	22,515
	DHS 2021	724,115	122,480	118,700	6,520	11,868	18,388
Maldives	DHS 2009	7,131	129	1,381	57	289	346
	DHS 2016	7,699	1,015	1,118	28	225	253
Nepal	DHS 2016	12,862	2,622	2,306	141	145	286
	DHS 2022	14,845	2,777	2,623	128	121	249
Pakistan	DHS 2012	4,112	567	2048	82	133	215
	DHS 2017	15,068	728	2,220	90	150	240
Sri Lanka	DHS 2016	18,302	229	1,439	94	297	391
Overall	Earlier round	743,918	130,147	131,844	10,000	14,410	24,410
Overall	Latest round	810,107	129,678	130,951	7,188	12,836	20,024

Exclusion criteria – women who are pregnant, who have children, whose height and weight were not recorded and who are not married.

population of women (15–49 years) for each country by the population of women for the SA region. The population was obtained from World Population Prospects for the corresponding survey years (17). Subsequently, this weight was multiplied by the survey sampling weight for each country and used for the analysis of the pooled dataset.

2.2 Socio-economic correlates

Based on the literature, several socio-economic factors associated with undernutrition among women were included in the analysis (Figure 1). Age (15–19 and 20–24 years), place of residence (urban and rural), education (Up to 10 years; more than 10 years), fertility intention (desire for a child/another child sooner or later, that is after 2 years or want no more), and the wealth quintile (bottom 40% and top 60%) provided by DHS based on a list of pre-defined assets were identified as important determinants of malnutrition.

Education was categorized using 10 years as the cut-off, based on both data considerations and the results of our sensitivity analysis. This threshold offered the best balance for minimizing skewness in the distribution of educational attainment across countries while maintaining an adequate sample size for each education category. Similarly, we merged the top three wealth quintiles to ensure sufficient observations within each category and to further reduce skewness in the wealth distribution.

2.3 Statistical analysis

Univariate analysis was conducted to examine the prevalence of thinness, severe thinness, and overweight and short stature in South Asia and for each country for both age groups. Bivariate analysis was conducted to estimate the prevalence by age and key socio-economic correlates (Supplementary Table S1). The analysis also included the changes in prevalence over time and across various sub-national regions.

Logistic regression models were applied to determine the association of selected variables with undernutrition among nulliparous women. Models were estimated separately for each undernutrition indicator as the dependent variable. The following econometric specification was used for estimation.

$$\text{logit}\ \pi_i = \beta_1 + \beta_2 X_i + \varepsilon_i$$

Where π_i = Probability ($Y_i = 1$). Y_i is binary and assumes a value of 1 if the woman is thin/overweight and 0 otherwise. Log of odds has been estimated for the model while controlling for several socio-economic and demographic correlates (denoted by X). The control variables which were used in the above equation are age, place of residence, education, fertility intention and wealth quintile. STATA 15 was used for all the statistical analysis. All statistical tests were two-sided and $p < 0.05$ was considered to determine statistical significance.

2.4 Annual rate of reduction and annual rate of increase

The Annual Average Rate of Reduction (AARR), which is the average relative percentage decrease per year in prevalence or rate (18), was calculated as follows. Here "n" is the number of years between the time periods denoted by "t" and "n + t," and P_{t+n} and P_t are the prevalence rates of the indicators (thinness/overweight) at time

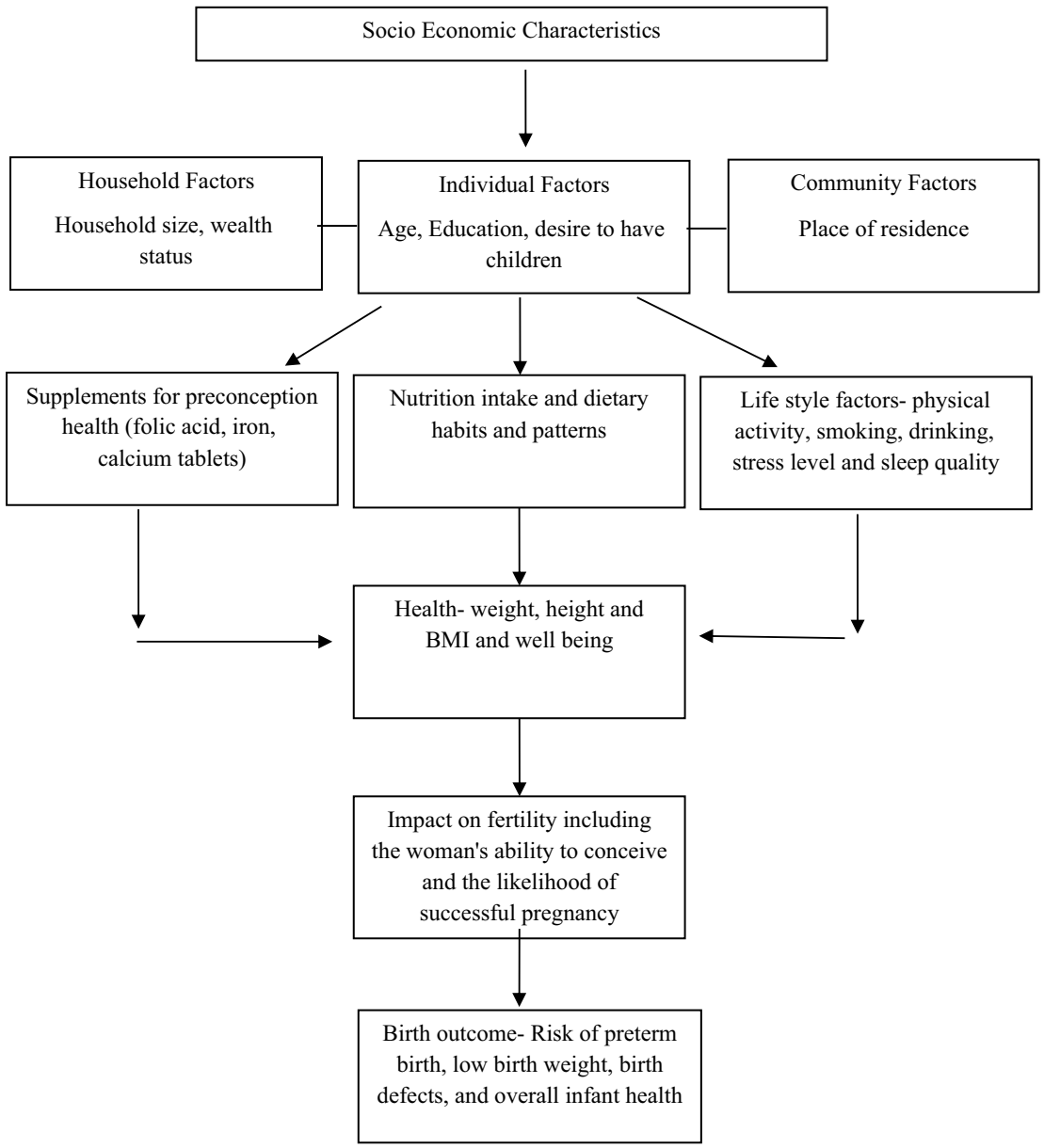

FIGURE 1
Directed Acyclic Graph (DAG) showing the potential relationship between socio-economic characteristics, anthropometric outcomes and pregnancy and birth outcomes.

points "t + n" and "t" respectively. The calculation is based on previous and latest rounds of DHS for the respective countries except for Sri Lanka, for which data was available for 2016 only.

$$AARR = \left(1 - \left(P_{t+n} / P_t\right)^{1/n}\right) * 100$$

A positive sign of AARR indicates a reduction or downward trend, while a negative sign indicates an increase or upward trend.

The Annual Average Rate of Increase (AARI), the average relative percentage increase per year in prevalence or rate, was calculated as

$$AARI = \left(\left(P_{t+n} / P_t\right)^{\frac{1}{n}} - 1\right) * 100$$

A positive sign of AARI indicates an increase or upward trend, while a negative sign indicates a decrease or a downward trend.

3 Results

Based on the latest rounds of DHS for respective countries, the pooled weighted prevalence of thinness was 24.4%, overweight was 24.8%, and short height was 11.3%. In South Asia, underweight

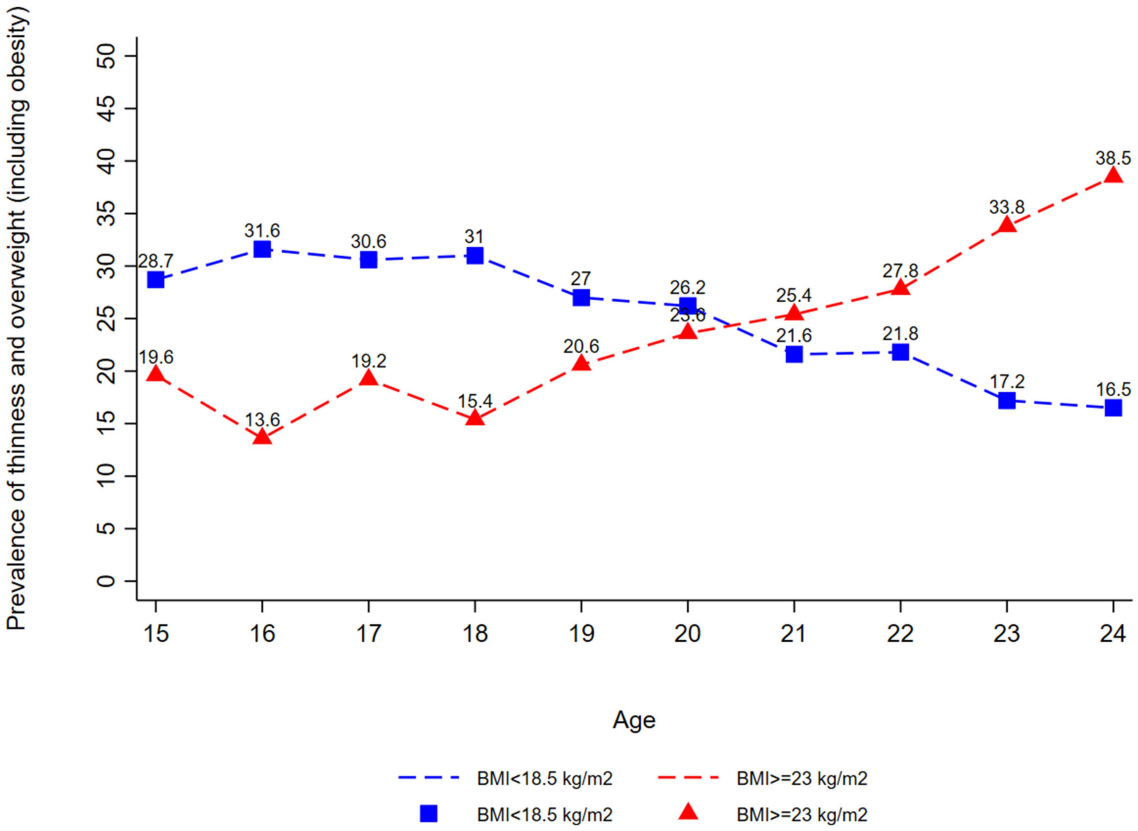

FIGURE 2
Thinness (BMI < 18.5 kg/m^2) and overweight or obesity (BMI ≥ 23 kg/m^2) among married nulliparous adolescents (15–19 years) and married nulliparous young women (20–24 years) by Age, South Asia based on the latest rounds for respective countries.

prevalence has decreased: Bangladesh from 20.4 to 18.2% (2018–2022), India from 29.9 to 25.9% (2016–2021), Maldives from 26.4 to 15.9% (2009–2017), Pakistan from 17.6 to 14.6% (2013–2018), Nepal from 23.3 to 22.4% (2016–2022), and Sri Lanka at 18.4% (2016). Conversely, overweight prevalence increased in most countries: Bangladesh from 29.7 to 32.4%, India from 17.1 to 22.2%, Maldives from 35.4 to 55.1%, and Pakistan from 27.2 to 45.3%, while Nepal decreased slightly from 19.5 to 17.9%, and Sri Lanka reported 43.3% (2016).

3.1 Change in nutritional status

Substantial variation was observed in the annual rate of reduction in the prevalence of underweight and the annual rate of increase in the prevalence of overweight across countries among married nulliparous adolescents and married young women (15–24 years) (Table 2). Maldives had the highest AARR in underweight prevalence (6.1%) while Nepal showed a minimal reduction of 0.7% from 23.3% in 2016 and 22.4% in 2022. The AARR in underweight prevalence was 2.9% in Bangladesh, 2.8% in India, and 3.7% in Pakistan. The AARI in the prevalence of overweight was highest in Pakistan (10.7%) followed by Maldives (5.7%), India (5.4%) and Bangladesh (2.2%). Nepal is the only country experiencing a reduction in overweight prevalence with AARR of 1.4%. However, the prevalence of thinness has increased among young women (20–24 years) in the country.

The AARR in the prevalence of short stature in the Bangladesh and Maldives was 18.3 and 11.4%, respectively. In, India, the percentage of short women has increased slightly in the latest DHS rounds. The AARR for short stature in young women (20–24 years) was highest in Bangladesh (23.6%).

According to the latest round of surveys, India had the highest prevalence of underweight at 25.9%, followed by Nepal (22.4%) (Supplementary Table S2). Overweight prevalence is very high in Maldives (55.1%), Pakistan (45.3%), and Sri Lanka (43.3%) (Supplementary Table S3). India has the highest prevalence of short stature at 12.3% (Supplementary Table S4). The study noted a decline in the prevalence of thinness from age 20 years while the prevalence of obesity increased with the age of the women (Figure 2).

The prevalence of anemia was assessed for three countries: India, Maldives, and Nepal (Supplementary Table S6). Based on the latest surveys, the anemia prevalence rate was high in India and Maldives at approximately 59%. The rate increased from 52.8% in 2016 to 58.3% in 2021 in India while it remained nearly static in Nepal (approximately 38%).

TABLE 2 Annual rate of reduction/increase in prevalence of thinness (BMI < 18.5 kg/m²) and overweight (BMI ≥ 23 kg/m²) and height less than 145 cm among married nulliparous adolescents and young women, South Asia.

			Overall			Adolescents (15–19 years)				Young women (20–24 years)			
	Round	*N*	<18.5 kg/m² (%)	≥ 23 kg/m² (%)	Less than 145 cm (%)	*N*	<18.5 kg/m² (%)	≥ 23 kg/m² (%)	Less than 145 cm (%)	*N*	<18.5 kg/m² (%)	≥ 23 kg/m² (%)	Less than 145 cm (%)
Bangladesh	DHS 2018	1,048	20.4	29.7	12.7	648	24.7	21.7	9.7	400	13.3	43.2	17.8
	DHS 2022	503	18.2	32.4	5.7	328.0	20.8	28.9	5.5	175.0	13.1	39.0	6.1
	Change		(2.9)	2.2	(18.3)		(4.2)	7.4	(13.3)		(0.3)	(2.5)	(23.6)
India	DHS 2016	22,515	29.9	17.1	11.9	9,072	35	10.9	13.1	13,443	26.3	21.4	11.1
	DHS 2021	18,388	25.9	22.2	12.3	6,520	31.6	14.4	14.9	11,868	22.4	26.8	10.7
	Change		(2.8)	5.4	0.7		(2.0)	5.7	2.6		(3.2)	4.6	(0.7)
Maldives	DHS 2009	346	26.4	35.4	6.6	57	27.2	31.3	5.6	289	26.2	36.1	6.8
	DHS 2017	253	15.9	55.1	2.5	28	22.4	66.4	7.6	225	15.3	54.1	2.1
	Change		(6.1)	5.7	(11.4)		(2.4)	9.9	3.9		(6.5)	5.2	(13.7)
Nepal	DHS 2016	286	23.3	19.5	10.9	141	30.9	9.4	13.4	145	16.3	28.9	8.7
	DHS 2022	249	22.4	17.9	9.4	128	23.9	15.3	6.5	121	21	20.4	12.1
	Change		(0.7)	(1.4)	(2.4)		(4.2)	8.5	(11.4)		4.3	5.6	5.7
Pakistan	DHS 2013	215	17.6	27.2	8.1	82	18	16	13.7	133	17.3	34.3	4.6
	DHS 2018	240	14.6	45.3	6.6	90	19.6	41.3	11.8	150	12.2	47.1	4.2
	Change		(3.7)	10.7	(4.0)		1.7	20.9	(2.9)		(6.7)	6.5	(1.8)
Sri Lanka	DHS 2016	391	18.4	43.3	5.5	94	22.9	37.5	6.4	297	17	45.2	5.2
Pooled	Earlier round	24,410	27.6	19.7	11.8	10,000	31.8	13.6	12.4	14,410	24.2	24.7	11.4
	Latest round	20,024	24.4	24.8	11.3	7,188	29.5	17.9	13.4	12,836	21.1	29.2	9.9

Pooled estimates for the earlier round do not include Sri Lanka as the survey was not conducted. Figures in parenthesis are AARR. Figures without parenthesis are AARI.

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TABLE 3 Prevalence of thinness (BAZ < −2SD), severe thinness (BAZ < −3SD) and overweight or obesity (BMI + 1SD) among married nulliparous adolescents (15–19 years), South Asia.

			z-score of BMI for age		
	Round	*N*	<−2SD (%)	<−3SD (%)	>+1SD (%)
Bangladesh	DHS 2018	648	5.3	0.4	12.6
	DHS 2022	328	3.1	0.42	17.3
India	DHS 2016	9,072	7.1	1.1	5.3
	DHS 2021	6,520	7.2	1	7.1
Maldives	DHS 2009	57	13	4.9	18.1
	DHS 2017	28	6.7	2.2	61.5
Nepal	DHS 2016	141	3.5	0	3.5
	DHS 2022	128	1.6	0	5.9
Pakistan	DHS 2013	82	3.1	1.3	7.5
	DHS 2018	90	10.6	0	27.7
Sri Lanka	DHS 2016	94	7.9	0	27.5
Pooled	Earlier	10,000	6.4	0.9	7.1
	Latest	7,188	6.8	0.8	9.7

3.2 Mean BMI and nutritional status based on BMI-for-*z* score

Based on the latest round of surveys, the mean BMI for women aged 15–24 years varied across South Asian countries, with the highest values observed in Maldives (24.1), followed closely by Pakistan (22.9) and Sri Lanka (22.8), indicating relatively better nutritional status in these regions (Supplementary Figure S1). Conversely, the lowest mean BMI was recorded in Nepal (20.8) and India (20.9), suggesting a greater prevalence of undernutrition among young women in these countries. Furthermore, mean BMI was observed to be higher for young women as compared to the adolescents (Supplementary Figures S2, S3).

The prevalence of thinness, assessed through the BMI-for-*z* score, revealed a concerning situation: Pakistan exhibited the highest prevalence of thinness at 10.6%, followed by India at 7.2%, Maldives at 6.7%, and Sri Lanka at 7.9% (Table 3). This data highlights the nutritional challenges faced by young women in these countries. Notably, Maldives also reported a striking prevalence of overweight at 61.5% based on the BMI-for-*z* score, indicating a significant shift toward higher weight categories among its young female population.

3.3 Socio-economic distribution

On average, 24.4% of women resided in urban areas. Approximately 50% of them had more than 10 years of education. A high proportion of women (89.8%) desired children soon. In the pooled sample based on wealth, 57.1% belonged to the top 60% wealth quintile group while 42.9% belonged to the bottom 40% group. More than 60% of women resided in households with more than four members. Overall, 61.2% of women were 20–24 years old, and 38.8% were in the 15–19 years age group. The country wise distribution of participants by socio-economic characteristics is shown in Supplementary Table S1.

The study observed a high prevalence of thinness and short height in rural areas (26.2 and 11.8%), among less educated (28.1 and 14.5%), and the bottom 40% wealth quintile groups (29.8 and 15.8%). The prevalence of thinness was high in household sizes greater than 4 (25.2%) and among 15–19 years (29.5%), while the prevalence of overweight was high in small households (27.2%) and among 20–24 years age group women (29.2%) (Table 4). The patterns are consistent across all countries (Supplementary Tables S2, S3).

Table 5 presents the association between underweight and the socio-economic characteristics among married nulliparous adolescents and young women aged 15–24 years across the countries, based on the recent rounds of DHS. Compared to young women (20–24 years), adolescent girls were 39% more likely to be underweight (OR: 1.39; 95% CI: 1.25, 1.54). Women residing in urban areas (OR:0.78: 95% CI:0.68, 0.89) and those with more than 10 years of education (OR:0.84: 95% CI:0.76, 0.93) were significantly less likely to be underweight than those in rural areas and with a low education. Women belonging to the top 60% were less likely to be underweight (OR:0.72: 95% CI:0.65, 0.80).

Table 6 presents adjusted odds ratios of overweight and the various socio-economic and demographic factors for women among married nulliparous adolescents (15–19 years) and young women (20–24 years). The results showed significantly higher chances of being overweight for the top 60% wealth quintile groups compared to the bottom 40% group (OR: 1.79; 95% CI: 1.56, 2.09). The adolescent girls aged 15–19 years had significantly lower chances of being overweight compared to young women aged 20–24 years (OR: 0.61; 95% CI: 0.54, 0.70). The chances of being overweight were significantly lesser for those residing in households with 4 or more members (OR: 0.83; 95% CI: 0.74;0.94).

Table 7 shows the adjusted odds ratios of short stature (height less than 145 cm) and socio-economic and demographic factors among married nulliparous adolescents (15–19 years) and young women (20–24 years). Adolescent girls and young women belonging to the top 60% wealth quintile were less likely to be of short stature than those belonging to the bottom 40% wealth quintile (OR: 0.52; 95% CI: 0.45, 0.60).

4 Discussion

The nutrition status of nulliparous married women remains an under-researched area despite having significant implications for birth outcomes as well as maternal health and wellbeing. This is one of the first comprehensive studies presenting the trends and patterns in thinness, overweight and short stature among nulliparous married women in six South Asian countries. The pooled prevalence of underweight was higher than the pooled prevalence of overweight. The analysis revealed a huge variation in the prevalence of thinness and overweight across the countries. The prevalence of thinness was high in India while the prevalence of overweight was more than 40% across Maldives, Pakistan, and Sri Lanka.

The findings showed place of residence, education, wealth, and age were important determinants of malnutrition. These results were in line with the findings of a recent critical review on malnutrition in

TABLE 4 Prevalence of thinness (BMI < 18.5 kg/m^2) and overweight (BMI ≥ 23 kg/m^2) and height less than 145 cm among married nulliparous adolescents and young women, South Asia based on the latest round of DHS for respective countries.

	Sample		BMI < 18.5 kg/m^2	BMI ≥ 23 kg/m^2	Height < 145 cm
	N	%	%	%	%
Sector					
Rural	16,366	75.6	26.2	22.5	11.8
Urban	3,658	24.4	18.6	31.9	9.8
Education respondent					
Up to 10 years	9,723	48.3	28.1	20.6	14.5
More than 10 years	10,301	51.7	20.9	28.7	8.3
Desire for children					
Want soon	17,631	89.8	23.9	25.5	11.1
Want no more/ Others	2,393	10.2	28.5	18.9	12.7
Wealth					
Bottom 40%	9,324	42.9	29.8	17.2	15.8
Top 60%	10,700	57.1	20.3	30.5	7.9
Household size					
≤4	7,812	38.4	23	27.2	12
>4	12,212	61.6	25.2	23.3	10.8
Woman age					
15–19 years	7,188	38.8	29.5	17.9	13.4
20–24 years	12,836	61.2	21.1	29.2	9.9
Total	20,024	100	24.4	24.8	11.3

TABLE 5 Adjusted odds ratios of underweight among married nulliparous adolescents (15–19 years) and young women (20–24 years).

	Bangladesh DHS 2022	India DHS 2021	Maldives DHS 2017	Nepal DHS 2022	Pakistan DHS 2018	Sri Lanka DHS 2016	Pooled Latest rounds
Sector							
Rural	1	1	1	1	1	1	1
Urban	1.37	0.77***	4.61*	1.39	0.68	0.9	0.78***
	[0.78, 2.43]	[0.67, 0.88]	[1.14, 18.74]	[0.71, 2.71]	[0.26, 1.76]	[0.35, 2.29]	[0.68, 0.89]
Education respondent							
Up to 10 years	1	1	1	1	1	1	1
More than 10 years	0.58	0.79***	1	0.97	1.05	1.14	0.84***
	[0.32, 1.06]	[0.72, 0.87]	[1.00, 1.00]	[0.49, 1.89]	[0.29, 3.78]	[0.31, 4.13]	[0.76, 0.93]
Desire for children							
Want soon	1	1	1	1	1	1	1
Want no more/ Others	0.61	1.23**	1.86	5.25	0.06*	1.03	1.21**
	[0.27, 1.39]	[1.08, 1.39]	[0.28, 12.53]	[0.61, 45.39]	[0.01, 0.58]	[0.45, 2.35]	[1.07, 1.38]
Wealth							
Bottom 40%	1	1	1	1	1	1	1
Top 60%	0.62	0.76***	0.51	0.88	0.51	0.67	0.72***

(Continued)

TABLE 5 (Continued)

	Bangladesh DHS 2022	India DHS 2021	Maldives DHS 2017	Nepal DHS 2022	Pakistan DHS 2018	Sri Lanka DHS 2016	Pooled Latest rounds
	[0.35, 1.09]	[0.69, 0.83]	[0.11, 2.41]	[0.45, 1.74]	[0.16, 1.63]	[0.39, 1.15]	[0.65, 0.80]
Household size							
≤4	1	1	1	1	1	1	1
>4	1.16	1.07	3.58	1.18	2.96	1.05	1.09
	[0.68, 1.96]	[0.97, 1.17]	[0.88, 14.55]	[0.60, 2.33]	[0.93, 9.43]	[0.61, 1.81]	[0.99, 1.21]
Woman age							
20–24 years	1	1	1	1	1	1	1
15–19 years	1.45	1.40***	1.97	1.13	1.82	1.39	1.39***
	[0.78, 2.71]	[1.28, 1.54]	[0.45, 8.59]	[0.56, 2.27]	[0.67, 4.93]	[0.76, 2.54]	[1.25, 1.54]
Constant	0.25***	0.39***	0.04***	0.21***	0.09***	0.22*	0.36***
	[0.12, 0.50]	[0.36, 0.43]	[0.01, 0.16]	[0.08, 0.52]	[0.03, 0.28]	[0.06, 0.89]	[0.32, 0.40]
N	503	18,388	242	249	206	391	19,990

Note: Levels of significance: * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

TABLE 6 Adjusted odds ratios of overweight among married nulliparous adolescents (15–19 years) and young women (20–24 years).

	Bangladesh DHS 2022	India DHS 2021	Maldives DHS 2017	Nepal DHS 2022	Pakistan DHS 2018	Sri Lanka DHS 2016	Pooled Latest rounds
Sector							
Rural	1	1	1	1	1	1	1
Urban	1.07	1.35***	0.52	1.23	0.49	0.79	1.23**
	[0.65, 1.75]	[1.18, 1.54]	[0.24, 1.12]	[0.57, 2.63]	[0.21, 1.17]	[0.39, 1.62]	[1.06, 1.41]
Education respondent							
Up to 10 years	1	1	1	1	1	1	1
More than 10 years	1.45	1.30***	1.88	0.68	0.86	0.62	1.12
	[0.92, 2.29]	[1.17, 1.45]	[0.55, 6.45]	[0.31, 1.48]	[0.33, 2.24]	[0.22, 1.75]	[0.98, 1.27]
Desire for children							
Want soon	1	1	1	1	1	1	1
Want no more/ Others	0.71	0.75***	0.37	1	2.09	0.56	0.72***
	[0.29, 1.73]	[0.64, 0.88]	[0.12, 1.18]	[1.00, 1.00]	[0.38, 11.43]	[0.27, 1.16]	[0.61, 0.86]
Wealth							
Bottom 40%	1	1	1	1	1	1	1
Top 60%	1.72*	1.63***	1.04	2.44*	3.19*	1.21	1.79***
	[1.05, 2.84]	[1.45, 1.83]	[0.52, 2.08]	[1.05, 5.68]	[1.27, 7.97]	[0.78, 1.87]	[1.56, 2.06]
Household size							
≤4	1	1	1	1	1	1	1
>4	0.79	0.81***	0.53	0.86	0.63	0.95	0.83**
	[0.51, 1.22]	[0.73, 0.89]	[0.22, 1.28]	[0.40, 1.88]	[0.26, 1.54]	[0.62, 1.46]	[0.74, 0.94]
Woman age							
20–24 years	1	1	1	1	1	1	1
15–19 years	0.76	0.56***	1.55	0.72	0.82	0.74	0.61***
	[0.47,1.23]	[0.50,0.62]	[0.50,4.88]	[0.34,1.53]	[0.38,1.75]	[0.45,1.24]	[0.54,0.70]

(Continued)

TABLE 6 (Continued)

	Bangladesh DHS 2022	India DHS 2021	Maldives DHS 2017	Nepal DHS 2022	Pakistan DHS 2018	Sri Lanka DHS 2016	Pooled Latest rounds
Constant	0.38**	0.24***	1.53	0.16***	0.81	1.29	0.28***
	[0.19, 0.74]	[0.21, 0.27]	[0.40, 5.87]	[0.06, 0.47]	[0.29, 2.24]	[0.44, 3.81]	[0.24, 0.33]
N	503	18,388	253	244	206	391	19,990

Note: Levels of significance: * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

TABLE 7 Adjusted odds ratios of short stature (height less than 145 cm) among married nulliparous adolescents (15–19 years) and young women (20–24 years).

	Bangladesh DHS 2022	India DHS 2021	Maldives DHS 2017	Nepal DHS 2022	Pakistan DHS 2018	Sri Lanka DHS 2016	Pooled Latest rounds
Sector							
Rural	1	1	1	1	1	1	1
Urban	0.44	1.17	1	1.7	2.99	0.69	1.14
	[0.18, 1.10]	[0.97, 1.41]	[1.00, 1.00]	[0.65, 4.41]	[0.56, 15.97]	[0.16, 2.95]	[0.93, 1.39]
Education respondent							
Up to 10 years	1	1	1	1	1	1	1
More than 10 years	0.73	0.66***	1	0.74	0.17	0.28	0.68***
	[0.33, 1.65]	[0.58, 0.75]	[1.00, 1.00]	[0.23, 2.32]	[0.01, 1.90]	[0.07, 1.07]	[0.59, 0.79]
Desire for children							
Want soon	1	1	1	1	1	1	1
Want no more/ Others	0.83	1.1	1	7.14	0.41	1	1.12
	[0.23, 2.98]	[0.92, 1.32]	[1.00, 1.00]	[0.70, 72.98]	[0.04, 4.24]	[0.21, 4.76]	[0.93, 1.34]
Wealth							
Bottom 40%	1	1	1	1	1	1	1
Top 60%	0.67	0.52***	0.41	0.54	0.84	0.86	0.52***
	[0.31, 1.46]	[0.45, 0.59]	[0.10, 1.69]	[0.18, 1.59]	[0.17, 4.13]	[0.34, 2.18]	[0.45, 0.60]
Household size							
≤4	1	1	1	1	1	1	1
>4	1.14	0.85*	0.77	2.45	1.82	0.89	0.89
	[0.52, 2.54]	[0.75, 0.96]	[0.18, 3.26]	[0.85, 7.04]	[0.27, 12.03]	[0.36, 2.18]	[0.78, 1.01]
Woman age							
20–24 years	1	1	1	1	1	1	1
15–19 years	0.76	1.22**	2.27	0.39	2.34	1.12	1.19*
	[0.35, 1.66]	[1.08, 1.38]	[0.45, 11.47]	[0.13, 1.17]	[0.61, 9.02]	[0.39, 3.24]	[1.04, 1.36]
Constant	0.12***	0.23***	0.09***	0.09***	0.03**	0.22*	0.20***
	[0.05, 0.26]	[0.20, 0.26]	[0.02, 0.31]	[0.03, 0.30]	[0.00, 0.33]	[0.05, 0.98]	[0.17, 0.23]
N	503	18,388	190	249	206	391	19,990

Note: Levels of significance: * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

South Asia which revealed poverty and food insecurity are the root causes of malnutrition (19). This study highlights a strong gradient concerning wealth which indicates poverty, by affecting the purchasing power of the households, could lead to food insecurity or consumption of a diet with low nutritional value. This linkage can also be established through the relationship between household size and the prevalence of thinness. The finding is consistent with a Turkish study which revealed the highest prevalence of thinness among adolescent students (aged 14–18 years) with the lowest household income and the largest household size (20).

India shares a large burden of malnutrition due to its large population. As per the estimates, 2.3 million married nulliparous women were thin (Supplementary Table S5). Notably, women in rural areas in India were likely to be underweight. The poor nutritional status can be attributed to gender inequalities in nutrition from an early age which has also been documented in a previous study (21).

The study noted a high prevalence of obesity with increasing urbanization. Previous research has demonstrated that urban populations were likely to be overweight/obese due to a sedentary lifestyle, intake of energy-dense foods, and lower engagement in physical activity (22, 23). Although there has been a consistent reduction in the prevalence of underweight, the rate of overweight has increased across countries, such as Maldives and Pakistan. This study found mean BMI increased by 11% in Maldives between 2009 and 2016 (Supplementary Figure S1). The results corroborated with previous studies assessing the trends in the prevalence of double burden of malnutrition which reported mean BMI was increasing across countries (7, 24, 25).

The annual rate of reduction in the prevalence of thinness was lowest in Nepal and India. In addition, the prevalence of severe thinness in India stagnated while the prevalence of anemia increased (Supplementary Tables S6, S7). A previous study noted a similar finding that the prevalence of anemia remained the same despite improvements in overall nutritional status (26). The author noted that AARI in case of India was at 2 for 15–19 years and 3.2% for 20–24 years, indicating the reduction rate has not changed despite policy impetus. The current study observed a slight decline in the prevalence of thinness in Nepal. On the contrary, previous studies based on earlier DHS survey rounds have reported Nepal's undernutrition rate has rapidly decreased (10, 27).

5 Limitations of the study

This study has several limitations. First, the study was based on cross-sectional data and therefore causality could not be inferred from the analysis. Second, the data does not consider seasonality which might affect the measurement of weight. Third, the study only included socio-economic and demographic characteristics. The genetic factors such as maternal and paternal anthropometric outcomes and dietary behavior, which are important determinants of nutrition, were not considered due to data unavailability. Another outcome that the study could not capture was anemia for all countries in South Asia. Only two of the countries (Nepal and India) had information available on hemoglobin. Lastly, there was significant heterogeneity in the time of data collection for each country. For instance, the last DHS was conducted in 2022 in Nepal and Sri Lanka and in 2021 in India. Therefore, the pooled analysis might not reflect the present nutrition status of women. The small sample size for most of the countries might affect the reliability of the estimates.

6 Future directions and conclusions

The study found an increase in overweight prevalence and a decline in underweight prevalence across the six South Asian countries, except Nepal. Despite the improvement in undernutrition status, the steady rise in the rates of overweight poses a serious challenge, particularly for Maldives and Pakistan. Socio-economic factors such as age, residence, education, wealth, and household size were significant determinants of nutritional status and should be considered in policy interventions by developing a multisectoral strategy. Similarly, camps within school premises could be organized for adolescent girls to monitor the progress in nutritional outcomes over time. Additionally, system strengthening efforts are required to expand the coverage of nutrition counseling services to assist adolescent girls, women, and their families in making decisions and taking action to improve nutritional outputs. Finally, the governments across these nations need to identify high-burden regions and prepare action plans tailored to their needs based on socio-economic characteristics. Future research should include nulliparous married women in nutrition monitoring and analyze dietary behavior to inform policies. These findings would highlight the need for evidence-based interventions to ensure equitable access to adequate nutrition and a healthier future for nulliparous women in South Asia.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://dhsprogram.com/data/available-datasets.cfm.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

Author contributions

AK: Formal analysis, Writing – review & editing. VS: Conceptualization, Writing – original draft, Writing – review & editing. ZM: Conceptualization, Writing – review & editing. AP: Formal analysis, Writing – review & editing. AS: Writing – original draft, Writing – review & editing. WJ: Conceptualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Caste, wealth and geographic equity in program reach and expected outcomes: an exploratory analyses of *Suaahara* in Nepal

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Introduction: Monitoring and evaluation of maternal and child nutrition programs typically concentrates on overall population-level results. There is limited understanding, however, of how intervention reach and expected outcomes differ among sub-populations, necessary insight for addressing inequalities. These analyses aim to determine if maternal exposure to social and behavior change (SBC) interventions is associated with scales of maternal practices (antenatal care, iron and folic acid in pregnancy, diet in pregnancy, postnatal care, iron and folic acid postpartum, and maternal dietary diversity) and child practices (institutional birth, health mothers' group participation, growth monitoring and promotion, early initiation of breastfeeding and infant and young child feeding) in Nepal, overall and by wealth, caste, and geography.

Methods: Cross-sectional data from 2022 from the USAID-funded Suaahara program in Nepal were used for analysis. The study focused on households with children aged 0–2 years (N = 1815). Descriptive analysis was followed by regression models, adjusted for potentially confounding child, mother, and household factors, as well as community-level clustering.

Results: Greater intensity of maternal engagement with the SBC interventions was positively associated with both scales for maternal and child nutrition-related practices. The magnitude of the positive associations, however, was less for the socially excluded caste versus others for maternal nutrition; there was almost no caste-based variation in associations for child nutrition. Positive associations were found only among the lower 40% socio-economically when mothers engaged with at least two platforms for maternal nutrition and at least three platforms for child nutrition. In contrast, engagement with one platform for the relatively wealthier was positively associated with both maternal and child outcomes. Similarly, the positive associations were stronger among those residing in the terai (lowland plains) than those in the hills and mountains for both maternal and child outcomes.

Discussion: The scope for improving maternal and child nutrition practices is significant, in part via well-designed, targeted, SBC programs. These analyses highlight the importance of considering different domains of equity both in implementation and related research. Further mixed methods research is

needed to more deeply explore why certain types of interventions reach and/or have a greater effect on sub-populations.

KEYWORDS

equity, Nepal, nutrition, implementation science, social and behavior change, caste, wealth, geography

1 Introduction

Investment in promoting healthy maternal and child nutrition practices in low- and middle-income countries is crucial to reduce morbidity and mortality as well as improve productivity, cognition, and executive function (1, 2). Improving maternal and child nutrition outcomes in South Asia remains a global priority. There is a wealth of literature that points to the importance of targeting interventions to mitigate the impacts of undernutrition on mothers and children during the thousand-day period between pregnancy and a child's second birthday. Optimizing nutrition during this critical period can have long-lasting benefits for the child's physical and mental development (3–5).

Despite progress made in the last few decades (6), undernutrition remains a severe public health problem for mothers and children. This global burden of undernutrition is not experienced equitably—every country in the world sees significant inequalities by factors such as location, remoteness, age, sex, education, and wealth. These health inequities are driven by social determinants of health including differences in access to and availability of quality health services, sufficient and healthy food, wealth, education, and social inclusion (7).

The Government of Nepal (GoN) has made significant strides in the past few decades to address poor maternal and child nutrition, building on its early success in increasing access to Vitamin A supplementation through the establishment of a cadre of female community health volunteers (FCHVs) (8). The GoN has prioritized key maternal and child nutrition programs, such as the Nepal Safe Motherhood and Newborn Health Road Map, 2019. In 2011, Nepal joined the Scaling Up Nutrition (SUN) movement that focused on multisectoral and multistakeholder approaches to improving nutrition outcomes, and the GoN then developed its first multi-sectorial nutrition plan (MSNP, 2013–2017) that brought together efforts across health and family planning; agriculture and markets; education; water, sanitation and hygiene (WASH); and other sectors (9). Despite progress between the start of the MSNP and its current third iteration (2023–2027), challenges persist including deeper vertical and horizontal collaboration requiring diverse actors to build relationships and scale-up of implementation of key interventions across sectors at the community level (10, 11).

Nepal's rapid reductions in child and maternal undernutrition in the past few decades have been documented in multiple studies, including decomposition analyses to identify contributing factors to this success (12). Secondary analyses of national survey data from 1996 to 2016 have also shown continued improvements in some infant and young child feeding (IYCF) practices, such as initiating breastfeeding within the first hour of birth, timely introduction of complementary feeding, child minimum dietary diversity (MDD) and minimum acceptable diet (MAD) (13). Despite this progress, as of 2022, about half of Nepalese children aged 6–23 months (52%) and women aged 15–49 years (44%) had diets that did not meet the MDD requirements (14). Critically, there is stark variation in the prevalence of these ideal practices. Specifically, households from a lower wealth quintile, traditionally excluded caste groups, or living in the *terai* (plains) region often have poorer nutrition practices than their counterparts. For example, in 2022, 39% of children from the lowest wealth quintile versus 67% from the highest wealth quintile consumed diets meeting the standard for MAD. These inequities may stem from lower coverage of programs, limited access to nutritious foods, geographic isolation, and other contributing factors (15).

There is extensive documentation on the benefits of nutrition programs using SBC approaches - interpersonal communication, community mobilization, and mass media (e.g., radio, social media, SMS)—to improve maternal and child nutrition practices (16–18). Greater behavior change success has been seen from programs that combine approaches such as implementing mass media and individual/community education interventions (19) and some evidence suggests benefit from greater intensity of messaging (i.e., reinforcing messages in different platforms) (20).

While the benefits of SBC in nutrition interventions are well supported, there is less evidence on the equity of uptake between more and less marginalized groups and what strategies are needed to ensure that everyone is reached. One study in Nigeria showed that pro-poor interventions could reduce inequities in exclusive breastfeeding (21). Another study in rural India found that frontline workers were less able to reach lower socio-economic status households, and the intentional design of the self-help groups to meet these women with maternal and newborn health interventions would be crucial (22). The common belief that improving intervention quality will inevitably help to close equity gaps has contributed to knowledge gaps on the role of equity in intervention design and measurement (23). In Nepal, inequities go beyond wealth differences and include caste/ethnicity as well as geography. For centuries, one's caste/ethnicity, assigned at birth in the Hindu system, has determined one's social identity and social inclusion and directly ties to the opportunities one does or does not have for social mobility. Similarly, given the extreme agro-ecological diversity in Nepal with altitude ranging from 60 to nearly 9,000 meters, geographic inequities persist: those in the *terai* have greater access to roads and markets whereas those in hills and mountains are increasingly remote and isolated. These inequities also interact with each other to create multiple layers of marginalization for some (24).

Suaahara II, a USAID-funded program, was implemented in all communities of 42 of Nepal's 77 districts from 2016 to 2023, building on the first phase of *Suaahara* (2011–2016). This large-scale initiative, aligned with Nepal's MSNP, aimed to reduce maternal and child undernutrition via interventions primarily in nutrition; health and family planning; WASH; agriculture and markets; and nutrition governance. *Suaahara II* invested heavily in multiple SBC platforms including: (1) interpersonal communication (IPC); (2) community events (CE) bringing groups together for activities such as food demonstrations and key life events (e.g., celebrations of a new pregnancy or a child turning 6 months of age), (3) *Bhanchhin Aama*, a weekly drama initially produced centrally and aired on radio and later locally produced and aired on radio as well as Facebook and YouTube, and (4) SMS messages timed based on age and stage of the 1,000-day period to

remind and motivate mothers and family members to seek care and adopt ideal nutrition-related practices. All interventions utilized a gender equality and social inclusion (GESI) approach to target women and disadvantaged groups and focus on GESI-related barriers to adopting promoted practices. Aligned with the complex program, *Suaahara II* had a complex monitoring, evaluation, and research (MER) system, including annual monitoring surveys to assess changes in key indicators over time; MER data was analyzed, and learnings were used to continuously improve intervention approaches and targeting.

The recently published household-level impact evaluation results highlighted that *Suaahara* improved a variety of child health and nutrition practices, but not maternal dietary practices or antenatal care or postnatal care participation (25). Given persistent undernutrition in Nepal and globally, as well as inequities in maternal and child nutrition outcomes, there is a need to study further how SBC interventions can improve maternal and child nutrition behaviors and whether these SBC interventions and their effects are experienced equitably among sub-populations. Using a cross-sectional dataset, our specific research questions include:

1 Is maternal engagement with *Suaahara II* SBC interventions associated with promoted maternal and child nutrition practices?
2 Do the associations between maternal engagement with *Suaahara II* SBC interventions and maternal and child nutrition practices vary by household wealth, caste, or geographic location?

2 Methods

The data used in this study is from the *Suaahara II* 2022 cross-sectional annual monitoring dataset, which was collected by an external survey firm (Figure 1). The survey employed multi-stage cluster sampling at the district, municipality, and community levels, using probability proportional to size (PPS) techniques to randomly select study sites at each level. Ultimately, households with a child aged 0 to 5 years were randomly selected for the study. Primary survey respondents included the mother of the selected child and the head of household (male if available). All analyses are limited to households with a child under 2 years (n = 1815) of age given this was *Suaahara II's* target population and the relevant age group for the child outcomes in this study.

The two primary outcomes were both constructed as continuous variables and included: (1) a scale of 6 maternal nutrition-related practices (antenatal care, iron and folic acid in pregnancy, diet in pregnancy, postnatal care, iron and folic acid postpartum, and maternal dietary diversity) and (2) a scale of 5 child nutrition-related practices (institutional birth, health mothers' group participation, growth monitoring and promotion, early initiation of breastfeeding and infant and young child feeding—exclusive breastfeeding or timely introduction of complementary foods, depending on child age), with the practices selected based on program focus on these behaviors in the year before the survey, during the COVID-19 context. The primary exposure variable was also constructed as a continuous variable, summing exposure to different platforms to create a scale (0–4) that measures the degree of maternal engagement with the four *Suaahara II* SBC interventions of interest. Three dimensions of equity, identified based on program focus and as key social determinants of health in Nepal—wealth (economic stability), caste (community and social context), and agro-ecological zone of residency (physical environment) - were

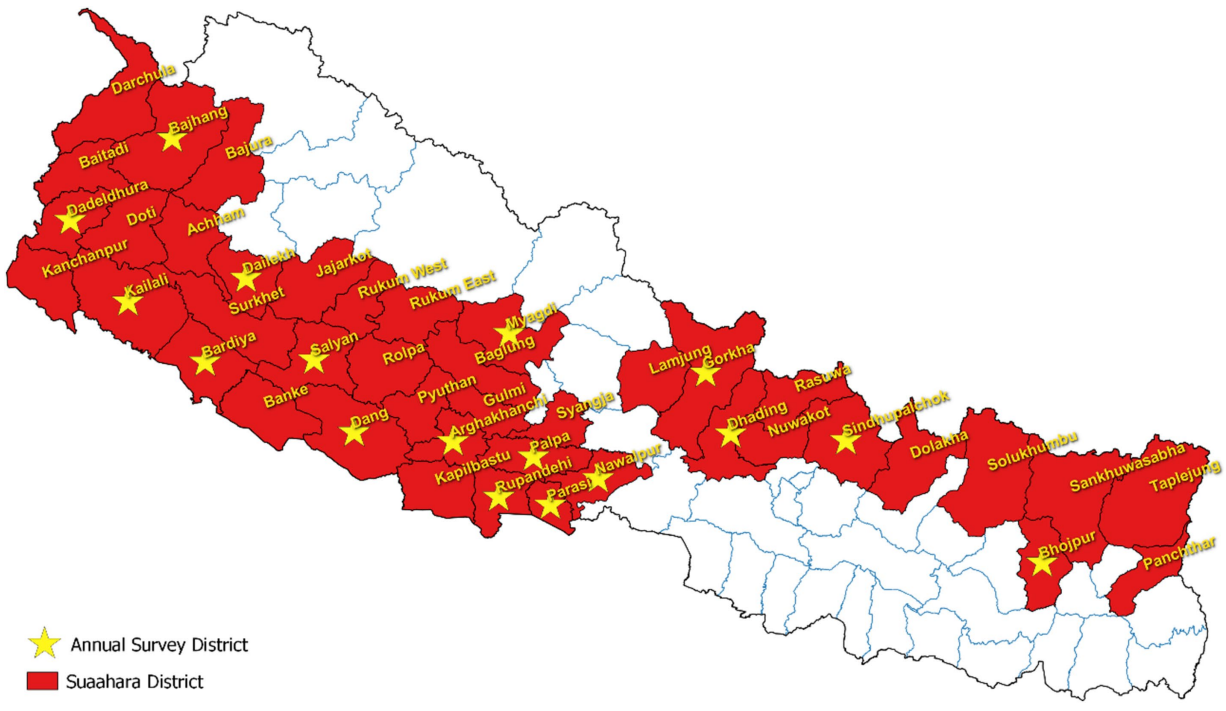

FIGURE 1
Annual survey districts.

utilized to answer the final research question, using a binary variable for each.

2.1 Outcome 1: scale (0–6) of maternal nutrition-related practices

Antenatal care: whether the mother participated in at least four antenatal care visits during her most recent pregnancy;

Iron and folic acid in pregnancy: whether the mother consumed at least 180 tablets during her most recent pregnancy;

Diet in pregnancy: whether the mother ate more food (i.e., one more meal per day) during pregnancy rather than the same or less than usual;

Postnatal care: whether the mother participated in at least three postnatal care visits after her most recent child delivery;

Iron and folic acid postpartum: whether the mother consumed at least 45 tablets after her most recent child delivery; and

Maternal dietary diversity: whether the mother consumed foods from at least 5 of 10 food groups in the 24 h prior to the survey (26).

2.2 Outcome 2: scale (0–5) of child nutrition-related practices

Institutional birth: whether the child was born in a health facility;

Health mothers' group participation: whether the mother participated at least once in an FCHV-led group meeting on health and nutrition in the 6 months prior to the survey;

Growth monitoring and promotion: whether the child was taken at least once for a growth monitoring and promotion check in the 6 months prior to the survey;

Early initiation of breastfeeding: whether breastfeeding was initiated within 1 hour after the child was born; and

Infant and young child feeding: whether infants were exclusively breastfed, meaning they only received breast milk without any additional liquids or solids, not even water, for the first 6 months (for those 0–5 months) or young children (6–23 months) were introduced to complementary foods (water/liquids, milk other than breast milk, semi-solid foods, solid foods, eggs, and meat) when they were 6–8 months of age.

2.3 Exposure: scale (0–4) of *Suaahara* SBC interventions (IPC + CE + BA+SMS)

Interpersonal communication (IPC): whether the mother ever met with a frontline worker in the 6 months prior to the survey;

Community events (CE): whether the mother participated in any community events (i.e., food demonstrations, key life events, etc. led by *Suaahara* staff and/or Female Community Health Volunteers) in the 6 months prior to the survey;

Bhanchhin Aama (BA): whether the mother ever listened to *Bhanchhin Aama* prior to the survey; and

SMS: whether the mother received any message on her mobile device about health or nutrition in the month prior to the survey.

2.4 Primary dimensions of equity

1 Wealth/Socio-economic status: measuring relative wealth, the equity quintile was generated using asset ownership and materials of the home[1] to categorize the households as lower 40% versus upper 60%;
2 Caste: categorized with Dalit, Muslim, or disadvantaged Janajati as socially excluded versus Brahmin, Chettri and other non-disadvantaged caste as non-socially excluded; and
3 Agro-ecological zone: residency in the plains (*terai*) versus hills and mountains.

First, descriptive analyses were conducted for socio-economic and demographic variables, outcomes, and exposure variables. Then, linear regression models were run to explore associations between the degree of maternal engagement with *Suaahara II* SBC intervention platforms (dummy variables of 0/1 for each of the four platforms, with 0 being the reference in the models) and both ordinal scales of 6 maternal nutrition-related practices and 5 child nutrition-related practices. Linear regression was done once both outcome scales were confirmed to be symmetrically distributed with the mean, median, and mode in the center of the distribution. Given that the four SBC interventions build on each other and are conceptually challenging to examine as if they are independent along with the vast number of models generated by each platform and each sub-group, we ultimately decided to model with an exposure variable that combines exposure to the four SBC interventions. Lastly, additional models were run separately for each sub-group of the association by wealth, caste, or geography. All models were adjusted for community-level clustering as well as demographic variables that could be potential confounders, including maternal age and education, gender of the household head, household caste, and socio-economic status (measured using equity quintiles) and community-level clustering. All descriptive and regression analyses were conducted using Stata statistical software.

Respondents gave written informed consent to participate in the survey, which was approved by the Nepal Health Research Council in 2019.

3 Results

3.1 Sample characteristics

Household, child, and maternal characteristics among sampled households are presented in Table 1. Slightly more than one-third of households were headed by a female (about 35%), and slightly more belonged to a socially excluded caste, including Dalit, Muslim, or disadvantaged Janajati (about 53%). A little less than one-third of households resided in the *terai* (approximately 32%) and about one-third (about 34%) belong to the two relatively lowest socio-economic groups/equity quintiles. Children were, on average, 11.9 months old and almost half (about 46%) were female. Mothers

1 https://www.equitytool.org/nepal-2/

10.3389/fnut.2024.1464902

TABLE 1 Background characteristics of the study population.

	Year 2022 (*N* = 1815)
	% or mean (SD)
Household characteristics	
Household head sex: female	34.5%
Household caste: socially excluded	53.6%
Household residency: *terai* (vs. lowland plains)	32.0%
Household wealth: lower 40%	33.7%
Child characteristics	
Child sex: female	45.8%
Child age (completed months)	11.9 (6.9)
Child age group	
0–5.9 months	22.7%
6–11.9 months	26.9%
12–17.9 months	22.2%
18–23.9 months	28.2%
Maternal characteristics	
Mother's age (completed years)	25.3 (5.2)
Mother's age group	
15–19.9 years	9.8%
20–24.9 years	40.0%
25–29.9 years	30.3%
30 years and above	19.9%
Mother's education group	
Never attended school/grade 1 not complete	7.2%
Some primary school	8.2%
Completed primary school	7.1%
Some secondary education	38.6%
Completed secondary education	19.5%
Completed class 12/higher education	19.5%

were, on average, 25 years old and more than a third of mothers had completed secondary education or beyond (approximately 39%).

3.2 Equity in exposures and outcomes

Overall, about half of mothers were exposed to each of IPC, CE, and *Bhanchhin Aama*, whereas only about 23% of mothers were exposed to the SMS intervention. Engagement with *Suaahara II* SBC interventions differed among sub-populations (Table 2). While more than four-fifths of the sampled population participated in at least one of the platforms, the largest gap found was by agro-ecological zone, with the lowest engagement in the *terai*: about 22% of mothers residing in the *terai* did not engage at all, versus only about 15% residing in the hills/mountains. Similarly, while about one-third (approximately 34%) of mothers residing in the mountains and hills engaged in at least 3 of 4 platforms, the prevalence of this intensity of engagement was less among *terai* mothers (approximately 24%). Maternal engagement with each SBC platform was similar between the two caste groups: engagement with frontline workers was slightly greater among the socially excluded (about 51% versus about 46%) than their counterparts. Among the relatively wealthier, engagement was greater with frontline workers (about 51% versus about 45%), community events (about 55% versus about 48%) and SMS (about 27% versus about 16%) than the relatively poorer 40% of the population. *Bhanchhin Aama* listenership had the greatest geographical difference, with a 21-percentage point gap favoring those residing in the hills and mountains (approximately 61% versus approximately 40%). The geographic difference for mothers having received SMS messages was smaller: 24% of those residing in the hills and mountains versus 21% of those residing in the *terai*.

Nearly all mothers (about 85%) had at least four antenatal care visits during pregnancy and nearly two-thirds (approximately 65%) took at least the recommended 180 iron and folic acid tablets during pregnancy. Not even half of mothers (about 38% to about 47%) adopted the other maternal nutrition-related practices (eating more food during pregnancy, at least 3 postnatal care visits, at least 45 iron and folic acid tablets in the postpartum period, and maternal minimum dietary diversity). Some of these practices had at least 5 percentage point equity-related gaps. By caste, the two largest differences were lower prevalence among the socially excluded than their counterparts for taking at least 45 iron and folic acid tablets in the post-partum period (about 36% versus about 41%) and minimum dietary diversity (about 43% versus about 49%). Furthermore, the relatively poorer 40% were lagging in all 6 maternal nutrition-related practices by a range of 5 to 16 percentage points. Similarly, mothers in the *terai* had a lower prevalence by 5 to 14 percentage points of five of the six maternal nutrition-related practices than mothers in the hills and mountains, with the largest gap being for maternal dietary diversity.

Almost all babies (approximately 88%) were born in a health facility, and a similar percentage participated in growth monitoring and promotion at least once in the last 6 months. Not even one-third (about 28%) participated in an FCHV-led health mothers' group meeting at least once in the last 6 months. Two-thirds (approximately 67%) of infants were breastfed in the first hour of life. Not even half (about 39%) met an ideal feeding standard for their age (exclusively breastfed for the first 6 months of life for those 0–6 months or introduction of complementary feeding between 6 to 8.9 months for those 6 to 23 months). Some of these child nutrition-related practices also had at least 5 percentage point equity-related gaps. A six-percentage point gap was identified for FCHV-led group participation (about 31% versus about 25%) and early initiation of breastfeeding (approximately 70% versus approximately 62%), with higher prevalences among the socially excluded mothers. Relatively poorer mothers had less uptake of institutional delivery (about 81% versus about 91%) and group meetings (about 25% versus about 30%) than relatively wealthier mothers, but the relatively poorer mothers had a higher prevalence of ideal age-appropriate infant and young child feeding than the relatively wealthier mothers (approximately 43% versus approximately 37%). While mothers from the *terai* seemed to give birth more regularly in a health facility (about 92% versus about 86%), the prevalence of their participation in growth monitoring and promotion was lower (about 79% versus about 88%) and the practice of early initiation of breastfeeding (approximately 63% versus approximately 68%) than mothers from the hills and mountains.

TABLE 2 Exposure to *Suaahara* interventions and key maternal and child health outcomes by caste, wealth, and geography.

	Total 2022 (*N* = 1815)	Household caste/ ethnicity		Household wealth status		Agro-ecological zone	
		Socially excluded (*N* = 973)	Not socially excluded (*N* = 842)	Lower 40% (*N* = 611)	Upper 60% (*N* = 1,204)	*Terai* (*N* = 580)	Hills/ mountains (*N* = 1,235)
Exposure to Suaahara interventions							
Interpersonal Communication	48.8%	51.0%	46.2%	44.7%	50.8%	46.0%	50.0%
Community Events	52.5%	53.6%	51.3%	48.5%	54.6%	50.7%	53.4%
Bhanchhin Aama	54.4%	54.4%	54.4%	53.2%	55.0%	39.8%	61.2%
Short Message Service messages	23.1%	23.4%	22.8%	16.4%	26.6%	21.2%	24.1%
Scale: none	17.4%	16.3%	18.5%	20.1%	16.0%	22.4%	15.0%
Scale: 1	26.3%	26.4%	26.1%	30.0%	24.4%	27.2%	25.8%
Scale: 2	25.2%	24.5%	26.1%	23.4%	26.2%	26.2%	24.8%
Scale: 3	22.5%	24.2%	20.6%	20.1%	23.7%	18.5%	24.4%
Scale: 4	8.7%	8.6%	8.7%	6.4%	9.8%	5.7%	10.0%
Maternal outcomes							
Antenatal care (4+) during pregnancy	84.9%	85.1%	84.7%	81.8%	86.5%	81.1%	86.7%
Iron and Folic Acid (180+) during pregnancy	65.0%	63.6%	66.5%	61.1%	66.9%	61.2%	66.7%
Eat more during pregnancy	46.5%	46.3%	46.7%	35.7%	51.9%	42.9%	48.1%
Postnatal care (3+)	38.7%	37.3%	40.4%	33.6%	41.4%	34.5%	40.7%
Iron and Folic Acid (45+) during the post-partum period	38.2%	35.8%	41.1%	32.6%	41.1%	37.2%	38.7%
Minimum diet diversity	45.2%	42.5%	48.5%	39.6%	48.1%	35.9%	49.6%
Scale (0–6)	3.18 (1.40)	3.10 (1.34)	3.28 (1.46)	2.84 (1.37)	3.36 (1.38)	2.93 (1.31)	3.30 (1.42)
Child outcomes							
Institutional delivery	87.6%	86.5%	88.8%	81.2%	90.9%	91.6%	85.8%
Health Mothers' Group participation	28.2%	31.1%	24.8%	24.6%	30.1%	27.1%	28.7%
Growth Monitoring and Promotion participation	85.2%	85.6%	84.8%	87.4%	84.1%	78.6%	88.3%
Early initiation of breastfeeding	66.6%	70.3%	62.2%	68.9%	65.4%	62.9%	68.3%
Exclusive breastfeeding/ Introduction of complementary foods (6–8.9 months)	38.7%	39.5%	37.9%	43.2%	36.5%	36.9%	39.6%
Scale (0–5)	3.06 (1.03)	3.13 (1.03)	2.99 (1.03)	3.05 (1.03)	3.07 (1.03)	2.97 (1.09)	3.11 (1.00)

3.3 Associations between engagement with Suaahara II SBC interventions and maternal and child nutrition outcomes: overall and by sub-population

Maternal engagement with *Suaahara II* SBC interventions was positively associated with the adoption of ideal, promoted maternal nutrition-related practices, with a consistent increase in magnitude of positive association for participation in more interventions (Table 3). Overall, and for all sub-populations other than the wealthy, engagement with at least two platforms was required for a meaningful positive association, and usually, engagement in three or more was needed for achieving one or nearly one (0.70 to 0.97) additional full behavior on the scale of 6 maternal nutrition practices used in this study. In the stratified sub-analyses, effect modification can clearly be seen with variation in the stratum-specific associations on either side of the overall association: the positive associations were slightly stronger for mothers from the non-socially excluded caste, the wealthier, and those residing in the *terai*.

Similar to the results for maternal nutrition practices, maternal engagement with *Suaahara II* SBC interventions was positively associated with the adoption of ideal, promoted child nutrition-related practices, with a consistent increase in the magnitude of association following participation in more interventions. Unlike the finding for the maternal nutrition models, however, overall and for nearly all sub-populations, engagement with even one platform was sufficient for a meaningful positive association to be found. In the stratified sub-analyses, there was little variation by caste. Socio-economic differences in the association were stark, however, highlighting effect modification. While any engagement with *Suaahara II* SBC interventions was positively associated with ideal child nutrition practices among the wealthier, the relatively poor required maternal engagement with at least three platforms for the association to exist. Additionally, the magnitude of association was larger for the wealthier at each level of engagement than for the relatively poorer. Finally, mothers residing in the *terai* seemed to have similar benefits as those residing in the hills and mountains, whether engaging one or two platforms, and only a slightly greater payoff for greater engagement. Effect modification was also found by agro-ecological zone of residency in the stratified models: the overall magnitude of association was much smaller for those in the hills and mountains versus those residing in the *terai*; engagement with even three platforms for mothers in the hills and mountains had a weaker association than for those residing in the *terai* who only engaged with one platform.

4 Discussion

In this study, maternal engagement with *Suaahara II* SBC intervention platforms was positively associated with both scales of promoted maternal and child nutrition practices. The degree of association varied by intensity of maternal engagement ranging from 0.2 to 0.8 for maternal nutrition-related practices and 0.3 to 0.7 for child nutrition-related practices. Effect modification was found through the stratified analyses. Wealth variation for both maternal and child outcomes highlighted that engagement with at least two of the four platforms was necessary for the positive association among poorer mothers, versus the positive association found for engagement with one platform among relatively wealthier mothers. Similarly, geographic-based findings suggested the magnitude of associations was stronger for mothers from the *terai* than from the hills and mountains for both the maternal and child outcomes. Models investigating caste/ethnicity differences found less variation but still some: engagement with at least two of the four platforms was necessary for the positive association to be found for the maternal outcomes; the positive association was found even for engagement with only one platform for the child outcomes.

TABLE 3 Associations between engagement with Suaahara II interventions and maternal and child nutrition practices: overall and by caste, wealth, and geography.

	Overall	Caste		Wealth		Agro-ecological zone	
	(*N* = 1815)	Socially excluded (*N* = 973)	Not socially excluded (*N* = 842)	Lower 40% (*N* = 611)	Upper 60% (*N* = 1,204)	Terai	Hills/ mountains
Maternal nutrition practices (scale 0–6: antenatal care, iron and folic acid in pregnancy, diet in pregnancy, postnatal care, iron and folic acid postpartum, and maternal dietary diversity)							
0	Reference						
1	0.20 [0.01–0.39]	0.15 [−0.10-0.39]	0.22 [−0.05-0.50]	0.06 [−0.23-0.35]	0.26* [0.01–0.51]	0.46** [0.13–0.80]	0.05 [−0.17-0.27]
2	0.46*** [0.26–0.66]	0.27* [0.01–0.56]	0.67*** [0.39–0.95]	0.48** [0.18–0.79]	0.41** [0.16–0.66]	0.55** [0.19–0.91]	0.37** [0.14–0.60]
3 or 4	0.81*** [0.61–1.01]	0.70*** [0.44–0.97]	0.94*** [0.65–1.23]	0.71*** [0.35–1.06]	0.83*** [0.58–1.07]	0.97*** [0.64–1.30]	0.71*** [0.46–0.97]
Child nutrition practices (scale 0–5: institutional birth, health mothers' group participation, growth monitoring and promotion, early initiation of breastfeeding and infant and young child feeding—exclusive breastfeeding or introduction of complementary foods)							
0	Reference						
1	0.30*** [0.14–0.46]	0.28** [0.09–0.46]	0.31** [0.09–0.54]	0.20 [−0.04-0.44]	0.34** [0.14–0.55]	0.62*** [0.34–0.90]	0.11 [−0.06-0.29]
2	0.40*** [0.24–0.56]	0.33** [0.13–0.53]	0.47*** [0.25–0.68]	0.21 [−0.05-0.46]	0.50*** [0.31–0.69]	0.66*** [0.42–0.90]	0.24** [0.06–0.42]
3 or 4	0.69*** [0.52–0.85]	0.68*** [0.50–0.87]	0.69*** [0.44–0.94]	0.44** [0.17–0.71]	0.81*** [0.61–1.01]	0.82*** [0.55–1.09]	0.58*** [0.40–0.76]

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

With the most consistent variation found in associations between exposure and key outcomes by agro-ecological zone of residency, these findings suggest that reaching households in the *terai* remains a challenge: population density means that IPC efforts require significant investments in human resources, whereas language variation and a highly mobile population moving back and forth across the border with India present other challenges for program implementation. Another well-documented *terai*-specific challenge is that socio-cultural norms often limit women's freedom of movement or prevent women's decision-making about their participation in groups. Creative approaches to overcoming these barriers should be implemented, as SBC efforts appear to have a greater impact on households in lowland plains compared to those in the mountains and hills. Similar evidence for geographic variation in maternal and child nutrition practices but with a focus on urban versus rural have been documented. For instance, a study conducted in India found that urban or rural residence was a predictor in the uptake of infant and young child feeding practices (27). Similarly, another study in Bangladesh found that urban or rural residence was a predictor for skilled birth attendance during delivery (28). Studies looking at other geographic-based variation, such as by agro-ecological zone, were not found.

A review of national datasets and even comparing the findings of these analyses with earlier *Suaahara* publications shows progress over the last decade for many nutrition-related practices (13). The Frongillo et al. paper based on the impact evaluation highlights *Suaahara's* role in the noted progress for many of these behaviors, particularly those related to infant and young child feeding (26), which is likely not only the effect of direct SBC interventions but the related documented impact of *Suaahara* on the health system and nutrition governance throughout Nepal (29, 30). Ideal maternal and child nutrition practices, however, still require further investment: at least half of the Nepalese 1,000-day population have still not adopted six of the 11 practices in this study. Furthermore, the stratified analyses highlight persistent equity gaps, usually by wealth and geography, but also some by caste. With poorer mothers having lower adoption of nearly all the ideal practices, the GoN and development partners should address barriers for these households that go beyond knowledge and SBC interventions. Similarly, the barriers created for some practices due to remoteness, terrain, or other factors related to agro-ecology must be acknowledged and acted upon to close these geography-related equity gaps.

The finding that maternal exposure to *Suaahara* intervention platforms is associated with ideal promoted nutrition-related practices and that there is a dose–response relationship is encouraging for SBC interventions. These updated data and analyses are consistent with and build on earlier findings of the positive associations, particularly with dietary practices, and the important benefits of more intense exposure (31). The magnitude of the associations found for mothers exposed to one, two, or three/four platforms was similar for the maternal and child outcome scales. It seems, however, that greater engagement is needed for the association with maternal outcomes to materialize, suggesting greater ease of adoption of promoted practices for the child. This is consistent with the main *Suaahara* impact evaluation finding that *Suaahara* did not improve maternal nutrition practices the way it did child nutrition practices, although it did reduce maternal underweight (26). Similarly, the recently published results of the *Suaahara* SMS trial show a positive effect of the intervention on child diets, IYCF knowledge, and other child-related outcomes but not maternal diets among those who received and read the messages (32). There are likely a variety of reasons this trend is emerging, which may be due to greater emphasis on infant and young child feeding than maternal-specific health and nutrition in the implementation of the SBC interventions or also socio-cultural factors, including that caregivers and families tend to prioritize taking care of the child over themselves when resources are tight.

Present-day caste inequity related to nutrition in Nepal is well-documented (33). For the maternal outcomes explored in this study, the positive associations were slightly larger for the upper caste. In contrast, there was almost no difference by caste for associations with child nutrition outcomes. Other studies have also identified that being from a lower caste group in Nepal can act as a barrier to adoption of some nutrition practices, such as early initiation of breastfeeding (34) and ideal complementary feeding practices (35). Since mothers from both caste groups had similar levels of exposure to each *Suaahara* intervention platform, it is likely that there is some socio-cultural barrier(s) among mothers from the socially excluded caste, complicating the uptake of promoted practices for maternal nutritional well-being that do not similarly hinder her uptake of promoted practices for child nutritional well-being.

Wealth-related gaps in nutrition are known (36). These analyses also suggest that Nepal is no exception. Poorer mothers consistently had less program uptake than wealthier mothers; the only platform that reached both at equal proportions was *Bhanchhin Aama*. The fact that the magnitude of associations between maternal exposure to Suaahara SBC interventions and nutrition outcomes was greater for the relatively wealthier households than the poorer households for both maternal and child outcomes also suggests resource barriers that SBC interventions do not address. For instance, service-related outcomes (e.g., antenatal care, postnatal care, growth monitoring) require time to travel and wait for healthcare and sometimes even money to pay for transportation; similarly, dietary diversity and introduction of complementary foods require access to and availability of foods locally and time to prepare foods for a healthy diet. Another study in Nepal found that wealth was a significant factor in explaining variation in the uptake of maternal practices, specifically having a skilled birth attendant present and that access to health promotion activities is inevitably tied to individual, socio-economic, and environmental conditions (37).

Geographic inequities persist for various reasons: distance and road conditions can create obstacles to seeking health and nutrition services, and rural and urban communities have differing access to markets, roads, and services. Additionally, the populations that reside in the lowland plains (*terai*) of Nepal versus the hills and mountains are also distinct with varying cultural practices, migration patterns, languages and more. These analyses show that while three of the four SBC interventions reached equally in the two geographic areas, *Bhanchhin Aama* is not as listened to by mothers in the *terai* as in the hills and mountains. This may be due to a preference for other medium, such as television; less awareness of the program's existence, or more frequent migration out of Nepal. The finding that the magnitude of association was stronger for *terai* mothers than their counterparts, especially for child nutrition practices, again suggests barriers beyond knowledge particularly for those residing in the hills

and mountains. It is likely that the environmental conditions present obstacles to adoption of ideal practices that require dietary diversity and travel to seek health and nutrition services.

From a global perspective, these research findings confirm the importance of having program interventions targeted and tailored to specific populations, with a specific focus on vulnerable households, across different geographic zones, taking into account local contexts and preferences. Likewise, the findings suggest that vulnerable households may need more intense interventions with several components to support behavior change. A similar observation is observed on behavior change in the newly published review by the Board for International Food and Agriculture development on increasing demand for healthy diets (38). The finding that the SMS intervention, which started many years after the IPC, CE and *Bhanchhin Aama* interventions, also highlights that it SBC interventions can take time to saturate target populations. Finally, this study highlights the need to understand local domains of inequity and the possible intersectionality of these domains.

5 Conclusions and recommendations

This is one of the few studies to interrogate equity in program exposure and in key nutrition outcomes. Using a large dataset to look across different sub-populations provides insights to guide future programs and policies. However, some limitations should be considered when interpreting the findings. First, these are cross-sectional regression models, so establishing causality is impossible. These analyses have controlled for as many confounding factors as possible. Still, there are likely other factors at play that are not included in our models due to data limitations and being unknown. Also, these analyses looked at each equity dimension separately and did not look at overlapping equity dimensions, which is an important consideration. For example, a mother from the *terai* and a socially excluded caste versus a mother from the *terai* but from an upper caste would fare differently. However, this could not be considered as this would greatly complicate the analyses given the number of potential combinations and in turn, magnify challenges related to statistical power and multiplicity.

As Nepal continues to tackle maternal and child malnutrition, it will be important to keep equity in mind regarding monitoring outcomes by sub-population and designing and implementing interventions so that all segments of the population can engage. Future research studies should ensure they are powered and designed to be able to explore not only the overall effect of interventions but also programmatic effects among sub-populations. Similarly, mixed-methods work will be important to understand the obstacles to intervention reach and uptake of key behaviors among different populations. Additional formative research may also be helpful in enhancing the intervention design itself, to ensure key program interventions are tailored to meet the needs of the communities they serve. While this study contributes to a global evidence base on the importance of intervention intensity, more research is needed to understand exactly how much of each intervention and in what combination and sequence is most effective for effective SBC for all population groups. This type of information would ensure that donors and implementers are well-informed and that investments have the biggest payoff possible for the target populations.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: these datasets have been submitted to USAID. The data used for these analyses are available from the first and corresponding authors, per request. Requests to access these datasets should be directed to Kenda Cunningham, kcunningham@hki.org and Ramesh Adhikari, RPAdhikari@hki.org.

Ethics statement

The studies involving humans were approved by Nepal Health Research Council, Kathmandu, Nepal. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

KC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. RA: Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. PG: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. SS: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. JC: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. AS: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. MS: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. KG: Conceptualization, Writing – original draft, Writing – review & editing. PP: Conceptualization, Writing – original draft, Writing – review & editing. DA: Funding acquisition, Writing – original draft, Writing – review & editing.

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Conflict of interest

Kenda Cunningham, Pooja Pandey Rana, Ramesh P. Adhikari, Manisha Shrestha and Kristine Garn were members of team that designed and implemented Suaahara, the program discussed in this article. Debendra P. Adhikari was affiliated with the donor; he reviewed the manuscript and provided interpretation of the results. Final decisions for content were made by the lead author.

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Effectiveness of a technical support program with women's self-help groups in catalyzing health and nutrition behaviors in Bihar—a multicomponent analysis

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Introduction: Bihar Rural Livelihoods Promotion Society launched the JEEViKA program in 2007 to improve livelihoods through the Self-Help Group (SHG) platform. Women's SHGs have shown members' health improvements by promoting awareness, practices and access to services. This study investigates whether Health & Nutrition (HN) interventions delivered by JEEViKA Technical Support Program (JTSP) via SHG platforms could improve maternal and newborn health and nutritional behaviors in rural Bihar.

Methods: Annual Household Survey and Married Women of Reproductive Age (MWRA) studies of Bihar Technical Support Unit were used to analyze the effectiveness of JTSP on HN behaviors for mother and their infants in Bihar during 2016–21. Descriptive analysis followed by multivariable (binary and multinomial) logistic regressions were conducted to determine the distribution of and associations between various individual/community and programmatic exposures and outcomes of interest.

Results: During 2016–2021, in Bihar, statewide increase (32 to 47%) in SHG membership across all population strata and expansion of HN layering of JTSP from 101 to 349 blocks corroborated with improvements in Maternal-Newborn-Child Health & Nutrition (MNCHN) indicators in JTSP blocks and SHG members. Substantial increase was observed in ≥3ANC visit (9% points), institutional delivery (10%), skin-to-skin-care (17%), dry cord-care (23%), early initiation of breastfeeding (19%) & complementary feeding (9%). Adjusting for socio-demographic factors and Front-Line Workers' (FLWs') advice/counseling, multivariable logistic regression revealed that SHG member in JTSP blocks delivering post-intervention (2021) were more likely (vs 2016) to practice: ≥3ANC visits (Adjusted Odds Ratio: aOR = 1.48, $p < 0.0001$), institutional delivery (aOR = 1.71, $p < 0.0001$), skin-to-skin care (aOR = 3.16, $p < 0.0001$) and dry cord-care (aOR = 2.64, $p < 0.0001$), early initiation of breastfeeding (aOR = 1.61, $p < 0.0001$), complementary feeding ($aOR_{6\text{-}8\ months} = 1.48$, $p < 0.0001$) and minimum dietary diversity ($aOR_{6\text{-}8\ months} = 1.24$). Better mobility, decision making, economic independence and overall empowerment were also evident among SHG member MWRA as opposed to non-members after both phases.

Discussion: The results highlight successful HN integration in JEEViKA by JTSP, demonstrating its effectiveness in integrating with State Rural Livelihoods Mission community platforms. JTSP showcases collaboration within a government system and emphasizes systematic introduction and strengthening at multiple levels. This integration has enabled JEEViKA systems to self-sustain its own HN implementation processes, paving the way for cross-sectoral comprehensive delivery mechanisms for social development.

KEYWORDS

self-help groups, JEEViKA technical support program, maternal health, newborn care, child nutrition, social development, women empowerment

Introduction

There has been substantial evidence suggesting economic growth with the incorporation of a well-developed and inclusive financial system, which in turn reduces income inequality and poverty (1). With the concept of financial system for poor, India's Self-Help Group (SHG) movement started over 30 years ago using micro-financing as a tool to alleviate poverty and to empower women via financial inclusion. Since then it has emerged as the world's largest women-owned community-based microfinance institution (2, 3). Similar groups based on the development of micro-finance institutions have been found in Kenya (4), Nigeria (5), Ghana (6, 7), Guatemala (7), and South East Asia (8). The concept of SHGs in India involves informal groups of 10–20 women having similar socio-economic background and living in close proximity. They come together for mutual aid and benefit with sources of finance via non-government organizations (NGOs) and nationalized banks (2, 9). Each member of the SHG contributes an amount of Rs 10 to Rs 100 to be deposited in the bank, and basis that the group can obtain loans from the bank out of their own funds (8). The SHG comprises of 2–3 elected leaders in the group, who maintain simple accounts of this collected money and given loans (10). The members conduct regular meetings of the SHG at periodic intervals, mostly once in a month (11). These microfinance institutions that offer small loans for self-employment help enhance livelihoods and quality of life (12–14). Several studies have shown the positive impact of SHGs on women's economic, social and political aspects (15–19). In developing nations, SHG membership is being promoted to improve access to credit and mobilize microfinancing (20). These women SHG-members come from marginalized and economically disadvantaged background, mostly rural, with minimal or no land ownership, low literacy levels, and lack agency on their own health and financial aspects (3, 21). The majority of the SHG women belong to the middle age group (36–50 years) (22–25). Several studies from India have investigated the factors influencing SHG membership, and have found that SHG membership tends to increase with the age of women, which might be attributed toward the greater social mobility for women in traditional settings as they take on caregiving roles within their families (26–29).

Research demonstrates women's SHGs as an opportunity to health improvement by increasing knowledge on healthy practices in the community that leads to behavioral changes, and by enhancing access to health-related services to the poor and marginalized communities through addressing financial, geographic and other barriers (30–33). In 1970, a community development initiative in Jamkhed, Maharashtra, India, used participatory approach, identified and trained women as health workers and provided with funds for health emergencies. Over the first 20 years, this program significantly improved health outcomes with infant mortality rates dropping from 176 to 19 per 1,000 live births, and the birth rate falling from 40 to 20 per 1,000 people. Access to antenatal care, safe delivery, and immunization became nearly universal, while malnutrition rates decreased from 40% to under 5% (34, 35). Another study on integrating a micro-credit forum with family planning and immunization programs revealed that membership in the forum positively impacted maternal knowledge of prenatal care, led to increased use of contraceptives, and contributed to a decline in fertility rates (36). Likewise, in a village in rural India, presence of SHG have shown increased knowledge of family planning and maternal health service uptake in the community (37). A systematic review of randomized controlled trials demonstrated the positive impact of community based women's groups on neonatal mortality across socioeconomic strata in a multi-country meta-analysis (38). Evidence also suggests significant impact of group-based nutrition behavior change communication (BCC) interventions on maternal and child nutrition and feeding practices as well as hygiene behavior, addressing undernutrition and health practices in the community (39–41). While substantial evidence indicates that interventions involving women's groups have a positive impact on health, questions remain about the coverage and effectiveness of these approaches when implemented on a larger scale. In addition, mixed results in the outcome have been common as well while implementing health interventions via SHGs, involving no significant impact on some outcome variables (42, 43). But with the reach and scale of SHG platforms, these studies indeed suggest the potential of these women groups to effectively extend the impact of thematic interventions by reaching more women and their families to encourage positive behaviors, leading to better outcomes.

With the vision of social & economic empowerment of the rural poor in the state of Bihar (India), Bihar Rural Livelihoods Promotion Society (BRLPS) under jurisdiction of the state Government of Bihar, with support from the World Bank, launched an ambitious program known as JEEViKA (meaning *"livelihood"*). The aim was to mobilize women through SHGs in rural Bihar and empower them with strategies to improve livelihoods and economic security. It started in the year of 2007 in 6 blocks of 6 districts of Bihar with plan for scale up to the entire state, and by 2014, JEEViKA had already formed around 350,000 SHGs across all the districts of Bihar (44, 45). The key purpose of Jeevika was to bring socio-economic change in rural Bihar, by mobilizing women from impoverished households into SHGs and then delivering targeted funds for credit, food security, health emergencies, and livelihood opportunities (46, 47). In the early stages

of the Jeevika intervention, evidence from a randomized controlled trial had observed a reduction in the debt and asset build up in the SHG (46).

Though the primary purpose of SHGs has been to economically empower women and communities, but with its broad population coverage, the platform has also been sought after to deliver development by layering it with various thematic interventions (48). Thus, considering health interventions layering onto SHG platforms, an NGO (Project Concern International (PCI)) led pilot project called Parivartan (meaning *"transformation"*) was implemented in 2011 funded by the Bill & Melinda Gates Foundation (BMGF). The strategic objectives were to influence specific maternal, newborn, & child Health, Nutrition and Sanitation (HNS) behaviors among women of reproductive age from the most marginalized communities in 8 programmatically prioritized districts in Bihar, by forming its own SHGs, and using this platform to promote healthy behaviors via community mobilization (45). The conceptual success of the Parivartan project and the need to address health and nutritional issues of women and children in an improved livelihood scenario with better economic stability, led to the idea of leveraging the SHG platform via JEEViKA at a larger scale to improve the maternal and child health and nutritional outcomes in the state. Thus in 2014, to test the feasibility of similar (Parivartan-like) interventions among JEEViKA groups and to learn how to work with the JEEViKA groups before suggesting a significant scale-up of HNS integration within the JEEViKA network, the Parivartan project was expanded to 9 more blocks with existing JEEViKA SHG networks. Findings from an evaluation showed encouraging results across most RMNCH indicators in the Parivartan intervention (49). It observed improved use of contraceptive methods, institutional delivery, skin-to-skin care, delayed bathing, timely initiation and exclusive breastfeeding, age-appropriate immunization among the SHG women as opposed to non-SHG (31). Similarly, another randomized controlled trial on a pilot intervention of health and nutrition BCC via Jeevika SHGs has demonstrated significant impacts on women and child dietary diversity, and consumption of iron–folic acid (IFA) tablets and calcium tablets for pregnant women, using strategic pathways of delivering key messages through the SHG platform and enhancing the knowledge on health and nutritional aspects for women (50). Empowerment being a key conceptual idea of JEEViKA's SHG platforms, several defining components of women empowerment such as mobility, decision making and economic independence were also within the pursuit of the interventions among women of reproductive age (15–49 years).

Ultimately, with the vision of layering HNS onto JEEViKA SHG network, a government-led initiative was conceptualized to provide technical support to JEEViKA by PCI in 2015, called JEEViKA Technical Support Program (JTSP). It started with the goals to provide better quality of life in terms of improved health, nutrition, and sanitation outcomes among the poorest and most marginalized populations (with a special focus on women and children) in Bihar. Objectives were to integrate health and nutrition within JEEViKA program's mandate; and to drive innovation and evidence-based approaches and capacity within JEEViKA to scale-up through their SHGs across Bihar. The first phase of JTSP took place between 2015 and 2018 in 101 blocks of 11 districts, with the layering of HNS interventions to JEEViKA at the state, district and block levels. During phase I, JTSP piloted a multi-touch point integrated HNS package, with three main interventions. SHG-level monthly roll out of 15 HNS themes were conducted, wherein the first weekly SHG meeting was designated for HNS activities, in which the community mobilizer would interact with the SHG members to build an environment, consensus and awareness on the HNS theme. Household level visits of target beneficiaries by designated members of the village organization (VO) called the health subcommittees (HSC), where JTSP developed tools to reinforce key messages and help the target beneficiary adopt relevant health and nutrition practices. Community based awareness events focused on various themes such as exclusive breastfeeding, diarrhea prevention and management, as well as complementary feeding.

Further, the second phase of JTSP initiated with a scale-up in 2018 and ended in 2020, during which the HNS interventions were expanded to 349 blocks of 35 districts of Bihar. During this phase, HNS became a mandate to JEEViKA, making all the related entities and people responsible for HNS along with JEEViKA's economic empowerment and livelihood programs. By 2018, a dedicated community cadre for Health and Nutrition (HN) had been introduced in the system, comprising of the Master Resource Person (MRP) at cluster level, and the Community Nutrition Resource Person (CNRP) at the panchayat level. The strategy of inviting Front-Line Workers (FLWs) to attend meetings and events helped them better engage in community-level campaigns. The evolution of JTSP's supportive work with JEEViKA led to the development of a multi-pronged behavior change intervention package (with multiple exposures) which was rolled out across Bihar, through JEEViKA community-based organizations as shown in Figure 1. The evolution of JTSP across phases through its expansion and modifications are explained in Figure 2.

This paper presents the findings from studies conducted by Bihar Technical Support Unit (BTSU), as part of a decade long statewide system strengthening effort, independent of the JTSP implementation. We hypothesized that HN interventions delivered with the support of JTSP via JEEViKA's SHG platforms would help in improving healthy behaviors for mother and newborn in rural communities of Bihar, thus emphasizing the importance of a technical support program to deliver additional strategies/interventions from different sectors using ready to implement government-based platforms. To test this hypothesis there was a need to analyze program monitoring data generated independent of JTSP intervention, to investigate whether health & nutrition (HN) interventions delivered by JEEViKA Technical Support Program (JTSP) via SHG platforms could improve maternal and newborn health and nutritional behaviors in rural Bihar.

Materials and methods

Measures: key outcomes and covariates

The SHG membership was considered among those households where either recently delivered women (mothers of children aged 0–11 months) or any other women of that household was a member of SHG.

The key outcomes were considered under three domains - maternal health (ANC clinic visits and institutional delivery), newborn care (skin-to-skin care, dry cord-care, early initiation of breastfeeding) for children aged 0 to 2 months, and child nutrition

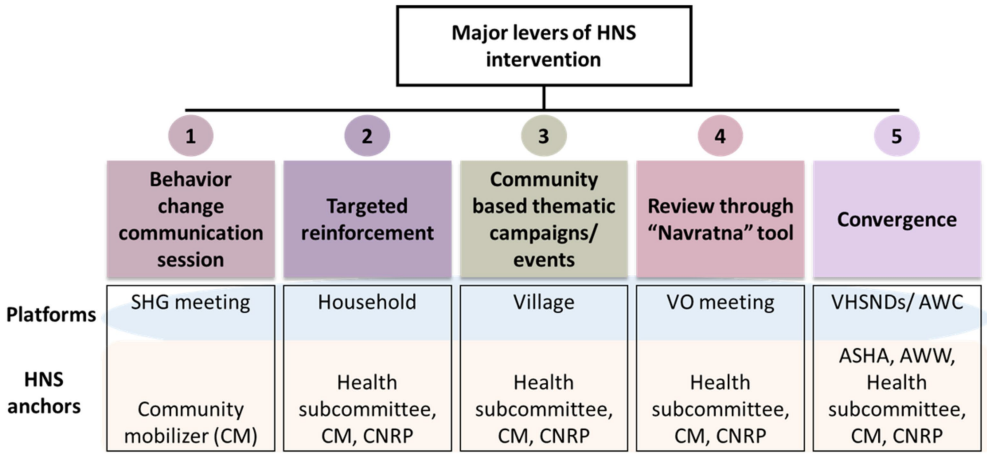

FIGURE 1
Five major levers of HNS intervention of JEEViKA technical support program (CNRP, Community Nutrition Resource Person).

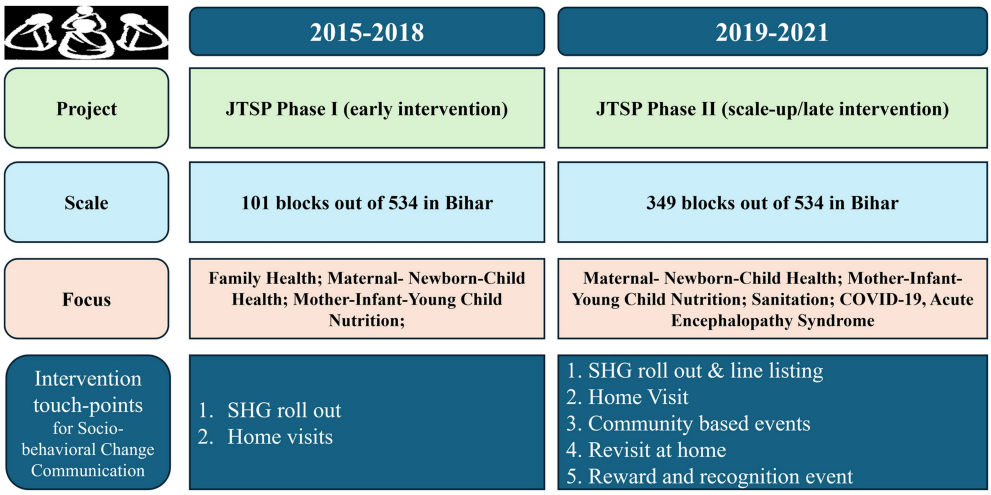

FIGURE 2
The evolution of JTSP through phases.

(initiation of complementary feeding, minimum acceptable diet, and minimum dietary diversity) for children aged 6 to 8 and 9 to 11 months.

Mothers of infants aged 0–2 months were enquired about the number of ANC clinic visits (to determine any, ≥3 & ≥4 ANC visit) made during their last pregnancy. Institutional delivery was defined as whether the mother of 0 to 2 months-old infant delivered her youngest child at a health facility (institution) or not. Whether or not the mother of 0–2 months-old infant had her baby kept naked on her chest, next to her skin immediately after delivering the baby constituted the practice of skin-to-skin care. The practice of dry cord-care was measured based on whether 'anything' or 'nothing' was applied to the cord immediately after cutting or later, until the cord fell off. The initiation of breast-feeding within an hour after birth was defined as early. All indicators of nutrition were defined based on IYCF guidelines and standard definitions. Timely initiation of complementary feeding was measured based on whether anything other than milk, water or medicine was fed to the infant after completing 6 months of age. For infants aged 6 to 8 months and 9 to 11 months, dietary diversity and minimum acceptable diet were measured using 24-h recall data. Whether or not the infant was given greater than or equal to four out of seven food groups constituted minimum dietary diversity. Minimum acceptable diet comprised of minimum dietary diversity as well as whether solid/semi-solid/soft food was given to the infant aged 6–8 months at least twice a day and to infants aged 9–11 months at least thrice a day.

To measure the impact of the program beyond health, indicators of women empowerment - mobility, economic independence, and women's participation in household decisions were included in the analysis. Responses to individual items under each of the three components were summed up to get an aggregate score which was categorized into "poor," "average," "good" based on tertile boundaries to measure overall level of women empowerment, along with individual component indicators of women empowerment.

Known socio-demographic indicators of health inequities and factors known to affect healthcare utilization were measured as potential confounders. This included mother's age, parity, religion, caste, education (years of formal education of the mother collected as a continuous variable and was adjusted in the regression models) and wealth tertile (based on tertile distribution of multi-components, pre-validated log-transformed asset index).

Led by a not for profit, non-governmental organization: CARE India Solutions for Sustainable Development, BTSU was functional since 2013, in all 38 districts of Bihar and was working closely with the State Government of Bihar under financial patronage of the Bill and Melinda Gates Foundation. As a Technical Support Unit, BTSU provided catalytic support to the Health and Social Welfare Departments of Government of Bihar (GoB) for systems strengthening in maternal and child health, family planning and nutrition interventions. The Concurrent Measurement and Learning (CML) Unit of BTSU conducted regular data collection on an ongoing basis to inform programs. In the present piece of work, data from Annual Household survey and Married Women of Reproductive Age (MWRA) study have been used to analyze the effectiveness of JTSP in Bihar for HN layering in SHGs during 2016–21. Using multistage cluster random sampling with systematic random sampling at the household selection with a random start, the studies used as the data source for this analysis did recruit a statewide representative sample of rural Bihar (for MWRA study it was both urban and rural Bihar).

Study design, participants and sampling strategy

The household survey

Several rounds of household surveys, concurrent with program implementation timelines, were conducted across Bihar, by BTSU, during 2011–2021 to assess changes in key HN indicators or healthy practices promoted via various interventions in the state. In these surveys, recently delivered mothers of children aged 0 to 2, 3 to 5, 6 to 8, 9 to 11, and 12 to 23 months were interviewed to understand their health-related practices for themselves during pregnancy, neonatal care, child nutrition, and immunization. In the present work, data from 2016 to 2021 have been analyzed.

Sample size was estimated using binomial formula for a proportion with finite population correction: $n = [p(1\text{-}p)\ ^*N]/[N^*D + p\ (1\text{-}p)]$; where p = expected proportion (here 0.5 was used to be most conservative); N = Total population size; $D = B^2/(Z\alpha/2)^2$; where: B is half of the width of the desired confidence interval.

The surveys included samples from all blocks of all districts (38) of Bihar. The required number of Anganwadi Centers (AWCs: based on sample size calculation and least possible number per block being 19) were randomly sampled from the list of all AWCs per block and 1 sample (consisting of one child from each of the five age groups) per selected AWC selected systematically. In each selected AWC, after selecting the index house randomly, following a right hand rule (always move to right), households are selected with an interval of five to recruit the next eligible mother/child. Only one child was recruited in each household and the mother was interviewed. Thus, a total of 78,435 mothers (15,687 from each age group) were finally interviewed.

Survey of married women of reproductive age

It was a large survey across all 38 districts of Bihar conducted in multiple iterations in 2016, 2018, and 2021 to capture a comprehensive understanding of family planning interventions, behavior and practices from Married Women of reproductive age 15 to 49 years. The survey employed a multi-stage, stratified probability sampling technique in three stages - district, block and AWC/Ward. The sample size was calculated following the binomial formula: Assuming an α error of 5%, β error of 20% (power = 0.8) and absolute precision of 10%, the desired sample size for each district turned out to be 384 which got inflated to 576 after incorporating a design effect of 1.5. To account for 2–4% data loss, a rounded figure of 600 per district was decided upon.

To recruit the participants for the interview, 5 blocks and 120 AWCs were selected based on proportional allocation from each of the 38 districts. 'Buildings' or 'structures' containing human dwellings were identified from the sampled AWCs (for rural areas) and Wards (for urban areas) for conducting the interviews. Thus, the total sample of 22,800 (600*38 districts; MWRA) respondents were recruited and interviewed from the entire state during 2016 and 2018 while in 2021, 22,668 MWRAs were interviewed.

Reach of JTSP in the community via women's SHG platform and the effectiveness of HN interventions through these platforms on maternal, newborn and child health behaviors were determined using a representative sample of mothers with children aged 0–11 months in JTSP blocks of rural Bihar during Phase I and II.

Given that the JTSP program was ongoing in 101 blocks during 2016 and scaled-up to 349 blocks during 2018, the responses from participants of these blocks were analyzed to assess the program effectiveness on outcome indicators of interest (programmatically relevant to JTSP) using the samples of mothers having babies belonging to following 3 age groups: 0 to 2, 6 to 8, and 9 to 11 months from HHS.

The interviews were conducted using pre-tested structured digital questionnaires in Hindi language.

Statistical analysis

Descriptive [frequency, proportions and the corresponding 95% confidence Intervals (95% CIs)] analysis was conducted to determine the distribution of various parameters in the study population. Multivariable logistic regressions were conducted further to determine the associations between various individual, community and program related predictors and outcomes of interest, adjusting for potential confounders (respondents' age, religion, caste, education and wealth-tertile as well as corresponding FLW advice/counseling on specific practices). All analyses were conducted using SAS version 9.4.

Ethics approval

The study protocols and procedures were reviewed and approved by the Ashirwad Ethics Committee, Ashirwad Hospital & Research Center, Ulhasnagar, India. Verbal informed consent was obtained from each agreeing participant before the interview, after explaining the details of the study in the local language.

Results

Table 1 presents the expansion of SHG membership state-wide and in JTSP blocks during 2016 to 2021, describing the reach of JTSP among households of recently delivered women. At state level, the SHG membership increased from 32 to 47% in this period. In the 101 JTSP phase I blocks, the proportion of households with SHG members increased from 39% in 2016 to 46% in 2018. During the JTSP scale-up phase during 2018 to 2021, in 349 blocks, the households with SHG membership increased from 42% to ~48%.

Tables 2, 3 present the distribution of the participants and SHG households, across sociodemographic strata. Majority (both overall and in SHG households) were aged between 20 to 30 years, Hindu and multiparous. The distribution of SHG membership across sociodemographic strata revealed that during both Phases, I (2016 to 2018) and II (2018–2021), the membership increased substantially among recently delivered women as well as women of reproductive age (15–49 years) of all categories of age, parity, religion, wealth tertile/economic backgrounds and also among non-marginalized in JTSP blocks. During scale-up phase from 2018 to 2021, there has been slight increase (4–6%) in SHG membership of women belonging to all categories of ages, parity, religion (both Hindu & non-Hindu), caste (both marginalized & non-marginalized) and economic backgrounds.

During JTSP phases, corroborating rise in several Maternal-Newborn-& Child Health & Nutrition (MNCHN) indicators signified the uptake of recommended practices related to health and nutrition by the recently delivered women with children aged 0–11 months. Pre-post comparison for Phase I (2016 vs. 2018) revealed increased ANC visit by pregnant women in JTSP-Phase I blocks (101): 42 to 53% for ≥3 and 23 to 28% for ≥4 visits. The institutional delivery increased in JTSP blocks from 73 to 80%. During the same phase, in those blocks, the practice of newborn care with indicators such as skin-to-skin care, dry cord-care and early initiation of breastfeeding also improved to 50, 51 and 74% from 36, 44, and 65%, respectively. The nutritional practices by mothers improved showing a 13 and 11% rise in initiation of complementary feeding for children aged 6–8 months and 9–11 months respectively, whereas, the practices almost doubled for minimum dietary diversity (6 to 10% for 6–8 months and 14 to 24% for 9–11 months) and minimum acceptable diet (5 to 9% for 6–8 months and 11 to 18% for 9–11 months) in both the age groups.

Post-Phase II, in JTSP-Phase II blocks (349): improvement was observed in ANC visits for ≥3 (51 to 62%) and ≥ 4 visits (29 to 36%) by the pregnant women from 2016 to 2021. A 10% rise in institutional delivery was observed during the span. Remarkable rises in newborn care practices such as skin-to-skin care (32 to 59%), dry cord-care (41 to 64%) and early initiation of breastfeeding (62 to 71%) were also recorded during the scale-up phase. The nutritional practices improved with initiation of complementary feeding for both children aged 6–8 months (51 to 60%) and 9–11 months (74 to 84%). The minimum dietary diversity (14 to 17%) and minimum acceptable diet (11 to 14%) also increased for children aged 9–11 months (Table 4).

Adjusting for socio-demographic factors such as caste, religion, education, wealth index and parity, as well as FLW advice/counseling on relevant MNCHN practices, it was observed that post JTSP Phase I (in 2018), ANC visits had higher odds of happening for any visit, 3 or more visits, and 4 or more visits, as compared to 2016. Higher odds (aOR = 1.44, $p < 0.0001$) for institutional delivery was also noticed. The newborn care practices were significantly improved for skin-to-skin care, dry cord-care, and early initiation of breastfeeding post JTSP Phase I ($p < 0.0001$). As for nutritional practices, statistically significant positive associations were found for initiation of complementary feeding, minimum dietary diversity and minimum acceptable diet with JTSP Phase I.

Post scale-up in 2021, pregnant women had significantly higher odds of ANC visits as opposed to 2016. The odds of institutional delivery were also higher (aOR = 1.71, $p < 0.0001$). Newborn care practices such as skin-to-skin care (aOR = 3.16, $p < 0.0001$) and dry cord-care (aOR = 2.64, $p < 0.0001$) were practiced more. The early initiation of breastfeeding was also more in 2021 as opposed to 2016. Nutritional practices including initiation of complementary feeding, minimum dietary diversity and minimum acceptable diet for both 6–8 and 9–11 months old children were significantly higher in 2021, compared to 2016 (Table 5).

Certain parameters to measure women empowerment among MWRA (15–49 years) were also compared between members and non-members of SHG in JTSP blocks. At the end of Phase I (2018) in the JTSP blocks, good mobility (52% vs. 37%), decision making (72% vs. 64%), economic independence (13% vs. 6%), and overall women empowerment (51% vs. 32%) were reported by more SHG member MWRA as opposed to their non-member counterparts. Likewise, at the end of Phase II in 2021, good mobility (55% vs. 39%), decision making (62% vs. 56%), economic independence (11% vs. 5%) and overall women empowerment (40% vs. 33%) were reported by more SHG member MWRA as compared to non-member MWRA (Table 6).

TABLE 1 Reach of SHG membership during the duration of JEEViKA Technical Support Program (JTSP) among families of recently delivered (in last 1 year) women in Bihar.

Year	Statewide (All 534 blocks)			Phase I (101 JTSP blocks)			Phase II (349 JTSP blocks)		
	N	N	Percent (95% CI)	N	n	Percent (95% CI)	N	n	Percent (95% CI)
2016	62,667	20,832	32.0 (31.6–32.4)	11,184	4,482	38.6 (37.6–39.6)	–		
2017	62,748	25,198	38.6 (38.2–39.0)	11,184	5,052	44.0 (43.0–45.0)			
2018	62,748	27,819	42.7 (42.3–43.2)	10,044	4,775	46.1 (45.1–47.2)	41,508	18,318	42.0 (41.5–42.6)
2019	62,748	27,830	42.9 (42.4–43.3)	–			41,508	18,392	42.6 (42.0–43.1)
2020	62,748	31,218	48.6 (48.2–49.0)				41,508	20,724	48.3 (47.8–48.9)
2021	62,748	30,392	47.4 (46.9–47.8)				41,507	20,161	47.2 (46.6–47.7)

N refers to the total sample of women who delivered in last one year across different sets of blocks in Bihar in specific years. n refers to the total number of women from SHG families, who delivered in last one year across different sets of blocks in Bihar in specific years.

TABLE 2 SHG membership across sociodemographic strata among mothers of children aged 0–11 months in JTSP blocks of Bihar (2016–2021).

Sociodemographic strata		Phase I (101 blocks)						Phase II (Scale up: 349 blocks)					
		2016 (*N* = 11,184)			2018 (*N* = 10,044)			2018 (*N* = 41,508)			2021 (*N* = 41,507)		
		N	SHG membership (4482)		N	SHG membership (4775)		N	SHG membership (18318)		N	SHG membership (20161)	
			n	Percent (95% CI)		n	Percent (95% CI)		n	Percent (95% CI)		N	Percent (95% CI)
Age (in years)	Below 20	1,285	527	11.8 (10.8–12.7)	1,023	498	10.4 (9.6–11.3)	3,593	1,662	9.1 (8.7–9.5)	3,242	1,575	7.8 (7.4–8.2)
	20–30	9,099	3,607	80.5 (79.3–81.6)	8,459	3,991	83.6 (82.5–84.6)	35,279	15,458	84.4 (83.9–84.9)	35,750	17,307	85.8 (85.4–86.3)
	31–40	378	178	4.0 (3.4–4.5)	308	151	3.2 (2.7–3.7)	1,362	629	3.4 (3.2–3.7)	1,325	660	3.3 (3.0–3.5)
	More than 40	422	170	3.8 (3.2–4.4)	254	135	2.8 (2.4–3.3)	1,274	569	3.1 (2.9–3.4)	1,190	619	3.1 (2.8–3.3)
Parity*	0 or 1	3,258	1,233	27.6 (26.3–28.9)	2,924	1,310	27.4 (26.2–28.7)	12,620	5,181	28.3 (27.6–28.9)	12,089	5,374	26.7 (26–27.3)
	2	3,146	1,173	26.2 (24.9–27.5)	2,861	1,277	26.7 (25.5–28.0)	11,812	4,958	27.1 (26.4–27.7)	12,947	6,003	29.8 (29.1–30.4)
	More than 2	4,748	2066	46.2 (44.7–47.7)	4,259	2,188	45.8 (44.4–47.2)	17,076	8,179	44.7 (43.9–45.4)	16,471	8,784	43.6 (42.9–44.3)
Religion	Hindu	9,880	4,085	91.1 (90.3–92)	8,990	4,372	91.6 (90.8–92.3)	36,188	16,635	90.8 (90.4–91.2)	36,104	18,272	90.6 (90.2–91.0)
	Non-Hindu	1,304	397	8.9 (8.0–9.7)	1,054	403	8.4 (7.7–9.2)	5,320	1,683	9.2 (8.8–9.6)	5,403	1889	9.4 (9.0–9.8)
Caste	Marginalized	3,108	1,543	34.4 (33–35.8)	2,871	1,532	32.1 (30.8–33.4)	11,207	5,872	32.1 (31.4–32.7)	10,980	6,021	29.9 (29.2–30.5)
	Non-marginalized	8,076	2,939	65.6 (64.2–67.0)	7,173	3,243	67.9 (66.6–69.2)	30,301	12,446	67.9 (67.3–68.6)	30,527	14,140	70.1 (69.5–70.8)
Wealth tertile	Lower	3,883	1,560	34.8 (33.4–36.2)	3,286	1,469	30.8 (29.5–32.1)	12,617	5,540	30.2 (29.6–30.9)	12,942	6,251	31.0 (30.4–31.6)
	Middle	4,032	1,677	37.4 (36.0–38.8)	3,253	1,659	34.7 (33.4–36.1)	13,990	6,593	36.0 (35.3–36.7)	13,984	7,164	35.5 (34.9–36.2)
	Upper	3,269	1,245	27.8 (26.5–29.1)	3,505	1,647	34.5 (33.1–35.8)	14,901	6,185	33.8 (33.1–34.4)	14,581	6,746	33.5 (32.8–34.1)

*Parity information was available for 11,152 participants in 2016. N refers to the total number of mothers of children aged 0–11 months in JTSP blocks of Bihar in specific years or in specific sociodemographic strata. n refers to the number of mothers of children aged 0–11 months of SHG families in JTSP blocks of Bihar in specific years, in specific sociodemographic strata.

Multinomial multivariable logistic regression revealed that Post JTSP Phase I in 2018, the SHG member MWRA in JTSP blocks had statistically significant better mobility, decision making, and economic independence as compared to their non-member counterparts. Overall, better empowerment was evidenced among SHG member MWRA as opposed to non-SHG member MWRA. Similarly, post Phase II in 2021, the mobility, decision making and economic independence had significant positive associations with SHG membership among MWRA. Overall, the women empowerment was positively ($aOR_{average} = 1.75$, $p < 0.0001$; $aOR_{good} = 2.73$, $p < 0.0001$) associated with SHG membership in JTSP blocks (Table 7).

Similar positive associations were observed with ordinal logistic regression also (results not shown).

Discussion

Leveraging upon SHG platforms emerged as one of the major approaches of Indian government underlying the National Rural Livelihood Mission to support women in engaging in livelihood activities and rural development. By 2022, SHGs have already reached out to 79 million households in India and ~ 12 million households in Bihar (51). Though the SHGs primarily are directed toward rural development interventions, but with such an extended reach to households, they also provide a huge platform to reach out to community to deliver additional services, awareness and information (52). The current study also reveals about 47% households (having a mother of an infant) in Bihar (349 blocks) with at least one SHG member in 2021. Thus, these platforms provide a social medium for creating awareness on RMNCH through various strategies with an unprompted community mobilization among SHG members. Furthermore, cross-sectoral approaches are required more to meet the global needs in health and have potential for simultaneous achievement of both economic and health gains (30), and leveraging extensive SHG platforms has been a promising strategy. Several studies have demonstrated the impact of participatory communication with women's groups on healthy behaviors, safe practices, and better MNCH and nutrition outcomes (31, 49, 53). Such an extending and growing platform provides a number of opportunities to leverage groups as a platform for intervention delivery and reach out to many women at once with resources and information, thus providing a massive coverage. Additionally, integration of HN interventions onto existing SHG platforms also provides an organized structure ready to disperse additional interventions (32). Moreover, such platforms are optimal for behavior change interventions as they provide multiple touch points, involving community, peers and family members thus allowing for ample exposure and dosage of interventions to the target population to bring about a noticeable and sustainable change.

In concurrence to the extensive reach of the SHG platform and its usage for additional health and BCC interventions, our study results also suggested the reach of the program increasing among all strata of population, more among marginalized women, leaving no one behind.

Evidence has suggested that the delivery of development interventions through SHGs could potentially be cost-effective in provision of services at scale. Several studies have shown the maternal and newborn health interventions to be highly cost-effective when delivered through mobilized women's groups, suggesting that the usage of SHGs for health interventions can lead to cost advantages at a larger scale (54–58). As JEEViKA's vision was to form approximately

TABLE 3 SHG membership across sociodemographic strata among married women of reproductive age (15 to 49 years) in JTSP blocks of Bihar (2016–2021).

Sociodemographic strata		Phase I						Phase II (Scale up)					
		2016 (*N* = 4,319)			2018 (*N* = 3,645)			2018 (*N* = 15,771)			2021 (*N* = 15,223)		
		N	SHG membership (1001)		N	SHG membership (1412)		N	SHG membership (5124)		N	SHG membership (5731)	
			n	Percent (95% CI)		n	Percent (95% CI)		n	Percent (95% CI)		N	Percent (95% CI)
Age (in years)	Below 20	281	21	2.1 (1.2–3.0)	312	43	3.0 (2.1–3.9)	1,172	142	2.8 (2.3–3.2)	760	78	1.4 (1.1–1.7)
	20–30	2,170	451	45.1 (42.0–48.1)	1852	671	47.5 (44.9–50.1)	7,808	2,332	45.5 (44.1–46.9)	7,128	2,252	39.3 (38.0–40.6)
	31–40	585	162	16.2 (13.9–18.5)	488	240	17.0 (15.0–19.0)	2075	844	16.5 (15.5–17.5)	1972	889	15.5 (14.6–16.4)
	More than 40	1,283	367	36.7 (33.7–39.6)	993	458	32.4 (30.0–34.9)	4,716	1806	35.2 (33.9–36.6)	5,363	2,512	43.8 (42.5–45.1)
Parity	0 or 1	829	78	7.8 (6.1–9.5)	693	95	6.7 (5.4–8.0)	3,103	389	7.6 (6.9–8.3)	2,812	431	7.5 (6.8–8.2)
	2	804	144	14.4 (12.2–16.6)	723	243	17.2 (15.2–19.2)	3,142	838	16.4 (15.3–17.4)	3,390	996	17.4 (16.4–18.4)
	More than 2	2,686	779	77.8 (75.2–80.4)	2,229	1,074	76.1 (73.8–78.3)	9,526	3,897	76.1 (74.9–77.2)	9,021	4,304	75.1 (74–76.2)
Religion	Hindu	3,819	922	92.1 (90.4–93.8)	3,216	1,275	90.3 (88.8–91.8)	13,627	4,631	90.4 (89.6–91.2)	13,425	5,185	90.5 (89.7–91.2)
	Non-Hindu	500	79	7.9 (6.2–9.6)	429	137	9.7 (8.2–11.2)	2,144	493	9.6 (8.8–10.4)	1798	546	9.5 (8.8–10.3)
Caste	Marginalized	1,191	352	35.2 (32.2–38.1)	871	388	27.5 (25.2–29.8)	3,947	1,662	32.4 (31.2–33.7)	2,983	1,446	25.2 (24.1–26.4)
	Non-marginalized	3,128	649	64.8 (61.9–67.8)	2,774	1,024	72.5 (70.2–74.8)	11,824	3,462	67.6 (66.3–68.8)	12,240	4,285	74.8 (73.6–75.9)
Wealth tertile	Lower	1,383	362	36.2 (33.2–39.1)	1,289	552	39.1 (36.5–41.6)	4,881	1894	37.0 (35.6–38.3)	4,757	2,187	38.2 (36.9–39.4)
	Middle	1,525	398	39.8 (36.7–42.8)	1,211	514	36.4 (33.9–38.9)	5,337	1948	38.0 (36.7–39.3)	5,199	2,176	38.0 (36.7–39.2)
	Upper	1,411	241	24.1 (21.4–26.7)	1,145	346	24.5 (22.3–26.7)	5,553	1,282	25.0 (23.8–26.2)	5,267	1,368	23.9 (22.8–25.0)

N refers to the total number of married women of reproductive age (15 to 49 years) in JTSP blocks of Bihar in specific years or in specific sociodemographic strata. n refers to the number of married women of reproductive age (15 to 49 years) of SHG families in JTSP blocks of Bihar in specific years, in specific sociodemographic strata.

1 million SHGs by 2020, across all blocks in the state of Bihar, JTSP exerted a multi-model approach by providing technical support to JEEViKA to transform lives and improve health outcomes through the social and economic empowerment of poor women and their families participating in the JEEViKA SHGs in Bihar. Such multi-model approach provides an efficient way of introducing several services through one platform with the complementarity of interventions. Sharma et al. (59) has also demonstrated the positive impact of a community-based intervention on both the health and economic outcomes of marginalized women (59). Considering the larger program implementation picture, JTSP enabled JEEViKA to design the Social Behavior Change package, keeping multiple levels of stakeholder influence in mind, not only targeting the individuals for HNS behavior change but also influencing family, community, leaders of community-based organizations and FLWs. The program identified barriers to key HNS behaviors and worked toward them to trigger awareness, action, review and change in practices. Alike others (60), our findings revealed the positive outcome of JTSP interventions with associated increase in uptake of maternal and newborn care practices such as ANC visits, institutional delivery, skin-to-skin care, dry cord-care, and early initiation of breastfeeding in the community. Nutrition related interventions were designed to achieve outcomes related to breastfeeding (early initiation and exclusive) and complementary feeding (dietary diversity in particular) among SHG members. Promising results are shown in the findings with improvement in initiation of complementary feeding, minimum dietary diversity and minimum acceptable diet among children aged 6–11 months during the intervention period (both phases). In line with our study findings, several studies have highlighted the implementation of health interventions via women's groups with positive outcomes on maternal and newborn health behaviors (37, 42, 49, 57, 61, 62). The systematic plan of determining MNCHN related behavioral practices in the community, analyzing barriers, designing specific interventions, developing key messages toward doable actions, ensuring optimum reach and exposure during implementation, as well as quality probably led to positive outcomes across all domains, thus highlighting the influence of interventions like JTSP in the community.

Another aspect of women's ability to sustain healthy behaviors for themselves and their children is coupled with their empowerment. Several strategies that can be adopted to empower women include provision of livelihood options, financial independence, encouraging them to compete for leadership positions in the community, gender-equitable division of labor in household, building perceptions of autonomy and self-wellbeing, improving women's negotiation skills with their normative boundaries, and others (16). Self-confidence, familial and community support help a women to make better and informed decisions toward her own and children's health (63). SHGs emerged as a platform for women development enabling them to collectively identify the problems in their social and economic environment. Among limited published evidence, a systematic review found that these platforms indeed have positive impact on women's mobility and economic empowerment (64). Another qualitative study found that access to funds via community platforms did improve women's independence and decision making (65). This corroborates to the current findings of enhanced empowerment among women SHG members in terms of their mobility, decision making and economic independence and overall empowerment as opposed to non-SHG members.

TABLE 4 Uptake of recommended MNCHN practices by mothers of children aged 0–2 months, 6–9 months and 9–11 months across JTSP blocks pre-post phase 1 and phase II (Scale-up).

Practices	Age category (months)	Phase I (101 blocks)						Phase II (Scale up: 349 blocks)					
		2016			2018			2016			2021		
		N	Doing recommended practice		N	Doing recommended practice		N	Doing recommended practice		N	Doing recommended practice	
			n	Percent (95%CI)		n	Percent (95%CI)		n	Percent (95%CI)		n	Percent (95%CI)
Any visit to ANC clinic	0 to 2	2,796	2,689	96.2 (95.4–96.9)	2,505	2,430	97.3 (96.6–97.9)	10,376	10,122	97.5 (97.2–97.8)	10,364	10,175	98.2 (97.9–98.5)
≥3 visit to ANC clinic		2,773	1,125	41.8 (39.9–43.8)	2,430	1,258	52.5 (50.3–54.6)	10,309	5,183	50.8 (49.7–51.9)	10,175	6,286	62.2 (61.1–63.2)
≥4 visit to ANC clinic		2,773	607	23.3 (21.6–25.1)	2,430	657	27.6 (25.6–29.5)	10,309	2,870	28.7 (27.7–29.7)	10,175	3,631	36.4 (35.3–37.5)
Institutional delivery		2,796	2038	73.0 (71.2–74.8)	2,511	2018	80.3 (78.6–82.0)	10,376	7,589	72.5 (71.5–73.5)	10,377	8,603	82.9 (82.0–83.7)
Skin-to-skin care		2,561	941	35.9 (33.9–37.9)	2,257	1,122	49.6 (47.4–51.8)	9,322	2,923	32.1 (31.0–33.1)	9,170	5,507	59.3 (58.2–60.5)
Dry cord-care		2,346	1,067	44.0 (41.8–46.1)	2,183	1,109	50.9 (48.6–53.1)	8,856	3,683	40.9 (39.7–42.0)	9,157	5,909	64.1 (62.9–65.2)
Early initiation of breastfeeding		2,796	1798	64.8 (62.9–66.6)	2,511	1842	73.7 (71.9–75.5)	10,376	6,383	61.8 (60.7–62.8)	10,377	7,329	70.7 (69.8–71.7)
Exclusively breastfed in last 24 h		2,780	2,264	82.4 (80.9–83.9)	2,511	2035	81.0 (79.4–82.7)	10,275	8,051	79.6 (78.8–80.5)	10,377	8,327	81.0 (80.2–81.8)
Initiation of complementary feeding	6 to 8	2,796	1,257	46.6 (44.6–48.6)	2,511	1,437	59.5 (57.4–61.5)	10,376	5,266	50.6 (49.6–51.7)	10,377	6,171	60.0 (59.0–61.1)
	9 to 11	2,796	1865	68.8 (67.0–70.6)	2,511	1957	79.8 (78.1–81.4)	10,377	7,676	74.3 (73.4–75.2)	10,377	8,723	84.2 (83.5–85.0)
Minimum dietary diversity in children	6 to 8	2,796	148	5.5 (4.6–6.4)	2,511	248	9.9 (8.6–11.1)	10,376	625	5.7 (5.2–6.2)	10,377	814	7.4 (6.8–7.9)
	9 to 11	2,796	376	13.8 (12.4–15.2)	2,511	582	23.8 (22.0–25.6)	10,377	1,499	14.3 (13.5–15.0)	10,377	1923	17.4 (16.6–18.2)
Minimum acceptable diet	6 to 8	2,796	136	4.9 (4.1–5.8)	2,511	224	9.1 (7.9–10.4)	10,376	543	5.0 (4.5–5.4)	10,377	772	7.0 (6.4–7.5)
	9 to 11	2,796	302	10.7 (9.5–11.9)	2,511	419	17.6 (15.9–19.2)	10,377	1,185	11.1 (10.4–11.8)	10,377	1,596	14.3 (13.5–15.0)

N refers to the total number of mothers of 0–2/6–8/9–11 months old children in JTSP blocks of Bihar in specific years. n refers to the number of mothers of 0–2/6–8/9–11 months old children, who are doing recommended practices in JTSP blocks of Bihar in specific years.

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TABLE 5 Association* of recommended RMNCH practices by recently delivered mothers in JTSP blocks with JTSP intervention [both phase post-JTSP (2018 and 2021) as opposed to pre-intervention (2016)].

MNCHN indicators	Age category (months)	Phase I	Phase II (Scale up)
		Post-intervention (2018) [Ref: Pre (2016)]	Post-intervention (2021) [Ref: Pre (2016)]
		AOR*	AOR*
Made any ANC clinic visit (ref = not visited)	0 to 2	1.36 (1.30–1.42)	1.19 (1.15–1.23)
Made 3 or more ANC clinic visit (ref = not visited)		1.53 (1.51–1.56)	1.48 (1.46–1.49)
Made 4 or more ANC clinic visit (ref = not visited)		1.20 (1.17–1.22)	1.30 (1.29–1.32)
Institutional delivery (ref = no)		1.44 (1.41–1.46)	1.71 (1.69–1.73)
Provided skin-to-skin care (ref = no)		1.80 (1.77–1.83)	3.16 (3.13–3.19)
Provided dry cord-care (ref = no)		1.33 (1.31–1.35)	2.64 (2.62–2.67)
Initiated early on breastfeeding (ref = no)		1.58 (1.55–1.60)	1.61 (1.59–1.62)
Exclusively breastfed in last 24 h (ref = no)		0.92 (0.90–0.94)	1.14 (1.13–1.16)
Initiated on complementary feeding (ref = no)	6 to 8	1.68 (1.66–1.71)	1.48 (1.46–1.49)
	9 to 11	1.83 (1.80–1.86)	1.82 (1.80–1.84)
Received minimum dietary diversity (ref = no)	6 to 8	1.83 (1.78–1.89)	1.24 (1.21–1.26)
	9 to 11	1.87 (1.83–1.91)	1.19 (1.18–1.21)
Received minimum acceptable diet (ref = no)	6 to 8	1.88 (1.82–1.94)	1.37 (1.34–1.39)
	9 to 11	1.72 (1.68–1.76)	1.24 (1.23–1.26)

*Presented as adjusted odds ratios (considered statistically significant as $p < 0.0001$) from binary multivariable logistic regressions adjusted for caste, religion, education, wealth index, parity and FLW advice/counseling.

Alike any other observational study, the current study also had some important limitations. First of all, in the current study the effectiveness of the JTSP program was determined at the population level by comparing practices after the intervention periods (both phases) as opposed to before, not as an experimental study. Owing to the nature of the study being such an observational one, determined associations should not be interpreted as causal, although we tried to minimize the contribution of other pathways of change by controlling for the FLW counseling. This again may have resulted in underestimation of the effectiveness of the program by removing the indirect impact path of JTSP program through FLW channel (as JTSP program induced changes also likely to happen through FLW counseling owing to their engagement with SHGs). Self-reported nature of the practices may also be confounded by indication – those who were practicing may actually be recalling their exposure to FLW counseling better and thus likely to further reduce the magnitude of the associations observed. Despite these potentials for underestimation the substantial magnitude of observed positive associations suggests considerable impact of the JTSP program on the positive deviances in MNCHN practices. The population subsections with better awareness regarding health and nutritional recommended practices may always more self-select themselves into SHG membership and non-response among them are less likely as opposed to their less aware counterparts. These could well generate the potential for selection bias while analyzing the SHG member group and the study samples. Self-selection into SHGs, may result in already existing better practices and behaviors among households with SHG membership confounding the relationship between SHG membership and health outcomes. We tried to minimize these by having a multistage random sampling method to recruit samples with very low non-response. Still the possibility of selection bias should not be ignored. Response bias is also common in studies like serial cross-sectional studies, but given the large universe from where the samples were selected, this was less probable in the current study. In this study the key outcomes were not hard outcomes with definitive clinical endpoints, rather they were mostly behavioral outcomes which have potential for social desirability bias, especially in case of self-reported nature like in this study. Although this kind of information bias are more likely to be non-differential (hence likely to culminate in underestimation of the program effectiveness for most of the binary outcome variables) because in non-JTSP block also there are sources of information regarding recommended practices, still there remains some possibility of such bias. There may also be recall bias given the self-reported nature of study from mothers about their health practices and behaviors, though we minimized the recall period to less than 3 months. There also remains potential for residual bias arising due to comparison of findings over time, although we tried to address this by adjusting for rounds of observation, in our regression models. Separate regression model was also run for each of the outcome variables to avoid issues arising out of multiple comparisons.

By virtue of the large sample size, robust analysis using multiple methods of modeling (Multinomial and Ordinal Multivariable Logistic Regressions) and numerous variables to examine the domains of enquiry, despite the limitations mentioned above, the current study could determine the effectiveness of the JTSP program with considerable precision and validity at the population level—which is a unique strength of the study. Generally, for these kinds of interventions at scale, it is quite impractical and infeasible to determine the attributional path for the population level changes. Hence it is expected that the findings of the current study are likely to inform the system strengthening programmatic efforts for health and nutrition through existing channels in the state of Bihar as well as elsewhere in similar settings.

TABLE 6 Women empowerment among SHG member (vs. non-members) married women of reproductive age (15-49 years) in JTSP blocks during phase I and phase II (Scale-up).

Characteristic	Category	Phase I – 2018 (*N* = 3,795)				Phase II (Scale-up) – 2021 (*N* = 15,223)			
		SHG members (*N* = 1,461)		Non-SHG members (*N* = 2,334)		SHG members (*N* = 5,731)		Non-SHG members (*N* = 9,492)	
		n	Percent (95% CI)	n	Percent (95% CI)	n	Percent (95% CI)	n	Percent (95% CI)
Mobility	Poor	331	22.7 (20.5–24.8)	994	42.6 (40.6–44.6)	1,478	25.8 (24.7–26.9)	4,214	44.4 (43.4–45.4)
	Average	375	25.7 (23.4–27.9)	479	20.5 (18.9–22.2)	1,126	19.6 (18.6–20.7)	1,550	16.3 (15.6–17.1)
	Good	755	51.7 (49.1–54.2)	861	36.9 (34.9–38.8)	3,127	54.6 (53.3–55.9)	3,728	39.3 (38.3–40.3)
Decision making	Poor	248	17.0 (15.0–18.9)	545	23.4 (21.6–25.1)	1,298	22.6 (21.6–23.7)	2,637	27.8 (26.9–28.7)
	Average	158	10.8 (9.2–12.4)	304	13.0 (11.7–14.4)	911	15.9 (14.9–16.8)	1,540	16.2 (15.5–17.0)
	Good	1,055	72.2 (69.9–74.5)	1,485	63.6 (61.7–65.6)	3,522	61.5 (60.2–62.7)	5,315	56.0 (55.0–57.0)
Economic independence	Poor	59	4.0 (3.0–5.0)	209	9.0 (7.8–10.1)	155	2.7 (2.3–3.1)	662	7.0 (6.5–7.5)
	Average	1,213	83.0 (81.1–85.0)	1988	85.2 (83.7–86.6)	4,959	86.5 (85.6–87.4)	8,383	88.3 (87.7–89.0)
	Good	189	12.9 (11.2–14.7)	137	5.9 (4.9–6.8)	617	10.8 (10.0–11.6)	447	4.7 (4.3–5.1)
Overall empowerment	Poor	138	9.4 (7.9–10.9)	466	20.0 (18.3–21.6)	681	11.9 (11.0–12.7)	2,181	23.0 (22.1–23.8)
	Average	584	40.0 (37.5–42.5)	1,133	48.5 (46.5–50.6)	2,277	39.7 (38.5–41.0)	4,208	44.3 (43.3–45.3)
	Good	739	50.6 (48.0–53.1)	735	31.5 (29.6–33.4)	2,773	39.7 (38.5–41.0)	3,103	32.7 (31.7–33.6)

TABLE 7 Association* of SHG membership with women empowerment among married women of reproductive age (15–49 years) in JTSP blocks during phase I and phase II (Scale-up).

Indicators	Category	Phase I (101 blocks) - 2018	Phase II (Scale-up: 349 blocks) – 2021
		SHG members (Ref: Non-SHG member)	SHG members (Ref: Non-SHG member)
		AOR*	AOR*
Mobility (Ref: Poor)	Average	2.11 (2.04–2.17)	1.87 (1.84–1.90)
	Good	2.28 (2.22–2.34)	2.15 (2.12–2.18)
Decision making (Ref: poor)	Average	1.17 (1.12–1.22)	1.24 (1.22–1.26)
	Good	1.60 (1.55–1.64)	1.44 (1.42–1.46)
Economic independence (Ref: poor)	Average	2.34 (2.22–2.46)	2.69 (2.61–2.77)
	Good	4.77 (4.49–5.08)	5.37 (5.18–5.56)
Empowerment (Ref: poor)	Average	1.74 (1.68–1.80)	1.75 (1.72–1.78)
	Good	3.08 (2.97–3.20)	2.73 (2.68–2.78)

*Presented as adjusted odds ratios (considered statistically significant as $p < 0.0001$) from multinomial multivariable logistic regressions, adjusted for caste, religion, education, wealth index & parity.

Finally, the study results suggest successful HN Integration in JEEViKA with a Technical Support program, i.e., JTSP and provide evidence for the effectiveness of JTSP's multi-pronged social behavior change communication approach of integrating HN within State Rural Livelihoods Mission community platforms, as well as scalability to impact a larger community. JTSP provides learnings on how to work as a technical support program for the rural development and better livelihood working collaboratively within a government system. It provides evidence that the successful HNS integration within the rural livelihoods mission, needs systematic introduction and strengthening at multiple levels. This was achieved through several modalities such as policy-advocacy (at the national level, with partners and with JEEViKA's leadership), strategy development, capacity strengthening, quality monitoring, all of which enabled JEEViKA systems to own, and self-sustain its HNS agenda and implementation processes. Integration of such technical programs into the system bring forth great promise toward implementation of cross-sectoral comprehensive delivery mechanisms for social development.

Although implementation of behavior change interventions in large, diverse populations is complex and challenging, JTSP has addressed this complexity and employed a systematic approach, focusing on barrier understanding, tailored intervention design, and rigorous implementation. Considering the vast geography of the state of Bihar, it is possible to have variability in outcomes with uneven quality and rigor in interventions across all regions. Moreover, multiple other priorities of Jeevika may have impacted the depth and intensity of HNS-related activities. While JTSP successfully

transitioned many roles to JEEViKA's staff, community leadership in HNS remains underdeveloped. Ensuring that community institutions can truly and sustainably steer the HNS agenda independently is an ongoing challenge that needs more strategic focus and resources. Deeply ingrained cultural norms and socioeconomic barriers in rural Bihar may have also limit the effectiveness of interventions resulting in less optimal participation and addressing these requires long-term engagement and tailored strategies. These programmatic aspects and challenges affecting the outcomes can be addressed in the next phase of the program.

Data availability statement

The datasets generated for this study and used for analysis shall be available on request to the corresponding author.

Ethics statement

The study protocols and procedures were reviewed and approved by the Ashirwad Ethics Committee, Ashirwad Hospital & Research Center, Ulhasnagar, India. Verbal informed consent was obtained from each agreeing participant before the interview, after explaining the details of the study in the local language.

Author contributions

SM: Conceptualization, Project administration, Supervision, Writing – original draft, Writing – review & editing. IB: Formal analysis, Methodology, Writing – original draft, Writing – review & editing. SA: Project administration, Resources, Supervision, Writing – review & editing, Writing – original draft. IC: Conceptualization, Project administration, Supervision, Writing – review & editing, Writing – original draft. NP: Project administration, Resources, Supervision, Writing – review & editing, Writing – original draft. SK: Formal analysis, Methodology, Writing – original draft, Writing – review & editing. SSA: Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. RJ: Methodology, Project administration, Supervision, Writing – review & editing, Writing – original draft. MS: Data curation, Formal analysis, Writing – review & editing, Writing – original draft. SD: Data curation, Formal analysis, Writing – review & editing, Writing – original draft. AP: Project administration, Supervision, Writing – review & editing, Writing – original draft. AM: Writing – original draft, Conceptualization, Data curation, Methodology, Writing – review & editing. TM: Writing – original draft, Conceptualization, Formal analysis, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Centering community-based maternal and child nutrition services in Bangladesh's rural primary healthcare: what has potential to scale

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Introduction: The extensive network of community health workers in rural Bangladesh has the potential to deliver maternal and child nutrition services, while promoting linkages with healthcare facilities. A strategy for strengthening community-based nutrition services was developed and tested.

Methods: The three-phased strategy included review of existing community-based systems, co-designing service package with multi-sector government representatives, and testing implementation feasibility. Integrated health and nutrition service delivery, supportive supervision, and increased accountability of local government were core components of the service package being implemented in selected geographies since March 2023. The assessment followed a mixed-method design with household survey of 1,166 pregnant women, mothers of children under-6 months and 6–23 months, and observations of 965 service delivery points along with qualitative study.

Results: A higher proportion of children received growth monitoring and promotion (GMP) services through expanded program on immunization (EPI) sessions, with better compliance to service delivery protocol in intervention areas compared with controls. Maternal nutrition services of gestational weight gain monitoring and distribution of supplements were better available in intervention areas. However, minimum dietary diversity among pregnant women (69% intervention, 72% control), early initiation of breastfeeding (55% intervention, 51% control), and complementary feeding practices were comparable in intervention and control areas. Nutrition services were successfully integrated in supervision which earlier covered EPI and family planning. The local government contributed to strengthening nutrition services but at a small scale.

Discussion: There is potential to scale-up GMP services through EPI and merging antenatal clinics with GMP and EPI such that all maternal and childcare services are available at the same place and same time. A coordinated investment and oversight from multiple national government departments is needed. At district and sub-district levels, scale-up requires joint annual planning of nutrition and EPI services, strengthened management of nutrition services, bridging health worker vacancies, introducing volunteers in sites with high EPI case load,

capacity building, and supportive supervision. Replacement of multiple health and nutrition records with a single mother and child health and nutrition card is also feasible. However, behavior change interventions through home visits and courtyard meetings need more testing before recommending scale-up.

KEYWORDS

community health workers, maternal and child nutrition, growth monitoring and promotion, social and behavior change, diets

1 Introduction

Bangladesh has made significant progress in achieving global health and nutrition targets over the last decade and is on track to achieve the World Health Assembly 2025 target of a 40% reduction in the number of stunted children (1–3). However, some challenges persist. Repeat antenatal care (ANC) visits to maintain continuity of maternal nutrition services are missed by half the pregnant women who initiate these visits, and 35% still opt for home delivery (4). The prevalence of low birth weight is estimated at 23%, with over 70% of the effect explained by intrauterine growth retardation mainly due to poor maternal nutrition (5, 6). Nearly 60% of infants are not breastfed immediately after birth, and a similar proportion are not exclusively breastfed. The prevalence of child wasting increased between the two recent rounds of Demographic Health Survey from 8 to 11% (2, 4). Children 6–23 months fed minimum acceptable diet decreased in the same time frame from 35 to 29% (2, 4).

In 2011, the National Nutrition Services was launched to anchor nutrition programming and integrate activities into existing health and family planning programs. Nutrition services were to be embedded into routine primary healthcare (PHC) with gradual skill enhancement of community health workers (CHWs). In rural Bangladesh, there are three types of government supported CHWs—Community Health Care Providers (CHCP), Family Welfare Assistant (FWA), and Health Assistant (HA). The CHCP and HA are under the Directorate General of Health Services (DGHS) and FWA under the Directorate General of Family Planning (DGFP). The CHCP is stationed at the most accessible PHC structure for rural communities, the community clinic. The FWA and HA have outreach responsibilities in addition to seeing community clinic clients 2 and 3 days per week, respectively. A skilled Family Welfare Visitor, stationed at a union-level facility that serves the population of three or more community clinics, conducts outreach activities four to eight times per month.

The Government of Bangladesh in its 4th Health Nutrition and Population Sector Program (2016–2024) further intensified efforts to strengthen outreach services by CHWs (7, 8). Since 2016, a comprehensive competency-based training on nutrition, ranging from 3 days for CHWs to 5 days for their supervisors, was phased in to cover the entire country. The nutrition program currently focuses on strengthening last mile delivery of maternal infant and young child nutrition (MIYCN) services through capacity building of CHWs and their supervisors, increased investment in social and behavior change (SBC), and creating community demand for MIYCN services. It aims to integrate growth monitoring and promotion (GMP) into the widely accessible Expanded Program on Immunization (EPI) (9). Recognizing the inter-connectedness of health and nutrition services with other development sectors such as agriculture, education, and local governance, over 20 ministries collaborate under the Bangladesh National Nutrition Council (10). Under the Ministry of Local Government, Rural Development and Co-operatives (MOLGRD&C) elected representatives at the union level, the smallest rural administrative unit, form a Union Parishad that leads planning and implementation of several centrally funded development and welfare schemes (11).

To maximize the nutrition integration through community engagement, National Nutrition Services with other operational plans (thematic verticals under Health Population and Nutrition Sector Program), United Nations Children's Fund (UNICEF), and FHI 360 designed and tested an innovative strategy for community outreach, engagement, and accountability for improving MIYCN and linked PHC services in rural Bangladesh (referred to as community-based engagement strategy). The theoretical strength of delivering MIYCN integrated with PHC platforms is recognized at the policy level (9). However, the practical aspects including feasibility, implementation challenges, and sustainability of integrating MIYCN into PHC are not fully understood in Bangladesh context. Thus, an independent assessment was conducted in addition to routine system monitoring to generate evidence on feasibility and effectiveness of implementing the community-based services package. The objectives of the assessment were to (1) assess effect on GMP and maternal nutrition service coverage along with system readiness and compliance to service protocols, (2) impact of the intervention on the infant and young child feeding practices and dietary diversity among pregnant women, and (3) capture the factors influencing implementation and pre-requisites for possible scale-up in future.

2 Methods

2.1 Community-based engagement strategy

The strategy consisted of three phases: phase (1) review and mapping of community-based health and nutrition initiatives in rural Bangladesh (2020–2021), phase (2) consultative development of a community-based service package (2021–2022), and phase (3) implementation of this service package in 12 upazilas since 2023, including system preparedness activities to initiate implementation. On average, each upazila includes 10–11 unions although this number can vary significantly. It ranges from 5 to 16 in the 12 implementation upazilas.

In phase 2, the service package co-designed with government leadership, first line supervisors, and CHWs consisted of three components: (1) integrated community-based services through home visits, courtyard meetings, EPI outreach, and satellite clinics, (2) supportive supervision balancing administration, capacity building,

and problem-solving, and (3) institutionalized accountability for MIYCN and inter-linked services by community groups and Union Parishads. Table 1 summarizes the routine services, that is, services already available under PHC and augmented services as per community-based engagement strategy.

The augmented services were delivered entirely by government supported service providers, supervisors, and managers. One coordinator, appointed through UNICEF-FHI 360, was stationed at the upazila level to provide technical assistance at both managerial and supervisory levels. S/he conducted field visits with and without system supervisors and facilitated the information needs for the monthly upazila review meetings of DGFP and DGHS by supporting system statisticians in data consolidation and analysis.

In phase 3, the selection of 12 upazilas was based on relatively poorer performance on selected nutrition indicators compared to other upazilas in the same district, completion of comprehensive competency-based training on nutrition for all CHWs and their supervisors and consultation with local and national government. The upazilas were Ajmeriganj and Baniachong in Habiganj district, Begumganj and Subarnachar in Noakhali district, Bhola Sadar and Daulatkhan in Bhola district, Durgapur and Purbadhala in Netrokona district, Kaliganj and Shyamnagar in Satkhira district, and Nageshwari

TABLE 1 Routine services versus augmented services under community-based engagement strategy.

Service component	Routine services	Augmented services
Component 1: Integrated community-based services	GMP at community clinics only. GMP includes measuring MUAC, weight, and height, updating growth charts, providing counseling, and making referrals for children suspected of being affected by SAM.	GMP at all EPI outreach sites (24 in every union) every month following standard protocol (height measured at community clinics only). HA issues referral slip to all children suspected of growth faltering, advising caregiver to visit the community clinic for further screening of the child.
	Satellite clinics* ranging from 4 to 8 every month depending on Family Welfare Visitor's availability.	All satellite clinics co-located with GMP and EPI sites to create a one-stop service for maternal and childcare.
	Maternal nutrition services available at satellite clinics. However, satellite clinics not organized in absence of Family Welfare Visitor (skilled worker).	Maternal nutrition services of iron folic acid and calcium tablets distribution, weight gain monitoring and counseling delivered by FWA (a CHW) even in absence of Family Welfare Visitor. Introduction of maternal nutrition protocol for ANC.
	FWA undertakes home visits for registration of pregnant women, at least one visit post-partum to check on mother-baby preferably within 24 h in addition to visits to eligible couples for family planning services.	FWA undertakes at least two home visits to pregnant women, in first trimester to register and promote uptake of ANC services and third trimester to confirm continuity of ANC and preparation for institutional delivery. Trained and equipped with maternal nutrition counseling resources.
	FWAs organize one courtyard meeting (group counseling) per month.	FWAs organize at least one courtyard meeting on a pre-decided theme. Trained on group counseling for (1) maternal nutrition in ANC, PNC, (2) GMP and infant and young child feeding, and (3) early childhood care and development.
	HA undertakes home visits before EPI Day to inform families and promote attendance.	HA trained on GMP and infant and young child feeding to counsel mother/family members during these visits.
	Families maintain separate records for ANC, immunization, GMP.	Mother and child health and nutrition card covering all records from conception till child is 5 years of age, along with messages on recommended health and nutrition practices, provided to all pregnant women on registration and to mothers if they missed it during pregnancy. CHWs and other service providers trained on using the card.
Component 2: Supportive supervision	Supervision visits checklists cover EPI and family planning services. Targets driven supervision. Upazila monthly review meetings cover EPI and family planning as main agenda items.	Checklists cover nutrition services (observations at GMP sessions, satellite clinics, home visits, and courtyard meetings) in addition to EPI and family planning. Microsoft Excel spreadsheet introduced to consolidate and analyze supervision data. Realistic supervision visits targets set to meet all job expectations. Supervisor trained on observing services, providing feedback, and on the job training. Upazila review meetings include nutrition services in agenda.
Component 3: Institutionalizing accountability through community groups and Union Parishads	Community groups are involved in management of community clinics and promote increased utilization of services. CHCP organizes monthly meetings with group members. Union Parishad ideally develops annual plans with budget for health and development activities, holds review meetings with representative from different departments and organizes public meetings.	Members of community groups and Union Parishad oriented to augmented service package and potential of their support. Union Parishads guided on activities that can be funded by them (examples-volunteers for GMP sites, SBC resources, logistics for courtyard meetings).

*Outreach clinics for ANC, PNC, family planning services.

and Ulipur in Kurigram district. Preparedness for implementation was achieved through orientations from national to upazila levels, 1-day training on augmented service package for CHWs and 2-day training for supervisors, and the procurement and deployment of anthropometric equipment including newborn, child and adult weighing scales, length and height boards measuring up to 210 cm, and mid-upper arm circumference (MUAC) tape for children along with counseling resources. At the upazila level, the annual EPI microplans which outline the number of EPI eligible children under-2 years of age, along with a calendar of EPI sessions, were modified to include GMP sessions, satellite clinics, and courtyard meetings.

TABLE 2 Qualitative study participants, sample size, and tools used.

Participants/ Observations	Round 1	Round 2	Tools used
National level managers	5	5	KII
District and upazila managers	17	21	KII
Frontline supervisors	14	16	IDI
CHWs	25	32	IDI
Service delivery observations	19	21	Observation checklist
Total	**80**	**95**	

Bold values indicate total sample size for qualitative and quantitative study.

2.2 Assessment design and sampling

The assessment was a mixed-method study conducted by BRAC James P Grant School of Public Health. The upazilas with at least 9 months of package implementation were considered for the assessment to ensure full period of ANC coverage for near-term pregnant and recently delivered women. 6 of the 12 upazilas met this criteria. Of these six, two namely Begumganj from district Noakhali and Kaliganj from district Satkhira were selected for the assessment based on relatively fewer hard-to-reach areas and mid-to-large area and population. For the quantitative study, a control upazila, that is, where augmented service package was not implemented, was selected from the same district but not having common borders with the implementation upazila (also referred to as intervention upazila). Controls were matched against demographic variables including head count ratio for people living below poverty line, access to electricity and housing condition, prevalence of child stunting and underweight, and coverage of selected health and nutrition services.

2.2.1 Qualitative study

The qualitative study was undertaken at two time points in the intervention upazilas: Round 1 (May and June 2023) early in the implementation as an exploratory study and Round 2 (December 2023 and January 2024) late in the implementation to provide deeper insights into the implementation processes and better understanding of quantitative findings. Selection criteria for participants of key informant interviews (KIIs) were minimum posting of 3 months and only those CHWs and supervisors who were trained on augmented service package in early 2023, or received refresher training, were considered for in-depth interview (IDI) (Table 2).

2.2.2 Quantitative study

The quantitative study was a one-time household survey covering 1,166 population with 337 pregnant women, 490 children under-6 months, and 339 children 6–23 months. The sample size calculation for pregnant women was based on iron folic acid (IFA) consumption for at least 90 days, infants under-6 months on exclusive breastfeeding, and children 6–23 months on minimum acceptable diet (2, 12) (Table 3).

Pregnant women (15–45 years) who were residents of the area and/or living in that area for the 12 months preceding the survey were considered. Married adolescent mothers were included, and ethical procedures for minors as respondents were followed. Six unions were randomly selected from each upazila. List of pregnant women and children were obtained from CHWs and verified against the list at the community clinics in these six unions. Randomization was done individually for each sampling frame of participants (i.e., pregnant women, children under-6 months, and children 6–23 months) stratified by upazila. A random number generator was used to select the relevant sample size per upazila, and participant names were compiled into a participant list on Microsoft Excel and finalized for each upazila.

Service delivery observations were made at 965 sites covering 207 service providers. Sample size calculations for observation of ANC checkups and GMP sessions were based on estimates of service utilization (12, 13) (Table 4).

Observation visits were planned to ensure maximum coverage of all unions within each upazila. List of CHWs available with upazila coordinators were used to randomly select the three types of CHWs (CHCPs, FWAs, and HAs). Once CHW list was generated, annual EPI schedules available in upazila level microplans were used to select GMP sessions for observation visits. Similarly, monthly satellite clinic schedules available in the same microplan were used to select sites for ANC checkup observations for all four upazilas.

2.3 Data collection, tools, and training

2.3.1 Qualitative study

The KIIs and IDIs were conducted using detailed guides covering background information, respondent's role in service delivery, use of job aids, system readiness to support delivery of services, collection and use of data, and perspectives on improving service delivery. Interview time and location were decided in consultation with respondents. National level interviews were undertaken by senior research team and field interviews by trained enumerators supported by a research assistant.

Data enumerators for qualitative study underwent 7-day training. Training included overall health system structure, objectives of the study, ethical issues and safeguarding, use of interview guides, taking informed consent, sampling strategy, respondent selection and how to conduct interviews, note-taking, and transcript writing.

2.3.2 Quantitative study

Indicators to assess effectiveness of the package were Minimum Dietary Diversity-Women (MDD-W), early initiation of breastfeeding and exclusive breastfeeding among children under-6 months and MDD, and minimum meal frequency and minimum acceptable diet for children 6–23 months (14, 15). As data on maternal diet were unavailable from large-scale surveys, IFA consumption was used as proxy to estimate sample size for pregnant women as described under "Assessment design

TABLE 3 Sample size estimation for target groups.

Target group (indicator used)	Pre-intervention coverage (4)	Post-intervention expected coverage	DE	Non-response	2 arms [4 upazilas]	Per upazila
Pregnant women 15–45 years (IFA consumption)	52%	72%	1.7	5%	326	81
Children <6 months (exclusive breastfeeding)	65%	80%	1.7	5%	488	122
Children 6–23 months (minimum acceptable diet)	52%	72%	1.7	5%	326	81
Total					**1,140**	**284**

Bold values indicate the total estimated sample for the target groups and observations, which was lower than actual covered.

TABLE 4 Sample size estimation for observations.

	Pre-intervention coverage (4)	Post-intervention expected coverage	DE	Non-response	2 arms [4 upazilas]	Per upazila
a. System readiness (training, tools, equipment)	50%	75%	1.7	5%	205	51
b. Protocol compliance						
Observation of ANC checkup (nutrition)	30%	50%	1.7	5%	254	64
Observation of GMP	35%	50%	1.7	5%	600	150
Total					**854**	**214**

Bold values indicate the total estimated sample for the target groups and observations, which was lower than actual covered.

and sampling." Among children 6–23 months, unhealthy food consumption following WHO definition was also estimated (15).

Three quantitative closed-ended questionnaires were developed for pregnant women, and mothers of children under-6 months and 6–23 months. Observation checklist for GMP and maternal nutrition services at ANC were based on protocols introduced under community-based engagement package. Both checklists covered availability of logistics, steps in service delivery, and recording client information. All questionnaires were developed digitally using Kobo Toolbox, and data were collected via the Kobo Collect application v2023.2.4. Data enumerators were provided with electronic tablets pre-installed with Kobo Collect.

2.4 Data analysis

2.4.1 Qualitative study

Audio recording was done with consent in addition to capturing field notes. Audio recordings of the KIIs and IDIs were transcribed verbatim in Bangla by research assistants. Transcribed data were stored in encrypted servers and de-identified before analysis. ATLAS.ti 9 software was utilized for coding of the transcriptions. Thematic analysis was conducted using the inductive coding method. A codebook was generated after coding was completed for all the transcriptions. Data were reviewed and analyzed using the generated codebook.

2.4.2 Quantitative study

Stata 14 was used for quantitative analysis. Weights were used to report the aggregated estimate of coverage of the services after adjusting for the population size of the upazilas. Sample characteristics and summary statistics were reported between the intervention and the control upazilas. Sub-categories were created to compare background characteristics including wealth index. The wealth index was constructed using household asset data via principal components analysis as used in Demographic Health Surveys. Households were assigned a score based on the ownership of various assets, access to utilities such as electricity, sanitation, and housing characteristics such as flooring materials, and the number of rooms. Based on score rankings, households were divided into five equal groups representing relative wealth categories, from the poorest to the richest.

Binary variables were summarized as proportions, and continuous variables were summarized as mean values with standard deviations. The chi-square ($\chi 2$) test was used to test for significant differences between categorical variables and *t*-test for continuous variables in the study groups.

2.5 Ethics approval

The assessment was approved by the ethical committee of the Institutional Review Boards of James P Grant School of Public Health and FHI 360 Protection of Human Subjects Committee. The consent forms and tools were designed in English, translated into Bangla, verified, and approved by the ethical review committees. Both parental consent and minor assent forms were used adolescent girls (less than 18 years) and their guardians. A copy of signed consent forms, along with the name, phone number, and address of the study coordinator, was offered to every study participant by the data collectors.

2.6 System monitoring

The monitoring framework for community-based engagement was based on information available through the management information system (MIS) of the government. A total of 15 service delivery indicators for which data were routinely collected by CHWs, compiled by their supervisors and ultimately available with the upazila managers, were the mainstay of monitoring. Simple manual modifications such as adding columns for anthropometric measurements were made in the existing reporting formats to ensure reporting on GMP services from

EPI outreach sites which was earlier unavailable through MIS. Data for children suspected of growth faltering were highlighted in these formats for follow-up. Monitoring data were analyzed using Microsoft Excel.

3 Results

3.1 Background characteristics of household survey participants

Among the sampled pregnant women, the intervention and control upazilas in Noakhali and Satkhira were matched on eight and four of the nine background characteristics, respectively (Table 5). Among mothers of children under-6 months, intervention and control upazilas matched on four and five of the seven characteristics in Noakhali and Satkhira, respectively, while among mothers of children aged 6–23 they matched on six characteristics in Noakhali but only two in Satkhira (Table 6).

3.2 GMP for EPI eligible children

Monitoring data supported the gradual uptick in reach of child weight measurement services across all intervention upazilas (Figure 1). On an average, 300 GMP-EPI sessions are held every month in Kaliganj and 380 in Begumganj. The number of children at each EPI session ranged from under 40 to almost 100.

Based on the household survey, awareness on GMP services was significantly higher among mothers of children under-6 months and 6–23 months in Kaliganj compared with control upazila (91% vs. 17%; 80% vs. 9% $p < 0.001$), so was receipt of counseling services (84% vs. 13%; 74% vs. 6% $p < 0.001$). The reported receipts of counseling services in Begumganj and control upazila were comparable at 20 and 25% respectively, for mothers of children 6–23 months (Data not available in tables). Higher proportion of children were weighed, had length/height and MUAC measured, followed by correct plotting and counseling in intervention upazilas than control based on observations of GMP sessions (Table 7).

Monitoring data on referral revealed not as many children were identified with growth faltering and referred as would be expected considering the national prevalence of underweight and wasting at 22 and 11%, respectively (4).

3.3 Maternal nutrition services

The monitoring data for ANC and maternal nutrition services were deemed unusable as it indicated 100% or higher coverage throughout the implementation period. Observations at satellite clinics revealed higher proportion of women were weighed, had blood pressure measured, underwent physical examination, and received calcium tablets in intervention upazilas compared with controls (Table 8). In the household survey, almost all pregnant women reported consuming IFA tablets in their current pregnancy in both intervention and control upazilas (93% vs. 98%). Observations revealed IFA tablets were provided more frequently in Begumganj compared to the control upazila, but service providers missed advising on dosage and side effects.

Despite being a longstanding component of FWA job description, home visits to recently delivered women and newborns within 48 h of birth, that is, double the recommended cutoff time, were very low based on household survey (Table 9). Home visit coverage, without a 48-h cutoff, was higher in the intervention upazilas according to monitoring data for February 2024 compared to the household survey, at 31% in Kaliganj ($N = 313$ deliveries) and 65% in Begumganj ($N = 839$ deliveries).

3.4 Behavior change

Findings were comparable across intervention and control upazilas on behavior change indicators of MDD-W, breastfeeding, and complementary feeding (Tables 10, 11).

A significantly higher proportion of mothers reported being counseled on exclusive breastfeeding in Kaliganj than control (60% vs. 44%, $p = 0.01$), but the reverse was noted for Begumganj and control (50% vs. 69%, $p = 0.002$). Reported counseling on age-appropriate feeding (46% vs. 24%, $p = 0.002$) and responsive feeding (19% vs. 7% $p = 0.03$) was also higher in Kaliganj than control upazila. Counseling on early childhood care and development and play-based activities were less frequent. However, nurturing care and responsive feeding were discussed during courtyard meetings.

3.5 Feasibility of implementation

The findings from the qualitative component provided insights on feasibility of implementation.

3.5.1 Availability of CHWs and volunteers

National and upazila level officials strongly recommended dedicated service providers for nutrition services in villages. CHW vacancy ranged from 20% to a just over 40% across implementation upazilas.

> *"HR gap is a big issue. Previously 'Pushthi Apa' [female nutrition worker] worked at the field level… 'Pushthi Apa' would go from house to house making people aware of nutrition. We need someone focused only for nutrition service like her who will counsel and motivate people … if any volunteer or someone similar can be provided, that will work well." (KII, National Level).*

> *"In the absence of multi-purpose volunteers* [government supported volunteers piloted in few upazilas between 2019 and 2023], *we are providing GMP services … There are a lot of vaccines and administering them consumes considerable time. Consequently, providing GMP services afterwards poses challenges, particularly in measuring weight and height, providing counselling, filling the cards. Consequently, our [HA] service quality deteriorated both in terms of quality and quantity." (IDI, HA, Kaliganj, Satkhira).*

Union Parishads supported volunteers in some unions for promoting GMP and other MIYCN services. Selection of volunteers was prioritized in unions with high number of EPI eligible children. Such investment by Union Parishad was possible in upazilas where DGHS upazila managers actively engaged with the Upazila and Union Parishads and other officials of the MoLGRD&C. As Union Parishads are under a different Ministry, common platforms for discussion with health and family planning staff are limited. *There is a lack of communication with me and them [Union Parishad representative]*

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TABLE 5 Background characteristics of pregnant women.

Characteristics	Satkhira			Noakhali		
	Intervention	Control	*p*-value	Intervention	Control	*p*-value
	Kaliganj	Tala		Begumganj	Chatkhil	
	N = 82	*N* = 90		*N* = 81	*N* = 84	
Number of household members (Mean ± SE)	4.6 ± 0.2	4.5 ± 0.2	0.565	5.7 ± 0.3	5.3 ± 0.3	0.266
Per capita household expenditure in previous week (Mean ± SE)	717.4 ± 35.3	469.8 ± 25.4	<0.001*	814.3 ± 94.0	959.9 ± 57.5	0.185
Age of pregnant women (%)						
<20 years	25.6	21.1	0.619	24.7	17.9	0.009*
20 to 25 years	24.4	33.3		40.7	25.0	
26 to 30 years	29.3	27.8		24.7	28.6	
>30 years	20.7	17.8		9.9	28.6	
Multiparous (%)	28.1	41.1	0.080	45.7	31.0	0.056
Gestational age (%)						
First trimester	17.1	34.4	0.024*	21.0	20.2	0.970
Second trimester	62.2	53.3		56.8	56.0	
Third trimester	20.7	12.2		22.2	23.8	
Religion (%)						
Islam	96.3	77.8	<0.001*	100.0	96.4	0.246
Hindu	3.7	22.2		0.0	3.6	
Occupation of household head (%)						
Business/Trader	34.2	57.8	<0.001*	25.9	31.0	0.144
Service/Salaried Worker	22.0	26.7		48.2	33.3	
Unskilled/Housewife/Unemployed	43.9	15.6		25.9	35.7	
Years of formal education (%)						
<= 5 years	18.3	14.4	0.350	7.4	7.1	0.874
> 5 to <=10 years	65.9	61.1		69.1	72.6	
> 10 years	15.9	24.4		23.5	20.2	
Wealth index (%)						
Poorest	23.2	17.8	0.006*	30.9	15.5	0.182
Poorer	29.3	11.1		17.3	19.1	
Middle	20.7	20.0		14.8	22.6	
Richer	14.6	24.4		19.8	20.2	
Richest	12.2	26.7		17.3	22.6	

*Indicates significant change at $P < 0.05$.

I feel there is a great opportunity for the Union Parishad to play a major role. They need more involvement with us. If we want to make the program successful, we need to increase communication with all those who can influence it.—KII, Upazila manager, Begumganj, Noakhali.

> *"Having the card has been very beneficial. In the card, we show them age-appropriate recommendations, type of foods they should feed and other images. Even if they forget, seeing the card they remember." IDI, Begumganj, Noakhali.*

3.5.2 Availability of equipment, protocols, and resources to promote nutrition services

The qualitative study revealed improved availability of anthropometric equipment, GMP protocols, and SBC resources between the two rounds of data collection. CHWs mentioned curiosity among mothers about the mother and child health and nutrition card and understanding the growth of their children.

3.5.3 Capacity building through trainings and supportive supervision

The 1-day community-based engagement training for CHWs was perceived inadequate by CHWs and their supervisors. Continuing field support and refresher trainings were suggested. Completion of the supportive supervision checklists and data reporting improved between rounds 1 and 2 of the qualitative study. Supervisors

TABLE 6 Background characteristics of mothers.

Characteristics	Children under-6 months						Children 6–23 months					
	Satkhira			Noakhali			Satkhira			Noakhali		
	Intervention	Control	*p*-value	Intervention	Control	*p*-value	Intervention	Control	*p*-value	Intervention	Control	*p*-value
	Kaliganj	Tala		Begumganj	Chatkhil		Kaliganj	Tala		Begumganj	Chatkhil	
	N = 120	*N* = 124		*N* = 122	*N* = 124		*N* = 82	*N* = 90		*N* = 81	*N* = 84	
Number of household member (Mean ± SE)	5.6 ± 0.2	5.3 ± 0.1	0.206	6.2 ± 0.2	6.1 ± 0.2	0.759	5.5 ± 0.2	4.9 ± 0.2	0.040*	6.1 ± 0.3	6.0 ± 0.3	NS
Per capita household expenditure in previous week (Mean ± SE)	575.0 ± 22.4	381.7 ± 20.1	<0.001*	719.8 ± 48.2	963.3 ± 54.0	<0.001*	624.39 ± 31.83	426.56 ± 32.17	<0.001*	783.95 ± 74.70	946.86 ± 64.52	NS
Age of mother (%)												
<20 years	21.7	22.6	0.562	18.0	16.9	0.872	28.2	23.5	NS	11.1	19.3	NS
20 to 25 years	33.3	31.5		38.5	40.3		36.5	29.6		40.0	26.5	
26 to 30 years	20.0	14.5		23.8	20.2		16.5	30.9		18.9	27.7	
>30 years	25.0	31.5		19.7	22.6		18.8	16.1		30.0	26.5	
Religion (%)												
Islam	92.5	87.1	0.206	97.5	99.2	0.368	92.9	77.8	0.007*	93.3	96.4	NS
Hindu	7.5	12.9		2.5	0.8		7.1	22.2		6.7	3.6	
Occupation of household head (%)												
Business/Trader	53.3	61.3	0.013*	21.3	32.3	<0.001*	44.7	49.4	0.002*	30.0	38.6	0.010*
Service/Salaried Worker	20.8	27.4		61.5	33.1		24.7	40.7		53.3	31.3	
Unskilled/Housewife/ Unemployed	25.8	11.3		17.2	34.7		30.6	9.9		16.7	30.1	
Years of formal education (%)												
<= 5 years	10.8	8.9	0.465	7.4	4.8	0.705	5.9	8.6	NS	7.8	3.6	NS
> 5 to <=10 years	68.3	63.7		65.6	66.9		71.8	59.3		60.0	77.1	
> 10 years	20.8	27.4		27.1	28.2		22.9	32.1		32.2	19.3	
Wealth index (%)												
Poorest	23.7	18.6	0.477	30.6	10.5	<0.001*	30.6	9.9	<0.001*	26.1	16.9	NS
Poorer	20.0	20.2		20.7	20.2		23.5	16.1		13.6	24.1	
Middle	21.7	18.6		20.7	17.7		18.8	21.0		22.7	16.9	
Richer	21.7	18.6		12.4	27.4		18.8	21.0		17.1	22.9	
Richest	15.0	24.0		15.7	24.2		8.2	32.1		20.5	19.3	

*Indicates significant change at $P < 0.05$.

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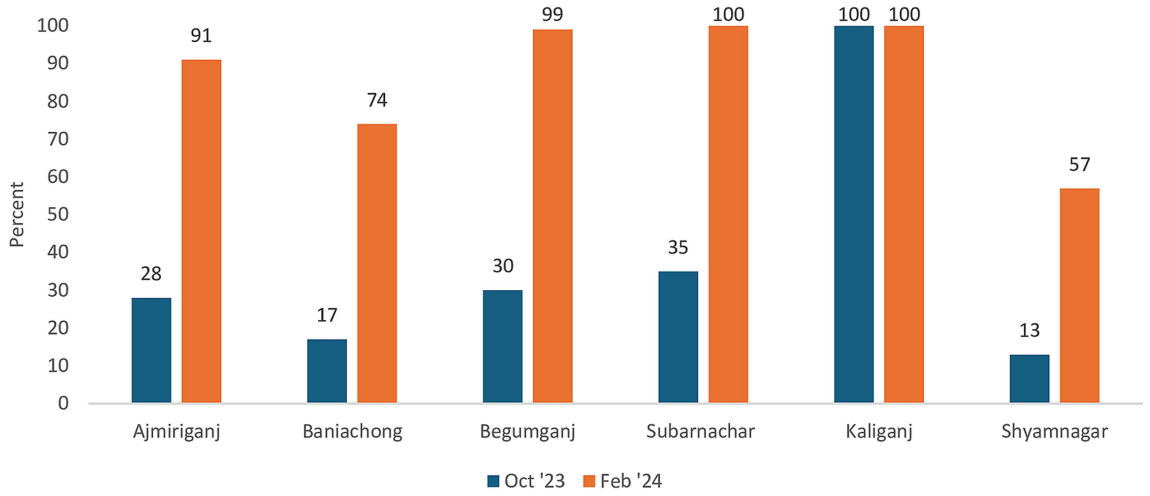

FIGURE 1
Coverage of child weight measurement across all intervention upazilas (monitoring data). Data for October 2023 and February 2024 were compared as all sites were equipped by October 2023 and one year of implementation was completed in February 2024. Coverage was over 100% in Kaliganj (139% in October 2023 and 124% in February 2024) and Subarnachar (108% in February 2024) due to some non-EPI eligible children also availing services and catchup due to disruption in organization of EPI session in January 2024, respectively.

TABLE 7 GMP services being provided per protocol based on observations.

GMP services per protocol (%)	Satkhira			Noakhali		
	Intervention	Control	*p*-value	Intervention	Control	*p*-value
	Kaliganj	Tala		Begumganj	Chatkhil	
	N = 153	*N* = 153		*N* = 209	*N* = 160	
Accurately recording children's age	97.4	98.7	0.984	99.5	100.0	0.984
Taking children's weight	97.4	5.2	<0.001*	88.0	1.9	<0.001*
Taking children's length#	24.2	0	-	26.8	0	-
Taking children's MUAC	45.8	5.2	<0.001*	23.4	0	-
Plotting the GMP measurements in color coded zones on GMP chart	94.1	0.7	<0.001*	66.5	0.7	<0.001*
Identifying children's nutritional status according to color zones of GMP chart	91.5	0	-	64.6	0	-
Including information on GMP services in the tally list/sheet	78.4	0	-	32.1	0	-
Listing the non-attendees and follow-up	28.8	33.3	0.387	47.9	46.3	0.761
Advice on the nutrition of the child according to the growth status of the child as per GMP card	66.0	1.3	<0.001*	40.7	3.1	<0.001*
Using SBC materials	17.0	0	-	29.7	6.9	<0.001*

*Indicates significant change at $P < 0.05$.
#Available at community clinics only.

mentioned challenges in filling a lengthy checklist during round 1. The checklist was simplified based on this feedback, and by round 2, it was fully executed. However, supervisors were hesitant to report non-compliance to protocols CHWs as they feared it could reflect poorly on the CHWs' performance.

3.5.4 Joint inter-department annual planning and progress reviews

Most respondents acknowledged coordination challenges between DGFP and DGHS. They alluded to annual microplanning for nutrition services along with EPI and joint DGFP and DGHS review meetings at all administrative levels as good initiatives to improve coordination. However, there were concerns on sustainability of such platforms post-project life. Respondents from national and upazila level recommended continued UNICEF-FHI360 support for community-based engagement for longer period of time to have a notable impact on nutritional indicators.

4 Discussion

The assessment findings provided evidence in support of the different components of the community-based service package. First, evidence supported layering GMP services consisting of weighing, MUAC

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TABLE 8 Maternal nutrition and ANC services being provided per protocol based on observations.

Maternal nutrition and ANC services	Satkhira			Noakhali		
	Intervention	Control	*p*-value	Intervention	Control	*p*-value
	Kaliganj	Tala		Begumganj	Chatkhil	
	N = 73	*N* = 65		*N* = 87	*N* = 65	
Determining the number of ANC visit	89.0	90.8	0.737	92.0	81.5	0.055
Determining expected date of delivery	35.6	67.7	<0.001*	78.2	69.2	0.112
Height measurement	28.8	0	-	17.0	0	-
Weight measurement	78.1	41.5	<0.001*	57.5	10.8	<0.001*
Blood pressure measurement	86.3	40.0	<0.001*	36.8	9.2	<0.001*
Clinical examination for anemia	46.6	17.0	<0.001*	19.5	9.2	0.079
Confirming the blood and urine tests were done	32.9	10.8	0.002*	10.3	0	-
Registering into register book assigning an ID	30.1	64.6	<0.001*	72.4	67.7	0.558
Providing mother child health and nutrition card	34.3	0	-	57.5	0	-
Updating mother child health and nutrition card (among those who received)	83.6	0	-	66.7	0	-
Determining the health status of pregnant women according to the physical examinations	74.0	40.0	<0.001*	43.7	13.9	<0.001*
Providing IFA tablets	83.6	93.9	0.068	63.2	10.8	<0.001*
Providing Calcium tablets	82.2	67.7	0.048*	46.0	9.2	<0.001*
Advising on dosage, side effects and management for IFA and calcium tablets	22.0	53.9	<0.001*	26.4	0	-
Listing non-attendees and follow-up	23.3	39.1	0.046*	39.1	92.3	<0.001*
Providing nutritional counseling	71.2	76.9	0.447	83.9	53.9	<0.001*
Using job aids	30.1	0	-	43.7	0	-
Using SBC materials	30.1	4.6	<0.001*	38.0	6.2	<0.001*

*Indicates significant change at $P < 0.05$.

TABLE 9 Visits to recently delivered women and newborn based on household survey.

Indicators (%)	Satkhira			Noakhali		
	Intervention	Control	*p*-value	Intervention	Control	*p*-value
	Kaliganj	Tala		Begumganj	Chatkhil	
	N = 120	*N* = 124		*N* = 122	*N* = 124	
Visited by any service provider within 48 h. of most recent birth	3.3	2.4	0.719	1.6	6.5	0.102
Service provider supported them to breastfeed baby during any home visit	4.2	15.3	0.003*	23.1	40.3	0.004*
Service provider provided IFA tablets during any home visit	5.8	4.8	0.729	13.1	15.3	0.620

*Indicates significant change at $P < 0.05$.

measurement, plotting growth chart, and counseling (referral), on the EPI platform. In addition, co-locating satellite clinics such that all preventive and promotive services for pregnant women, breastfeeding mothers, and children were available at the same place and same time was possible in the context of rural Bangladesh. Leveraging the high footfall and efficient service delivery of the EPI platform made it ideal for integrating other preventive services. While GMP services were earlier available at community clinics, they were underutilized as children were brought to community clinics only when unwell. The opportunity cost of visiting community clinic for only GMP services was prohibitive for most families that stayed at a distance from these clinics. The success of GMP integration with EPI defied known challenges of increased workload of CHWs due to high vacancies and low community demand for GMP (16, 17). Volunteers supported by Union Parishads helped in managing high EPI case load sites but were available in very few areas. Program managers and service providers acknowledged systemic challenges but also demonstrated a very positive and optimistic view regarding integrating GMP into EPI. As integration of GMP in EPI with additional human resource support was also recommended in the mid-term review of the ongoing health, population, and nutrition sector program, the findings from this assessment are foundational for scaling up GMP in EPI outreach sites (9).

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TABLE 10 Food group consumption and MDD-W estimates for pregnant women, household survey.

Consumption of food groups (%)	Satkhira			Noakhali		
	Intervention	Control	*p*-value	Intervention	Control	*p*-value
	Kaliganj	Tala		Begumganj	Chatkhil	
	N = 82	*N* = 90		*N* = 81	*N* = 84	
Grains, roots, tubers, and plantains	100.0	98.9	1.000	98.8	100.0	1.000
Pulses	37.8	42.2	0.555	56.8	45.8	0.159
Nuts and seeds	26.8	28.9	0.764	22.5	15.7	0.266
Milk and milk products	56.1	76.7	0.004*	49.4	67.5	0.019*
Meat, fish, and poultry	89.0	80.0	0.104	85.2	81.0	0.469
Eggs	54.9	58.9	0.596	46.9	59.5	0.105
Dark green leafy vegetables	47.6	58.9	0.137	43.2	61.5	0.019*
Vitamin A-rich fruits	43.2	42.2	0.896	29.6	38.1	0.251
Other vegetables	54.9	58.9	0.596	46.9	51.2	0.583
Other fruits	42.7	64.4	0.004*	44.4	47.6	0.683
Consumed > = 5 food groups	73.2	74.4	0.849	65.4	69.1	0.621

*Indicates significant change at $P < 0.05$.

TABLE 11 Infant and young child feeding estimates, household survey.

Infant and young child feeding practices	Satkhira			Noakhali		
	Intervention	Control	*p*-value	Intervention	Control	*p*-value
	Kaliganj	Tala		Begumganj	Chatkhil	
Breastfeeding practices (%) (Children < 6 months)	*N* = 120	*N* = 124		*N* = 122	*N* = 124	
Ever breastfed	100.0	98.4	0.498	100.0	100.0	-
Initiation of breastfeeding within an hour of birth	52.5	57.3	0.455	45.9	45.2	0.907
Exclusive breastfeeding (fed only breast milk in the last 24 h)	52.5	51.6	0.890	59.0	62.1	0.621
Exclusively breastfed for the first 2 days after birth	50.8	43.6	0.254	29.5	29.8	0.955
Mixed milk feeding	19.2	20.2	0.845	23.8	13.7	0.043*
Complementary feeding practices (%) (Children 6–23 months)	*N* = 85	*N* = 81		*N* = 90	*N* = 83	
Minimum dietary diversity	55.3	60.5	0.498	52.2	49.4	0.710
Minimum meal frequency	89.4	87.7	0.722	75.6	71.1	0.506
Minimum acceptable diet	50.6	59.3	0.262	46.7	42.2	0.552
Eggs and/or flesh food consumption	81.2	92.6	0.030*	71.1	69.9	0.859
Sweet beverage consumption	22.4	38.3	0.025*	51.1	32.5	0.013*
Unhealthy food consumption	75.3	81.5	0.334	65.6	61.5	0.575
Zero vegetable or fruit consumption	30.6	33.3	0.705	31.1	38.6	0.304
Bottle feeding	22.4	16.3	0.322	36.7	30.1	0.362

*Indicates significant change at $P < 0.05$.

Though better than the control upazilas, there were challenges in complying to the GMP protocol including quality of anthropometric measurements, counseling, and record keeping and reporting. Supervisory support needs to be enhanced, and additional trainings provided to improve quality of anthropometry and counseling. Digitalization of GMP data and analytics could reduce errors in reporting on children affected by growth faltering but needs to be tested. Furthermore, through the EPI platform, children up to age two were reached, and not according to the recommend frequency of weight and height measurement at every month and every 3 months, respectively. Thus, in addition to increasing the availability of GMP services at EPI sites, the use of community clinics needs to be promoted to ensure growth tracking as per recommendation, and counseling for all children under five.

Second, maternal nutrition services of weight measurement, screening for anemia, and provision of IFA and calcium supplements had better coverage in intervention upazilas. However, there were missed opportunities in providing comprehensive and continuing ANC services, counseling on diets, and consumption of IFA and calcium supplements. Home visits are critical platform for individual counseling

on maternal nutrition. Among recently delivered women who deliver at home, the need for home visits is enhanced as women have restricted mobility the first few weeks after delivery due to health and/or cultural reasons. The coverage of home visits did not match the expected 15 to 30% reported home deliveries in Begumganj and Kaliganj, respectively (as per recent monitoring data). Under community-based engagement, the attempt was to regularize these visits with additional job aids and closer monitoring of these visits through supervisors. However, the assessment revealed that CHWs did not revisit a hamlet already covered in a month, despite births being reported from the area. The 24-h window was thus missed in most cases. The high proportion of adolescent pregnancies and young mothers in the survey exacerbated the issue of low domiciliary visits to this target group.

The augmented services did not have any impact on behavior change related to mothers' diet and infant and young child feeding practices. This is contradictory to the findings from a recent study in an urban setting. Provision of nutritional services including counseling through dedicated staff at urban health centers increased dietary diversity among women and resulted in a 7% increase in early initiation of breastfeeding when compared to control areas (18). This difference between our study could be related to intervention elements including a dedicated nutrition cadre/staff, study setting, and duration of intervention. Quality of counseling needs concerted attention as counseling was reportedly being provided but not translating to behavior change. Group counseling through courtyard meetings requires a rethink in design and implementation.

Tools and training were provided to equip service providers and supervisors with the necessary skills and knowledge to deliver MIYCN services effectively. In addition, facilitatory materials, including job aids and protocols, were developed to provide clarity and guidance on roles. The supportive supervision component improved as CHWs nutrition roles were included in the scope of the supervision process and reporting. However, challenges in accurate and complete reporting continued despite simplification of supervision checklists. The implementation of the strategy required coordinated efforts at the national, district, and upazila levels. High-level oversight was provided by relevant authorities to monitor progress and inform planning and budget allocation. Meeting the pre-requisites to implement the service package and continual technical assistance at national, district, and upazila levels were possible through UNICEF and FHI360 support. Improving the visibility of nutrition services at the upazila level, so that they are integrated with EPI and family planning services, requires a coordinator to oversee nutrition programming, as was done in the 12 implementation upazilas.

Innovations led by Union Parishads in selected areas such as provision of SBC materials and transport support for volunteers have application in other similar contexts but require coordination between department of local government and upazila managers from health and family planning.

The study identified several systemic issues that could impact the effectiveness of MIYCN services. These included challenges related to human resource gaps, inadequate training, and coordination issues between relevant authorities. Additional capacity building is required in the form of refresher training or capsule training during monthly meetings. In future, additional training days should be considered in the community-based engagement cascade training program. There were also concerns about the sustainability of certain interventions, such as joint DGFP and DGHS review meetings, post-project completion.

5 Limitations

One major limitation of the quantitative study was the single time-point data collection design. While the assessment provided valuable insights into the current state of community-based engagement implementation, the absence of baseline measurements made it difficult to determine whether the observed outcomes were solely a result of the intervention or were influenced by external factors. The study, therefore, was unable to conclusively determine whether the observed values at the endline represent an improvement, decline, or simply the existing status quo prior to the intervention. Furthermore, the differences in background characteristics between intervention and control upazilas may have influenced some findings, particularly those impacted by belonging to different wealth index categories such as dietary diversity. As the strategy was implemented in the most challenging upazilas in each district, comparing them with other upazilas has limitations. Some of the gains in dietary diversity and child feeding practices may be masked in the intervention upazilas due to this. Furthermore, the control upazila for Begumganj received multi-year donor investment to strengthen maternal and newborn care services which may have resulted in better performance on maternal nutrition indicators. Disaggregating data by upazilas was crucial for assessing implementation in areas with varying governance and previous donor investments, while the study was designed to compare overall performance between the intervention and control upazilas. A combined analysis was conducted on a limited set of data points, but no significant differences were found when compared to the disaggregated analysis. In the household survey, while service utilization data were verified through records, responses on behaviors-related questions specifically on maternal diet and infant and child feeding were susceptible to recall bias. Limitations were also noted in planning observation sessions. Providing prior notification may have influenced CHW preparation and organization of the sessions, potentially not presenting the typical service delivery scenario. Efforts were made to minimize any obtrusive effects, but the possibility that CHWs modified their normal practices due to the scheduled observations cannot be ruled out.

6 Conclusion

The community-based engagement strategy was successful in increasing availability of child weight and MUAC measurement, counseling, and referral for suspected growth faltering in EPI outreach sites. Compliance to recommended GMP service protocol was also better in intervention upazilas although more time is needed to improve screening and counseling as GMP in outreach sites is a new service for CHWs. These services have the potential to scale, provided pre-requisites of equipment, protocol, training, volunteer support in high EPI case load sites, supervision, and leadership support are in place.

Among maternal nutrition services, introduction of maternal nutrition protocol for ANC along with CHW training and supervision improved gestational weight gain monitoring, height measurement, and provision of IFA and calcium supplements. Finally, replacement of multiple health and nutrition records with a single mother and

child health and nutrition card was feasible and received high acceptance by all stakeholders.

At upazila level, integrating GMP, satellite clinics, and courtyard meetings into EPI microplans was a crucial management strategy to ensure ownership by upazila managers. Continued investments are needed in capacity building of service providers and supervisors especially on SBC, equipping service delivery points and CHWs, maintaining access to protocols and SBC resources, institutionalizing annual microplanning, progress review, and supervisory visits inclusive of MIYCN services. Dedicated nutrition cadre at upazila level is essential for technical oversight and prioritizing nutrition services. Concomitantly, systemic challenges of vacancies and intra-and inter-ministerial coordination need to be addressed to ensure the sustainability and scalability of interventions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by James P Grant School of Public Health and FHI 360 Protection of Human Subjects Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

SA: Conceptualization, Funding acquisition, Resources, Supervision, Writing – review & editing. AB: Conceptualization, Methodology, Writing – original draft, Project administration. MK: Conceptualization, Methodology, Project administration, Writing – review & editing. MB: Conceptualization, Project administration, Resources, Writing – review & editing. MR: Project administration, Supervision, Writing – review & editing. KA: Investigation, Methodology, Supervision, Writing – review & editing. TF: Conceptualization, Methodology, Supervision, Writing – review & editing. DS: Funding acquisition, Resources, Supervision, Writing – review & editing. AA: Resources, Supervision, Writing – review & editing.

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Galvanizing and sustaining momentum are critical to improve maternal nutrition in South Asia

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Introduction

The South Asia region is falling significantly short of achieving the Sustainable Development Goal (SDG-2) nutrition targets by 2030 (1). While there has been some progress in the last decade in select nutrition indicators such as exclusive breastfeeding (2012: 47%, 2022: 60%) and stunting among children under five (2012: 40%, 2022: 30%), two barometers reflective of the state of women's nutrition have remain unchanged—children born with low birth weight (25%, 2012 and 2022) and women aged 15–49 years who are anemic (48%, 2012 and 2019) (1). South Asia still hosts 114 million underweight girls and women (50% of the global burden), while a rise in overweight and obesity now also affects 20% of this group in the region (2). Clearly, despite several bouts of intentional efforts by governments, multilateral organizations and civil society, progress to tackle poor maternal nutrition in South Asia has not been swift enough.

To restate the fundamentals, poor maternal nutrition is a key concern because it perpetuates multigenerational cycles of malnutrition. It is a key driver of *in-utero* malnutrition resulting in children born with low birth weight, which in turn is associated with faltered growth in infancy and future risks of developing diabetes and obesity (3). There is compelling evidence that poor maternal nutrition is caused by interrelated drivers rooted in social injustice—poverty, harmful social and gender norms, low status of women, and low women's self-efficacy are at play alongside the harsh realities of gender segregation in labor markets, wage gaps and time poverty. These experiences remain root drivers of unequal opportunities for women and girls, denying them the power and resources to access nutrition and health services and make choices about what and how much to eat—which is often last and least (4–7). To compound these difficulties, as many as 28 per cent of young women are married as children in South Asia and three in four child brides give birth while they are still adolescents, with these girls experiencing compromised agency and increased risks to birth outcomes and for their own nutrition (2, 8).

To achieve the goal of ensuring women have access to nutritious diets, nutrition services and positive nutrition practices, programmes should include a package of five essential nutrition actions: (i) access to fortified nutritious foods; (ii) micronutrient supplementation; (iii) nutrition information, education and counseling; (iv) safeguards against infections; and (v) healthy weight gain monitoring, nutrition risk screening and services for those most at-nutritional-risk at individual and population levels (cash, food vouchers, food rations and balanced energy and protein supplements). While most countries in the region do have strong policy and programme frameworks for delivering nutrition actions for pregnancy (Table 1), effective coverage of programmes

TABLE 1 Availability of policies and programmes for delivering essential nutrition actions in pregnancy across South Asia.

Yes policy, yes program universal	
Yes policy, program in some geographies not universal	
Yes policy, no program	
No policy, no program	
Intervention not relevant to context	NA

Domain	Intervention	Nutrition intervention included in policy and programmes								# countries with policy	# countries with universal programme
		Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka		
Nutrition information, education and counseling	Nutrition information and education on healthy eating physical activity, reduce caffeine/tobacco intake, seeking access to services, family planning									8	8
Healthy weight gain monitoring	Gestational weight gain monitoring and identification of flag signs (no, less or excessive weight gain)									8	8
Access to essential micronutrients	Iron folic acid supplementation (IFA)									8	8
	Multiple micronutrient supplements (MMS)									6	2
	Folic acid supplementation in first trimester									6	4
	Calcium supplementation (context specific)									8	6
Infection prevention (context-specific)	Deworming prophylaxis, in areas with worm infestation									6	3
	Provision of bed nets in malaria endemic areas									6	6
Nutrition status screening and interventions benefiting those at-nutritional risk at population level	Nutrition risk screening (underweight, adolescent, overweight)									0	0
	Nutrition risk specific counseling									0	0
	Social protection interventions (take home ration/ cash/ balanced energy protein supplementation)									5	3
	Anemia screening and treatment									8	8

Source: UNICEF (9).

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remains low. About one in three women and girls in South Asia do not receive an antenatal check-up in the first trimester and in most countries in the region <50% of women consume iron supplementation for at least 90 days of their pregnancy (9). Existing maternal service delivery platforms have programmatic challenges that constrain the availability of essential maternal nutrition services. To name but a few: (1) Priority is still accorded to reducing maternal mortality and not morbidity. Focus remains on delivering interventions to reduce child mortality and severe maternal anemia, but not on maternal morbidity or services available at women's life stages beyond pregnancy. (2) A lack of operational know-how on enacting time-efficient workflows to deliver all constituents of nutrition services at maternal and child contact points (10). (3) A cadre of trainers who understand nutrition and dietetics to support the maternal nutrition component of medical training is missing. (4) When nurses' and health providers' training takes place, the nutrition component is often weak or neglected (11). (5) Women who are thin, short, anemic, obese or with depression require "extra care" (12, 13) but this is often absent due to a lack of localized operational guidance for screening and management (10). At the planning level, there are opportunity gaps in including essential nutrition items (supplies, training, human resources, cadre, monitoring and research) in sectoral plans and budgets and missed opportunities to integrate height-weight gain monitoring, nutrition screening, macro and micronutrient supplementation, counseling and special care for nutritional risks for women into the same platforms that also reach children (14, 15). (7) Finally, despite increased attention to the need to address preconception nutrition, this is rarely provided owing to a lack of robust delivery platforms or large-scale implementation exemplars to provide the resources and programmatic know-how to cater for a large population in need.

To accelerate improvements in maternal nutrition—before, during and after pregnancy—the United Nations Children's Fund Regional Office for South Asia convened a regional conference on "Nourishing South Asia: Scaling-up equitable nutritional care for girls and women in South Asia," from 18–20 September 2023 in Kathmandu, Nepal (16). The conference brought together 120 stakeholders from the eight countries that encompass the South Asia region (Afghanistan, Bhutan, Maldives, Bangladesh, Nepal, India, Pakistan and Sri Lanka) to take stock of countries' progress against regional commitments made in 2018 and discuss challenges and shifts needed to accelerate this progress. Details of the conference methodology have been described elsewhere (17). Briefly, the participants included senior government policy decision-makers, researchers, implementation champions, jurists, United Nations partners and development partners working on adolescent and women's nutrition (country delegations size was 6–16 per country). The conference format included 16 oral presentations, two panel discussions, a marketplace with 22 posters from the eight countries showcasing on-ground experiences and open space technology-based participatory group discussions. Each country delegations used open space methodology (18) methodology to discuss existing policies and programmes against each of the five essential nutrition actions. For those interventions which had a policy and programme, using a rubric provided (Supplementary File 1a) the country delegations identified systems bottlenecks in programme delivery, which have been described in Supplementary Files 1b–d; identified priority country actions and framework for action, which was consolidated into a call to action, which has been described below.

2023 regional call for five actions for improving maternal nutrition

Develop national plans with commensurate budgetary allocations

These plans and budgets should be developed with clear targets to foster acceleration and guarantee delivery and coverage of a package of essential nutrition actions for adolescent girls and women—before, during and after pregnancy. Investments will be needed from multiple sectors, especially education, health, social protection and food systems. There is a need to increase investments to improve food environments in order to protect women from nutrient-poor and unhealthy ultra-processed foods and beverages and curb the rise in overweight and obesity. Plans should account for the differential strategies needed to reach the most marginalized communities, for example by increasing the reach of social safety nets through food assistance, cash transfers and maternity benefits which target economically vulnerable women.

Implement solutions that are not "to" women but "through and for" women

Leveraging women's movements and coalitions will enhance the visibility of women's nutrition rights within the broader women's rights agenda. This will include accelerating multi-sector actions that address the harmful gender and social norms that underlie maternal malnutrition and especially target those that work toward keeping girls in school, delay age at marriage and strengthen family planning (to delay age at first pregnancy and reduce the number of pregnancies).

Review and update service delivery intervention packages and toolkits to ensure comprehensiveness and alignment with global guidelines/recommendations to address all forms of malnutrition

Service delivery implementation strategies should be periodically reviewed and refined by incorporating learning from systems bottleneck analyses and systems research on "what works" at scale. Introducing innovative products with proven effectiveness such as Multiple Micronutrient Supplements (MMS) and delivering them at-scale within routine government systems offers one path to success in addressing the high burden of micronutrient deficiencies in pregnancy (19). To enhance the impact of these programmes, it would also be useful to design,

develop and implement a minimum nutrition package for preconception care and women's health before, between and beyond pregnancies, delivered through maternal health, family planning and women empowerment platforms using available evidence and learnings from the region (20–22).

Be intentional in scaling up efforts to address social and geographical inequalities that slow progress in nutrition, especially among girls and women living in the most challenging circumstances

This would entail identifying and working to close service delivery gaps, particularly at the subnational level. Extra attention and targeted nutrition action should be provided to reach malnourished adolescent girls and women who are at economic, social or geographic disadvantage. Social enterprises offer many opportunities to narrow inequities in nutrition outcomes by leveraging research and development capabilities, infrastructure, and capital from the private sector, reaching those consumer segments that could afford to buy low-cost products or services and cross-subsidizing products and services for nutrition by generating surplus from for-profit activities (23). e.g., women-led social enterprises in Afghanistan, India, Bangladesh and Nepal have worked to link "field to plate." Setting up micro-enterprises, establishing market linkage and food fortification and processing units, community cooking, and creating grain and seed banks. These approaches aim to enhance livelihoods, agricultural practices, and household food security. They have undertake activities to establish private clinics to provide primary healthcare support to women as their right (23, 24). In humanitarian settings, creating friendly spaces for girls and women may offer the best entry point for integrated programming, particularly in contexts where movements are restricted, and girls and women are confined to their homes (25).

Invest in knowledge—data and systems research, alliances and cross-border sharing

This would entail strengthening survey data systems and routine programme monitoring systems to close data gaps and improve the quality and timeliness of data for tracking nutritional status and the coverage of interventions. Promoting transparency in how this data is used and disseminated will further ensure that progress in implementation of strategies are both accessible and accountable to the communities they aim to serve. Strengthening academic–government collaboration in evidence-based policymaking and promoting exchange of knowledge and experience both within and between countries in South Asia can be implemented to foster support networks and a culture of cross-learning within the region to improve girls' and women's nutrition.

A year since the 2023 call to action

Each country identified their priority action(s) during the 2023 regional conference (17). UNCEF country offices with other development partners have been supporting national/sub-national governments to mobilize the required political, technical, and financial commitments to execute priority actions identified in regional conference (Supplementary Files 1c, d) through acceleration plans/strategies. In September, 2024—a year since the conference- UNICEF released a stock-take report—*Progress and Promise: Nourishing girls and women in South Asia* (26) to capture nineteen examples of on-ground implementation since the call to action. These examples serve as testimony to the ongoing efforts across the region to improve access to essential nutrition actions for accelerating maternal nutrition. Briefly, six countries in region have initiated integration of preventive multiple micronutrient supplementation in antenatal care (Afghanistan, Bangladesh, Bhutan, Nepal and Sri Lanka). Afghanistan and Pakistan have initiated cash transfer to women leveraging poverty alleviation platforms. Indian state of Maharashtra and Srilanka have strengthened and scaled-up preconception care programmes.

On-ground implementation was further propelled through launch of global maternal nutrition acceleration plan with assured financing through child nutrition matched fund (19) for 15 countries globally, which include five countries from South Asia.

Conclusion

South Asia remains the make-or-break region to turn around the global nutrition crises affecting girls and women and accelerate progress on the 2030 SDG nutrition targets. We urge governments in the region and their development partners to respond to the call to action and put "women at the centre" of convergent multi-sector nutrition solutions. Countries should seize the opportunity to tailor programmes to manage different nutritional risks, strengthen their focus on integrating preconception nutrition into maternal nutrition programmes, and address the gender inequalities that prevent women accessing nutritious diets, nutrition services and positive practices. Improving girls and women's nutrition is critical for accelerating progress on all SDG nutrition targets. We must not wait for another call to action to state once again what has already been asserted this decade—tackling women's malnutrition matters for nourishing South Asia!

Author contributions

VS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. ZM: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2025.1498171/full#supplementary-material

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Building a rights-based approach to nutrition for women and children: harnessing the potential of women's groups and rights-based organizations in South Asia

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Women face numerous gender-based barriers that hinder their access to resources, nutritious foods, nutrition services, and maternity entitlements. Evidence shows that certain types of women's groups can improve women's access to resources and social capital and in some approaches also improve health and nutrition outcomes. Women's rights-based organizations in South Asia have a longstanding tradition of collective action toward gender equality. Women's rights-based organizations work in areas such as microfinance, livelihoods, women's rights, health, and combating violence against women. In this perspective article, we explore how women's groups and rights-based organizations can leverage their collective strength to advance nutrition outcomes for women and children. We identify seven pathways implemented through women's groups toward improving nutrition outcomes. These pathways include (i) income generation, (ii) agriculture, (iii) health and nutrition behavior change communication and participatory learning and action, (iv) advocating for rights to better health and social services, (v) food access, (vi) cash transfers, and (vii) strengthening service delivery and fostering convergence with health systems. We also note that women's groups have the potential to implement integrated interventions through combined food-systems-rights pathways. Investing in this area can support transforming nutrition policy from a service delivery model to a rights-based approach.

KEYWORDS

women's groups, women's rights-based organization, nutrition, rights, pathways, South Asia

Introduction

South Asia accounts for 40 percent of the global burden of low birth weight (<2,500 gm) children (1), a barometer for women's poor nutrition status before and during pregnancy. In the region, one in five women and adolescent girls are underweight and one in two are anemic (1). Adolescent girls and women who belong to the poorest wealth quintiles, have limited education, and reside in rural areas experience higher rates of underweight, anemia, and short stature (1, 2). Many women in South Asia have sub-optimal dietary practices and poor access

to health and nutritional services, including antenatal care and iron supplementation, with geographic variation (2). Maternal nutritional outcomes are influenced by health system barriers that limit access to services. These include barriers related to frontline workers, such as vacancies, poor mentoring or motivation, increased work catchment load on existing health workers, and constraints in reaching distinct geographies (3–5). Discriminatory gender norms affect women's decision-making power and autonomy, which in turn can contribute to adverse birth outcomes (6, 7).

Women's groups are a common feature in most countries in South Asia (8). Women's groups are generally defined as a group of individual women from a community who come together toward a common purpose. These include economic groups such as self-help or livelihoods groups, collectives formed with social action, health, and empowerment objectives, community-based women's groups that work broadly on development objectives, or special population groups such as sex workers or new mothers' groups (9). Additionally, women's rights-based organizations have a long history in social and political movements in the South Asian region (10). These organizations are characterized by a collective pursuit of advancing women's rights in a range of domains, with achievements such as improving women's representation in political spaces (11), education, public and private safety, and gender-sensitive poverty alleviation (12). While there is some overlap, we have found that women's groups often implement localized and community-based interventions, whereas women's rights-based organizations work on a large scale.

Evidence from experimental studies indicates that membership in women's groups can improve women's financial inclusion, control over income, decision-making, and political participation (13–17), depending on specific design and implementation characteristics. Systematic reviews have also reported on the effectiveness of specific types of women's groups and approaches in reducing maternal and neonatal mortality (18) and improving perinatal and child health practices (19). Different types of nutrition interventions have been implemented and evaluated via women's groups to improve the nutritional outcomes of women and children. A 2018 systematic review by Kumar et al., summarizing 36 studies across Bangladesh, India, Nepal, and Pakistan, noted the potential of women's groups in improving some nutrition-related practices but also highlighted variations in outcomes across different types of intervention pathways (20). Kumar et al. developed a framework to describe four pathways through which women's group interventions can improve nutrition outcomes among women and children in South Asia, which include (i) income, (ii) agriculture, (iii) health and nutrition behavior change communication, and participatory learning and action, and (iv) rights (20). A subsequent 2020 systematic review in India found mixed evidence on the effectiveness of women's groups in improving health and nutrition outcomes, with participatory approaches most commonly reporting positive effects. The review highlighted the importance of understanding which approaches work, where, and for whom (19).

Nutrition outcomes are complex and challenging to achieve for multiple reasons. One, nutrition practices, such as iron folic acid consumption, dietary diversity, and exclusive breastfeeding, require sustained inputs and support (21). Two, the effects of optimal nutrition practices are not seen immediately on measurable long-term outcomes, such as anemia, thinness, overweight/obesity, stunting, and wasting. And three, negative influences of other social determinants including but not limited to food accessibility/affordability, gender stereotypes, and prevailing socio-cultural norms. These factors highlight the need for a multidimensional approach and pathways to improve nutrition outcomes among adolescent girls and women. In this perspective, based on our experience as researchers, practitioners, and donors, and drawing from a recent scoping exercise in South Asia, we explore ways to harness the potential of women's groups and rights-based organizations toward improved nutrition in South Asia.

Expanding ways through which women's groups intervention can improve nutrition outcomes

Expand intervention pathways

Building on Kumar's 2018 review that noted four pathways through which women's groups interventions can improve nutrition outcomes among women and children in South Asia, we synthesized 17 more recent studies and identified three additional pathways adopted by women's groups: (i) food access, (ii) cash transfers, and (iii) strengthening service delivery and fostering convergence with health systems (22). In practice, many interventions employed combinations of the seven pathways to improve nutrition outcomes for adolescent girls, women, and children (Figure 1).

For example, in India, most interventions (21, 23–32) implemented multiple pathways through women's groups, while only one (33) focused solely on the income pathway. One intervention utilized women's self-help groups to implement five pathways: income, agriculture and livelihoods, participatory learning and action, rights, and system strengthening, aiming to improve nutrition outcomes for adolescent girls, pregnant women, and mothers of children under two (27, 28). Another experiment combined participatory learning and action with food provisions for young children via crèches to improve birthweight and child anthropometric measures (23). Some interventions integrated participatory learning and action with agriculture, livelihoods, and rights-based interventions to enhance maternal and child nutrition outcomes, all through open participation and collective approaches. Other combinations of pathways implemented via women's groups included behavior change communication with either agriculture and livelihoods; social accountability actions; or health systems strengthening. Some interventions also focused on savings and credits through women's self-help groups to enhance health and well-being. Similarly, in Nepal, the combination of pathways includes participatory learning and action with food transfers and cash transfers for pregnant women to improve birthweight and child anthropometric measures (34). Another experiment in Nepal combined behavior change communication using traditional health education interventions with agriculture and livelihoods to improve child growth and diet (35). An intervention in Bangladesh applied behavior change communication combined with social accountability actions for improving child nutrition outcomes (36).

Tap the potential of women's rights-based organizations

Women's rights-based organizations in South Asia address a broad spectrum of issues, including microfinance, agriculture and

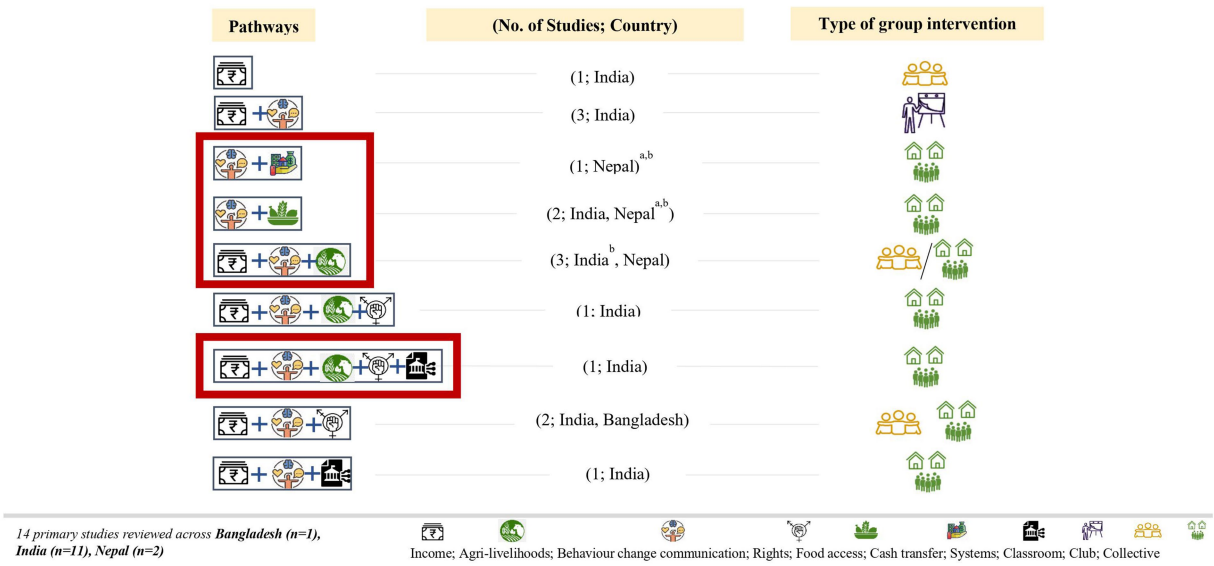

FIGURE 1
Women's groups and nutrition: Intervention pathways. Source: Rapid review of literature by the authors. Note: Total 17 studies, including 14 primary and 3 process studies related to primary studies; [a]One study in Nepal has two arms—cash and food transfer—for identifying the pathways, the authors have separated this study into two distinct pathways; [b]Three studies (41–43) are shown as they were process/qualitative evaluations of the two studies (30, 34).

livelihoods, natural resources and land rights, violence against women and girls, sexual and reproductive health rights, human rights and social justice, child rights, gender and security, skill development, political representation, and advocacy for special groups like home-based workers, sex workers and the LGBTQI community. Their geographic spread includes subnational, national and regional organizations.

We conducted a programmatic scoping review for the UNICEF Regional Office of South Asia from February to March 2023, engaging 20 organizations and seven experts in six countries: Afghanistan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka. The scoping review aimed to explore the potential of engaging women's rights-based organizations to improve women's nutritional outcomes in South Asian countries. We learned that the women's rights-based organizations act at three levels: mobilizing women at the community and grassroots level, through implementing programs, and by advocating for policy changes. They broadly focus on three intervention domains—(i) creating an enabling environment (governance, family-friendly policies, education, preventing child marriage, violence against women and girls), (ii) access to food (agriculture, food security), and (iii) access to services (maternity benefits, health, nutrition entitlements) (Figure 2).

Overall, 14 (of the 20) women's rights-based organizations we spoke with across Afghanistan, Bangladesh, India, and Nepal work on creating an enabling environment by adopting multi-pronged strategies. These include campaigns, peer support, and leadership development to empower women as change-makers. Some organizations in Bangladesh and India use social audits and participatory methods to identify and prioritize issues for collective action. They build alliances with other networks and local groups to address a wide range of issues including land rights, livelihoods, and social issues like alcohol abuse and domestic violence. An organization in Nepal adopts the approach of establishing dialogs with communities and governments, they aim to strengthen governance and promote inclusivity. They also engage community-based women's groups or networks to function as first responders or reporters of domestic violence cases and provide mental health support and psychosocial counseling. They undertake capacity building of local governments in addressing violence against women and facilitate dialogs with women's groups. Organizations in Afghanistan establish special groups to support marginalized women, providing essential services like shelter, childcare, and vocational training. A rights-based organization in Bangladesh has made efforts to advocate and strengthen the gender-responsiveness of government systems to address violence against women. Among these efforts are lobbying for better services and accountability within the system, mobilizing women's constituencies, engaging local government and constituencies for improved governance, and advocating for women's issues and redressal through increased women's representation at ward levels and forums.

We identified eight organizations from those we spoke with who were working to improve food access and agricultural practices. Some organizations in Afghanistan, India, and Nepal aim to improve access to natural resources as a right for the communities to ensure local availability of food, and access to resources, and promote local food production and consumption as well as food preservation. They organize women at the village level, arrange public hearings, and engage in campaigns. Interventions such as nutrition-sensitive agriculture methods are implemented to diversify food production for small-landholding and landless farmers. These interventions also promote local or indigenous food consumption to improve women's decision-making control over production, selling, and consumption, thereby linking 'field to plate'. Other interventions by organizations in Bangladesh, include setting up micro-enterprises, establishing market linkage and food fortification and processing units, community cooking, and creating grain and seed banks. These approaches aim to enhance livelihoods, agricultural practices, and household food security.

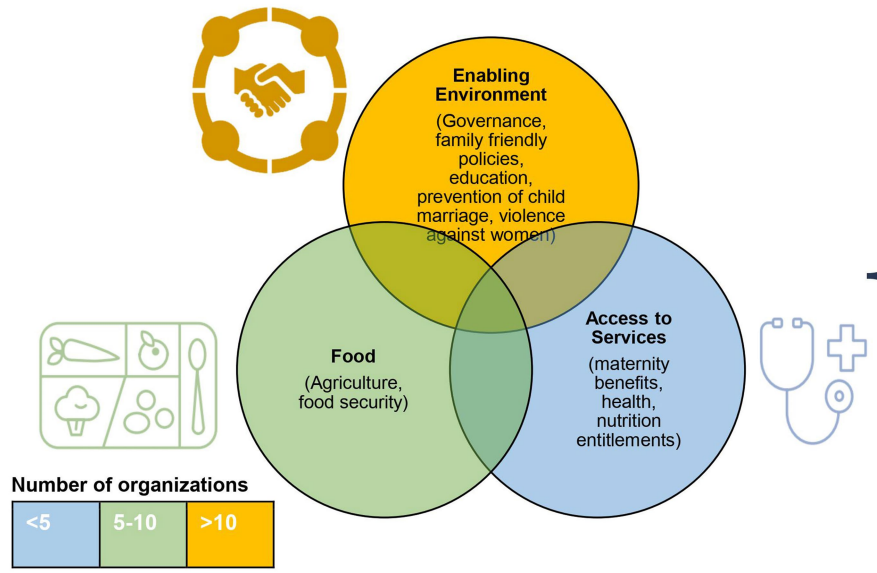

FIGURE 2
Approaches and actions used by women's rights-based organizations.

Five women's rights-based organizations in Afghanistan, Bangladesh, India, Nepal, and Pakistan adopt strategies to facilitate dialog between community and government systems to bridge the gap and build synergy to improve community access to health services and entitlements. For example, organizations in Bangladesh, India, and Nepal implement group-led activities, including health camps with local government, nutrition rehabilitation centers, and referral/ linkage to health services to facilitate access to reproductive health and nutrition rights. Organizations in humanitarian settings (Afghanistan) undertake activities to establish private clinics to provide primary healthcare support to women as their right. Efforts are also made to strengthen state institutions by providing technical assistance for capacity building, planning, and monitoring of interventions. An organization in Pakistan advocates for representation from women's organizations at forums and committees. It adopts a bottom-up approach to facilitate dialogs between women from communities and the government systems to address their demands and improve access, coverage, and quality of services, rights, and entitlements.

In addition, we found strategies in which local mobilizers with women's self-help groups implement actions at the community level to address gender norms and practices, create awareness, generate demand for services, and support access to rights. Organizations also foster multi- and inter-departmental convergence to improve coverage, intensity, and quality of services. Other methods implemented to improve access to maternity entitlements and rights for the unorganized rural sector include influencing acts, public hearings, networks and campaigns, and community-level monitoring of outcomes.

Priorities for investment and exploration

Partnering with women's groups and rights-based organizations offers an opportunity to invest in nutritional outcomes, a long-neglected area of women's rights. Women's group interventions have demonstrated the possibility of adopting a multi-sectoral approach to improve nutrition and health outcomes in South Asia. While evidence on their effectiveness is mixed, it is clear that interventions are more likely to improve nutrition outcomes through adopting multi-pronged, participatory strategies with adequate intervention intensity (19, 37).

Moreover, social determinants play a critical role in impacting nutritional outcomes. For example, gender inequality adversely affects the nutritional status of women and children (38, 39). We argue that to address the social determinants of poor health and nutritional outcomes, a rights-based approach is critical—moving beyond service delivery interventions. Investments need to be expanded in South Asia to ensure a key role for women's organizations and to experiment with various strategies, such as harnessing a combined food-systems-rights pathway and integrating participatory approaches to improve nutritional outcomes. However, improving such outcomes will require continuous, intensive, and sustained actions at scale (40). Any future experiments should consider a longer intervention duration, ensuring adequate program implementation intensity at scale and building capacities of communities for a sustained impact. It is critical to ensure local, women-led leadership to the spirit of a 'movement' grounded in rights approach rather than only service delivery or add-on interventions that use women's groups as a delivery mechanism.

Across countries, we propose that the next step could be the development of a network in South Asia that brings together organizations/ institutions to collaborate on a shared rights-based nutrition agenda. A network of organizations that collaborate and exchange knowledge and practices through convening's, joint research, and policy action. Moreover, joint activities can strengthen advocacy to ensure a key role for women's rights-based organizations in addressing nutritional outcomes across the region.

Conclusion

Women's groups and organizations are strategically placed to address nutrition through collective and group-level action. Working with women's groups and rights-based organizations can ensure justice and equity in nutrition agendas, where women are at the forefront of deciding their priorities, demanding their rights and services, and acting and pushing for social change and accountability through collective action. Such partnerships can support transforming nutrition programs from a service delivery to a rights-based approach.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MS: Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. VS: Conceptualization, Funding acquisition, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. AH: Conceptualization, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. ZM: Conceptualization, Writing – review & editing. RS: Data curation, Formal analysis, Investigation, Writing – review & editing. KW: Data curation, Formal analysis, Investigation, Writing – review & editing. AN: Writing – review & editing. VN: Writing – review & editing. SD: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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The hidden crisis: double burden of malnutrition among refugee children in South Asia – a systematic review and meta-analysis from observational studies

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Background: Children living in refugee camps in South Asian countries suffer from undernutrition. However, the emerging prevalence of double burden of malnutrition could potentially cause a crisis in the healthcare of the refugee population. Double burden increases the risk for co-morbidities, poor functional health, and increased risk for premature death among these children. The study aims to assess the prevalence of malnutrition among refugee children in South Asia.

Methods: This systematic review and meta-analysis followed the standard Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines using CoCoPop mnemonic approach. We searched JSTOR, Scopus, PubMed, Web of Science, and MEDLINE databases for studies on the prevalence of malnutrition in refugee children from 1984 to August 2024 with restricted English language. The screening of research articles was undertaken using COVIDENCE 2.0 software. The JBI checklist was used to assess the methodological quality of the included articles. The meta analysis was carried out using MedCalc 22.018 software. The gray literature was manually searched from the reputed organizations focusing on refugee children and was narratively analyzed for malnutrition statistics. Furthermore, the corroboration of primary research articles and gray literature was conducted for comprehensive understanding.

Results: The review included 10 full-text research articles, all with cross-sectional study design and 11 gray literatures. The 10 studies covered a total of 4,274 participants with 3,536 urban and 738 rural refugee children aged between 0 and 19 years [refugee children (n = 8) and refugee adolescents (n = 2)]. The sample size of the included studies varied between 58 and 1,087 and mostly from Bangladesh. The prevalence of stunting ranged from 3.9–75.4% in the included studies [pooled prevalence: 31.8% (95% CI: 18.6–46.6%)]; wasting between 0.3–24.3% [pooled prevalence:10.1% (95% CI: 4.6–17.3)]; underweight between 4.4–65% [pooled prevalence: 19.1% (95% CI: 10.8–29.2%)]; and overweight between 3 and 24% [pooled prevalence: 6.5% (95% CI: 2.6–12.1%)]. Time trend analysis of the prevalence of malnutrition showed a decreasing trend in underweight,

an increasing trend for stunting and wasting, and overweight including a rising prevalence of dual burden of under-and overnutrition.

Discussion: The study indicates a high prevalence of undernutrition and a rising prevalence of overnutrition -the Asian paradox of the double burden of malnutrition in refugee children living in South Asia. The coexisting double burden of malnutrition among refugee children calls for comprehensive programs and policies for the prevention and management of the double burden of malnutrition.

KEYWORDS

refugee children, South Asia, malnutrition, undernutrition, obesity, overweight, nutritional status

1 Introduction

South Asia is hosting nearly 3.6 million refugees and asylum-seekers experiencing the "Asian paradox" of double burden of malnutrition (1). This paradox involves both high rates of undernutrition and an increasing prevalence of over nutrition, underscoring the urgent need for comprehensive strategies and policies to address these issues effectively. The United Nations High Commissioner for Refugees (UNHCR) defines a refugee as "an individual who has been compelled to flee their country due to persecution, war, or violence, and who has a well-founded fear of persecution based on race, religion, nationality, political opinion, or membership in a particular social group" (2). In the Asia-Pacific region, approximately 15.7 million displaced individuals—including refugees, asylum-seekers, stateless persons, and returnees—are under the UNHCR's care, representing about 13 percent of the global refugee population (3). South Asia, in particular, hosts large numbers of refugees from Afghanistan and Myanmar, with Pakistan and Bangladesh being major host countries. Notably, children under 18 make up around 49% of the refugee population in this region (3). These children and their families typically reside in temporary camps or settlements, supported by the UNHCR, local governments, or various non-governmental organizations.

The process of migration can severely impact the health and nutrition of children, affecting their growth and development during critical years. Refugee children often suffer from chronic undernutrition in their home countries due to prolonged exposure to conflict and trauma. This situation is further exacerbated during their migration, increasing their susceptibility to infectious diseases, malnutrition, and higher mortality rates. In refugee camps, children commonly face food insecurity, inadequate clean water, poor shelter, and limited healthcare access, which worsens malnutrition. Additionally, adapting to new, resource-scarce environments and struggling to obtain sufficient and appropriate food can be particularly challenging and distressing (4). While previous studies from South Asia have highlighted high rates of undernutrition among refugees (5), recent research has also identified rising cases of overweight and obesity among these children (6, 7). This trend indicates a growing prevalence of the double burden of malnutrition—characterized by the coexistence of undernutrition (such as stunting, wasting, and underweight) and overnutrition (including overweight, obesity, and diet-related noncommunicable diseases) (8).

The coexistence of undernutrition (i.e., multiple micronutrient deficiencies, underweight and childhood stunting and wasting) and obesity/overweight with diet-related non-communicable diseases known as double burden of malnutrition (DBM) is common among children living in low- and middle-income countries (Popkin, Corvalan and Grummer-Strawn, 2020), and refugee children migrated to developed countries (9, 10). The phenomenon of coexisting under and overweight and obesity is less reported among refugee children of South Asian countries. However, if the prevalence of double burden of malnutrition surge above the thresholds of public health significance, could potentially result in grave health outcomes including early onset of non-communicable diseases and premature death of young adults (11).

Previous systematic reviews have primarily focused on various forms of undernutrition, such as stunting, among refugee children in South Asia (12, 13). There is a paucity of information on the double burden of malnutrition in refugee children living in settlements of South Asian countries. The evidence from the present review would be beneficial for policy makers, national and international organizations that care for refugee children. Information from the present review may initiate necessary deliberations among different stakeholders to develop programs and policies in the host countries to prevent and manage different forms of malnutrition among refugee children. Therefore, the present review aimed to summarize and derive pooled estimates of the different forms of undernutrition and overnutrition among refugee children in South Asia.

2 Methodology

The present review was prepared to assess the prevalence of childhood malnutrition in refugee children living in eight South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka) (14). Additionally, the primary studies were corroborated with the existing gray literature published by reputed organizations [United Nations High Commissioner for Refugees (UNHCR), UNICEF, Centre for Disease Control and Prevention (CDC), Internal Displacement Monitoring Centre (iDMC), IMPACT, Plan International, and Action Against]. The approach adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 guidelines for conducting systematic review (15).

2.1 Search strategy and selection criteria

All studies published in English between 1980 and 2024 were included in the review. A comprehensive search of original articles was performed using five electronic bibliometric datasets- JSTOR, SCOPUS, PubMed, Web of Science and MEDLINE. The following

terms and keywords were used in the search: Refugee: "refugee's"[All Fields] OR "refugees"[MeSH Terms] OR "refugees"[All Fields] OR "refugee"[All Fields] AND children: "child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields] OR "child's"[All Fields] OR "children's"[All Fields] OR "children'"[All Fields] OR "child'"[All Fields] AND South Asia: "asia, southern"[MeSH Terms] OR ("asia"[All Fields] AND "southern"[All Fields]) OR "southern asia"[All Fields] OR ("south"[All Fields] AND "asia"[All Fields]) OR "south asia"[All Fields] OR "Afghanistan"[All Fields] OR "Bhutan"[All Fields] OR "Pakistan"[All Fields] OR "India"[All Fields] OR "Bangladesh"[All Fields] OR "Nepal"[All Fields] OR "Maldives"[All Fields] OR "Sri Lanka"[All Fields] OR "Maldives"[All Fields] AND Nutritional Status: "nutritional status"[MeSH Terms] OR ("nutritional"[All Fields] AND "status"[All Fields]) OR "nutritional status"[All Fields] OR "stunting"[All Fields] OR "wasting"[All fields] OR "underweight"[All Fields] OR "overweight"[All Fields] OR "obesity"[All Field].

2.2 Eligibility criteria

The inclusion criteria used the CoCoPop mnemonic (Condition, Context and Population) approach to determine the prevalence of nutritional status in refugee children of South Asian countries from the original articles (16).

The inclusion criteria for the peer-reviewed research articles included observational study designs (i.e., cohort, cross-sectional, and case–control designs) for the estimation of the pooled prevalence estimates. Exclusion criteria comprised of research articles focusing on the Internally Displaced persons (IDPs), returned IDPs, naturalized refugees, and resettled refugees. Using the above exclusion criteria gray reports solely defining the integrated care, published in language other than English, population greater than 19 years of age and lacking the inclusion of South Asian countries were not listed for the present review (Table 1).

2.3 Study identification and data extraction

The original research articles that were retrieved were uploaded to COVIDENCE 2.0, a systematic review software by Veritas Health Innovation (17) to conduct the review. This software facilitates an unbiased screening process for selecting research articles for inclusion in the systematic review. The selection of articles for current systematic review was completed in four steps: firstly, uploaded the RIS/PubMed files to the COVIDENCE 2.0 software and removed duplicates; secondly, two reviewers independently screened the title and abstracts (TL and RSB); thirdly, after retrieving the full-text article, duplicate screening of full-text articles was conducted based on inclusion eligibility criteria (TL and RSB); and finally, the included research articles were incorporated for the systematic review and meta-analysis. Disagreements regarding study inclusion for full-text review were resolved through discussion and consensus with a third co-author (KM) and discrepancies were resolved.

Two authors independently performed the data extraction from eligible full-text articles. Discrepancies in data extraction were addressed through a meeting at the end of double extraction, with unresolved issues settled by PP. A Microsoft Excel spreadsheet was used for data extraction, and tables were prepared. From the eligible studies, information was collected, including the author's name, publication year, study location, country of residence for refugees, study design, number of participating refugee children, and prevalence of malnutrition in four categories: underweight, stunting, wasting, and overweight/obesity in refugee children up to 19 years of age. The gray literature data extraction included reports stating the title of report, agency of publication, age of population, prevalence data of underweight, overweight, stunting and wasting.

2.4 Critical appraisal checklist for studies reporting prevalence data

The Joanna Briggs Institute (JBI) critical appraisal tool for systematic reviews was used for critical appraisal of each article included in the study (16). The JBI critical appraisal tool for prevalence studies had nine questions in the checklist, and each question fell into one of four criteria: 'yes,' 'no,' 'unclear,' or 'not applicable.' Each checklist score was tallied and could have a maximum score of nine and a minimum of zero. A score between 0 and 3 was considered as low, 4–6 as medium, and 7–9 as high.

2.5 Data analysis

The data extracted was summarized based on the objective of the present review. The characteristics of the included studies were summarized, including author, year, age group of children, country of origin, sample size, and sub-categorized into rural–urban locations.

TABLE 1 CoCoPop mnemonic approach.

Parameters	Inclusion	Exclusion
Context	South Asia (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka) (14)	Non-South Asian countries
Condition	Prevalence of malnutrition based on anthropometric indicators underweight (WAZ < -2), stunting (HAZ < -2), wasting (WHZ < -2), and overweight (BMI-for-age Z score > +1 to +2 and WHA > 2) and -obesity (BMI-for-age Z Score > +2) (18)	Prevalence of malnutrition related to pre-existing conditions (any chronic or infectious diseases, genetic disorders, cognitive disorders, autoimmune disorders)
Population	Other people in need of international protection (OIP) refers to "*people who are outside their country or territory of origin, typically because they have been forcibly displaced across international borders, who have not been reported under other categories (asylum-seekers, refugees, people in refugee-like situations) but who likely need international protection, including protection against forced return, as well as access to basic services on a temporary or longer-term basis*" (39)	Children who live in normal zones and are unaffected by emergencies and Adults >19 years

Further, the prevalence of undernutrition underweight (WAZ < -2), stunting (HAZ < -2), wasting (WHZ < -2) and overnutrition indicators such as overweight (BMI-for-age Z score > +1 to +2 and WHA > 2) and obesity (BMI-for-age Z Score > +2), from the included studies were presented in the tables (18).

Meta-analysis was performed to estimate the pooled prevalence of malnutrition. A pooled estimate of underweight, stunting, wasting, and overweight prevalence was derived using a random-effects model (Dersimonian–Laird method) using MedCalc statistical software (version 22.018, MedCalc Software Ltd., Belgium). The random-effects model was used due to higher study variations. The MedCalc software was used for developing forest plots and analyzing the heterogeneity of the included studies (19). Given the diversity in geographical locations, sample sizes, participant ages, and outcome indicators across the retrieved studies, statistical heterogeneity was evaluated using Cochran's Q and I^2 statistics (I^2 > 75% indicates substantial heterogeneity). Publication bias was evaluated using Egger's test and Begg's rank test and represented as the Funnel plot; a *p*-value <0.05 indicated the publication bias. Similarly, reports from various organizations supporting the welfare of the refugee children, migrants, and international agencies were listed manually. The presence of data from the gray literature was presented as "▲" (available) and "-" (unavailable). The data for gray literature was narratively synthesized.

3 Results

3.1 Data search and screening results

The study analyzed 10 research articles and 11 gray literature reports that met the inclusion criteria. The results were compiled and analyzed through meta-analysis for the prevalence of malnutrition, while gray literature was summarized narratively.

A total of 9,752 research articles were retrieved from five databases from 1980 to 2024. The *Covidence 2.0* software was used for duplicate screening of research articles. Out of the 9,752 articles imported to the *Covidence 2.0* software, 6,224 were identified as duplicates. Subsequently, the title and abstract screening were conducted for the remaining 3,528 articles, resulting in 1743 exclusion as the primary research articles did not conform to the CoCoPop mnemonic approach. The remaining 1785 research articles were further screened for full text based on eligibility criteria. About 1775 articles, 700 articles for non-matching age groups of participants, 300 studies for non-South Asian locations (countries), and 775 research articles on not defining the prevalence values of under and over-nutrition were excluded. Finally, 10 full-text research articles, all with cross-sectional study design were included in the systematic review (6, 7, 20–27) (Figure 1). Additionally, gray literature consisting of reports from reputed organizations (*n* = 11) were included in the present review for strengthening the current review on the prevalence of malnutrition in refugee children from South Asian countries (28–37) (Figure 1).

3.2 Critical appraisal

A quality assessment of the included primary research articles was conducted using the JBI checklist for prevalence studies and the results showed that most studies were of high quality (a score of >7 out of 9). Out of 10 included studies, eight studies had complied on all the nine critical appraisal questions (i.e., the studies included sample frame to address the target population, analysis of the samples, sample size, study settings, coverage of the data, identification of the conditions, standard and reliable methods for study participants, appropriate statistical analysis and response rates of the participants) (Figure 2).

3.3 Characteristics of the included studies

The included studies represented four countries in the South Asian region: Afghanistan (*n* = 2), Bhutan (*n* = 1), Bangladesh (*n* = 6) and India (*n* = 1) (Table 2). The 10 studies included in the present review covered a total of 4,274 participants with 3,536 urban and 738 rural refugee children, and the studies followed a cross-sectional study design. The ages of the participants ranged from 0 to 19 years [refugee children (*n* = 8) and refugee adolescents (*n* = 2)]. Of the 10 studies, eight were from urban and two from rural locations. The sample size of the included studies varied between 58 (from Afghanistan) to 1,087 (from Bangladesh) refugee children. Most of the studies covered childhood prevalence of malnutrition among refugee children (*n* = 6) from Bangladesh. All included studies were published between 1994 and 2023 (Table 2).

3.4 Overall prevalence of malnutrition (undernutrition and over-nutrition)

The included studies used standard anthropometric indicators to assess childhood nutritional status. Indicators of malnutrition used included underweight (WAZ < -2), stunting (HAZ < -2), wasting (WHZ < -2) and overweight (BMI-for-age Z Score > +1 to +2 and WHZ > +2) and obesity (BMI-for-age Z Score > +2).

Seven included studies showed the prevalence of underweight (6, 7, 20–22, 26, 27); nine studies reported stunting (6, 7, 20–27) and eight studies reported for wasting (6, 7, 21–25, 27). On the other hand, three studies reported the prevalence of overweight (6, 7, 22), and two studies obesity among refugee children (6, 7) (Table 3).

The highest prevalence of stunting and wasting was reported in in refugee children living in Bangladesh (75.4, 24.3%, respectively) (26, 27), and underweight (65%) in Afghani children (24). An Indian study reported the lowest prevalence of stunting (3.9%) (20). Wasting remained as the nutritional challenge - Bangladesh refugee children showed the highest prevalence of wasting (24.3%), followed by Afghanistan refugee children (15.9%) (7, 24). Among refugee adolescents, those from Afghanistan had the highest level of stunting (35.3%), followed by Nepal (26.9%) (Table 3).

Notably, half of the studies reported a very high prevalence of stunting of public health emergency (i.e.,>30%) (6, 7, 22–24, 27). Further, two studies reported high (20–30%) (6, 21), and one medium prevalence (10–20%) (25) of public health concern. Similarly, three out of eight studies reported a very high prevalence of wasting (>15%) (7, 23, 24), two studies high (10–15%) (6, 22), and one study medium (5–10%) (21) prevalence of public health emergency (Table 3).

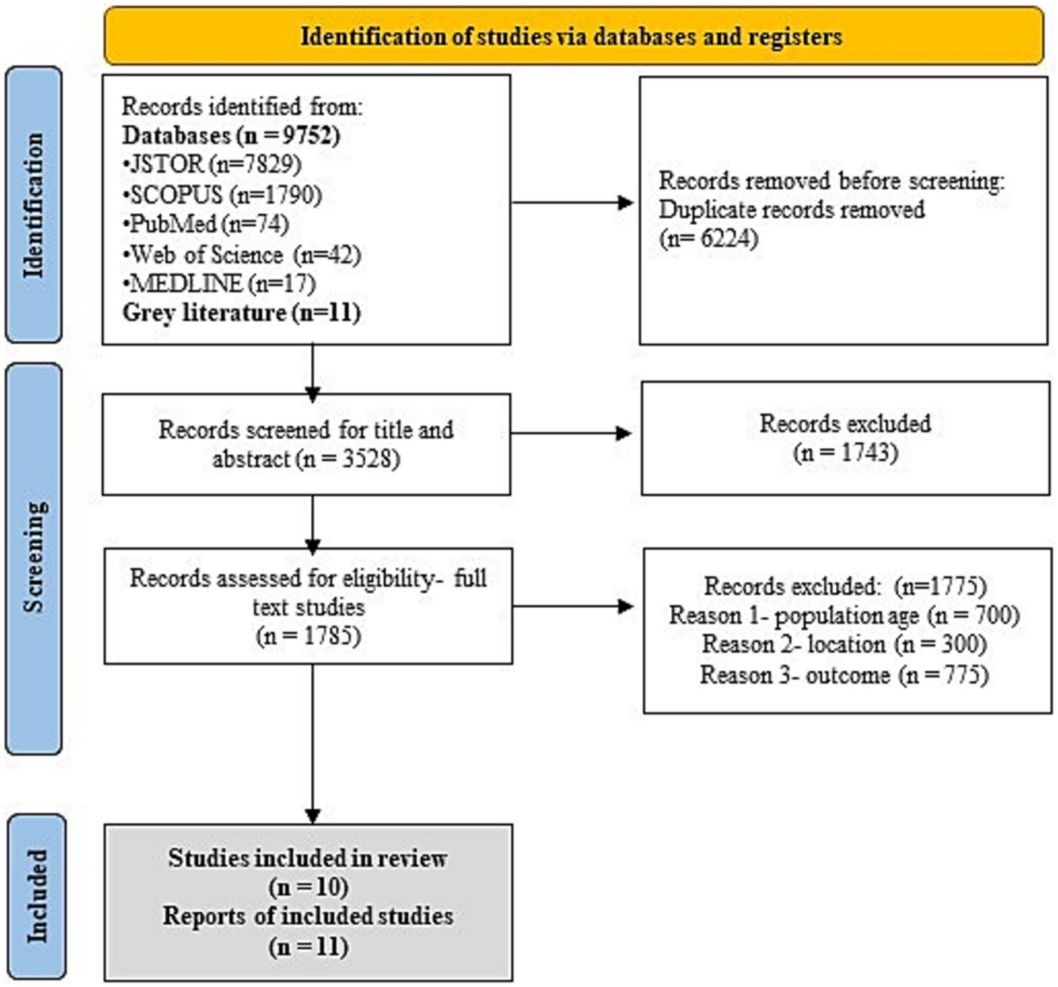

FIGURE 1
PRISMA flowchart.

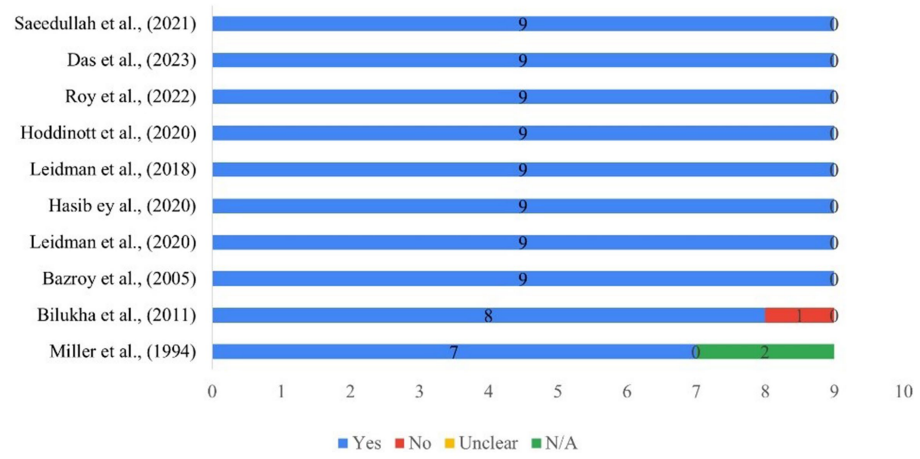

FIGURE 2
JBI scores for prevalence studies.

Surprisingly, two studies from Bangladesh and one study from Afghanistan reported overweight and obesity among refugee children (6, 7, 22). Two authors studied refugee children from urban areas (6, 22), while one study focused on refugee children from rural areas (7). Afghan rural refugee adolescents had the highest prevalence of overweight (24%) and obesity (5.2%) than urban studies (7).

TABLE 2 Characteristics of refugee children living in South Asian countries.

No	Author (Year)	Country of origin	Study settings	Study design	Population	Age (Years)	Sample size
Urban							
1	Das et al. (6)	Bangladesh	Urban	Cross-sectional	Children, Adolescent	0–17	547
2	Roy et al. (27)	Bangladesh	Urban	Cross-sectional	Children	0.6–4.9	645
3	Hasib et al. (22)	Bangladesh	Urban	Cross-sectional	Children	0–5	100
4	Leidman et al. (25)	Bangladesh	Urban	Cross-sectional	Children	0.6–4.9	1,087
5	Leidman et al. (24)	Bangladesh	Urban	Cross-sectional	Children	0.6–4.9	269
6	Bilukha et al. (21)	Bhutan	Urban	Cross-sectional	Children	0.6–4.9	569
7	Bazroy et al. (20)	India	Urban	Cross-sectional	Children	0–5	261
8	Miller (26)	Afghanistan	Urban	Cross-sectional	Children	0–11	58
Rural							
9	Saeedullah et al. (7)	Afghanistan	Rural	Cross-sectional	Adolescent	10–19	206
10	Hoddinott et al. (23)	Bangladesh	Rural	Cross-sectional	Children	0–2	532

Overnutrition was prevalent among refugee adolescents compared to refugee children under five (6, 7) (Table 4).

3.5 Estimates of pooled prevalence of stunting

Pooled estimates were calculated through meta-analysis software to summarize the prevalence of undernutrition and over nutrition in refugee children living in South Asia. Although the prevalence of stunting ranged from 3.9 to 75.4% in the included studies, the overall pooled prevalence of stunting was 31.8% (95% CI: 18.6 to 46.6%; Supplementary Table S1, Figure 3). A high heterogeneity was observed between the included studies (I^2: 98.9); $p < 0.0001$ (Figure 3). The Egger's test showed no statistically significant publication bias in the overall prevalence analysis of stunted refugee children ($p = 0.9$) (Figure 4).

3.6 Estimates of pooled prevalence of underweight

Similarly, the prevalence of underweight varied between 4.4 to 65% in the included studies, and the estimated pooled prevalence of underweight was 19.1% (95% CI: 10.8 to 29.2%) (Supplementary Table S2; Figure 5). Higher heterogeneity was observed between the included studies (I^2: 96.8%); $p < 0.0001$ (Figure 5). The Egger's test showed no significant publication bias in the overall prevalence analysis for undernourished refugee children ($p = 0.3$) (Figure 6).

3.7 Estimates of pooled prevalence of wasting

Further, the prevalence of wasting ranged from 0.3 to 24.3% in the included studies, and the estimated pooled prevalence of wasting was 10.1% (95% CI: 4.6 to 17.3%; Supplementary Table S3, Figure 7). A high heterogeneity was observed between the included studies (I^2: 97.5%); $p < 0.0001$ (Figure 7). The Egger's test showed no significant publication bias in the overall prevalence analysis for wasted refugee children ($p = 0.09$; Figure 8).

3.8 Estimates of pooled prevalence of overweight

On the other hand, three studies from South Asia reported a prevalence of overweight between 3 to 24%, and the estimated pooled prevalence of overweight was 6.5% (95% CI: 2.6 to 12.1%; Supplementary Table S4, Figure 9). Higher heterogeneity was observed between the included studies (I^2: 80.28%; $p = 0.01$; Figure 9). The Egger's test showed no significant publication bias in the overall prevalence analysis for over nourished refugee children ($p = 0.8$; Figure 10).

3.9 Time series analysis of malnutrition in refugee children

Time trend analysis of the prevalence of malnutrition was conducted using the prevalence rates reported in primary research articles. The prevalence of underweight in refugee children reported a decreasing trend while that of stunting and wasting, showed an increasing trend. A limited number of studies reported the prevalence of overnutrition, yet an increasing trend of prevalence in refugee children was noted.

3.10 Gray literature

For the present review, gray literature was searched manually for information, in addition to the original research articles, on the prevalence of malnutrition among refugee children in South Asia. The gray literature included reports and policy documents from various organizations, and the search results were summarized. Eleven reports from international organizations were obtained after the screening - four were from the United Nations High Commissioner for Refugees (UNHCR), three from UNICEF, two from the Centre for Disease Control and Prevention (CDC), and one each from Internal Displacement Monitoring Centre iDMC, IMPACT, Plan International (31), and Action Against Hunger (28–37).

TABLE 3 Prevalence of undernutrition in refugee children living in South Asian countries.

No	Author (Year)	Country of origin	Study settings	Study design	Population	Age (Years)	Sample Size (*n*)	Z Scores	Prevalence of stunting *n* (%)	*Z* scores	Prevalence of underweight *n* (%)	*Z* scores	Prevalence of wasting *n* (%)
Urban													
1	Das et al. (6)	Bangladesh	Urban	Cross-sectional	Refugee Children	0–5	299	HAZ < −2	94 (31.6)	WAZ < −2	81 (27.4)	WHZ < −2	36 (12.1)
					Refugee Adolescents	11–17	248	HAZ < -2 to −3	72 (28.8)	BMI-for-age Z Score < −2 to −3	25 (10.0)	–	–
2	Roy et al. (27)	Bangladesh	Urban		Refugee Children	0.6–4.9	645	HAZ < -2	486 (75.4)	WAZ < −2	40 (6.2)	WHZ < −2	2 (0.3)
3	Hasib et al. (22)	Bangladesh	Urban	Cohort	Refugee Children	0–5	100	HAZ	41 (41.0)	WAZ	18 (18.0)	WHZ	13 (13.0)
4	Leidman et al. (25)	Bangladesh	Urban		Refugee Children	0.6–4.9	1,087	HAZ	211 (19.4)	–	–	WHZ < −3	34 (3.13)
5	Leidman et al. (24)	Bangladesh	Urban	Cross-sectional	Refugee Children	0.6–4.9	269	HAZ < −2	117 (43.4)	–	–	WHZ < −2	65 (24.3)
6	Bilukha et al. (21)	Bhutan	Urban	Cross-sectional	Refugee Children	0.6–4.9	569	HAZ < −2	133 (23.4)	WAZ < −2	119 (20.9)	WHZ < −2	46 (8.1)
7	Bazroy et al. (20)	India	Urban	Cross-sectional	Refugee Children	0–5	261	HAZ	5 (3.9)	WAZ	62 (47.3)	–	–
8	Miller (26)	Afghanistan	Urban	Cross-sectional	Refugee Children	0–11	58	–	–	WAZ	38 (65.0)	–	–
Rural													
9	Saeedullah et al. (7)	Afghanistan	WAZ	Cross-sectional	Refugee Adolescents	10–19	206	HAZ < −2	73 (35.3)	BMI-for-age Z Score < −2	6 (4.4)	–	33 (15.9)
10	Hoddinott et al. (23)	Bangladesh	Rural		Refugee Children	0–2	532	HAZ < −2	175 (33.4)	–	–	WHZ < −2	82 (15.8)

Underweight (Weight-for-Age Z-Scores <−2), Stunting (Height-for-Age Z-Scores <−2), Wasting (Weight-for-Height-Z-Scores <−2), BMI-Body Mass Index.

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TABLE 4 Prevalence of overweight and obesity in asylum seeker children living in South Asian countries.

No	Author (Year)	Country of origin	Population	Age (Years)	Sample size (n)	Prevalence of overweight *n* (%)	Prevalence of obesity *n* (%)
Urban							
1	Das et al. (6)	Bangladesh	Adolescents girls	11–17	248	12 (5.0)	2 (0.7)
2	Hasib ey al. (2020)	Bangladesh	Children	0–5	100	3 (3.0)	-
Rural							
3	Saeedullah et al. (7)	Afghanistan	Adolescents	10–19	206	24 (24)	6 (5.2)

Overweight- BMI-for-age Z Score > +1 to +2 and WHZ >2, Obesity- BMI-for-age Z-Score > +2.

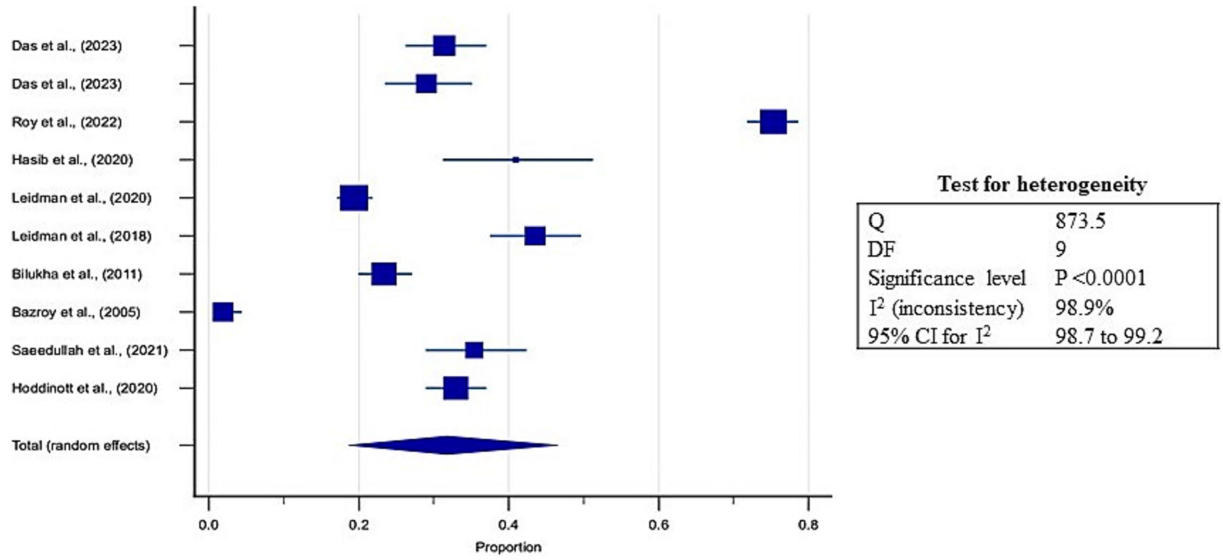


FIGURE 3
Forest plot for estimates of pooled prevalence of stunting in refugee children dwelling in South Asian Countries.

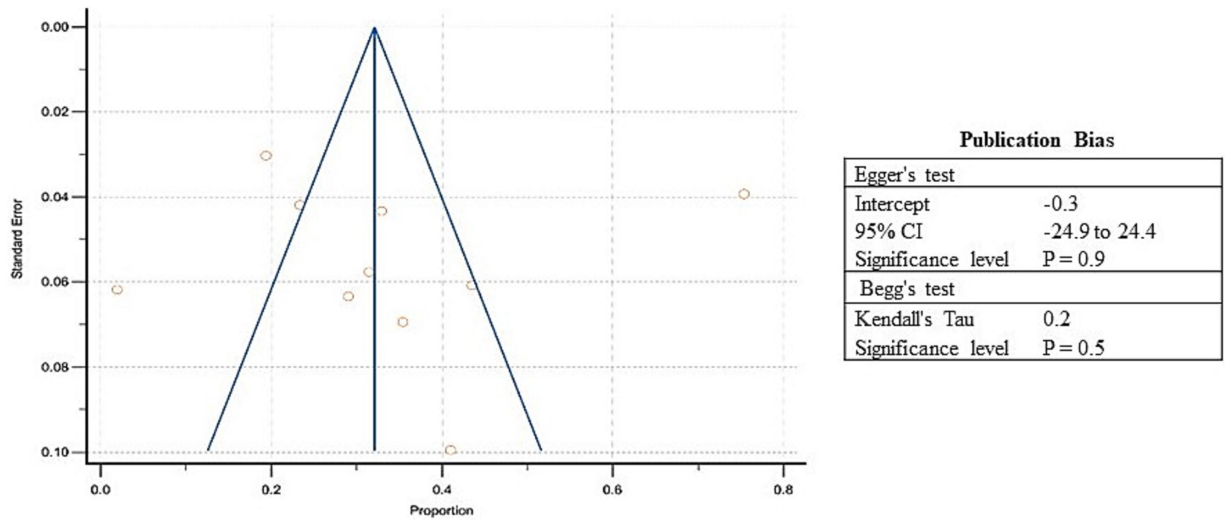
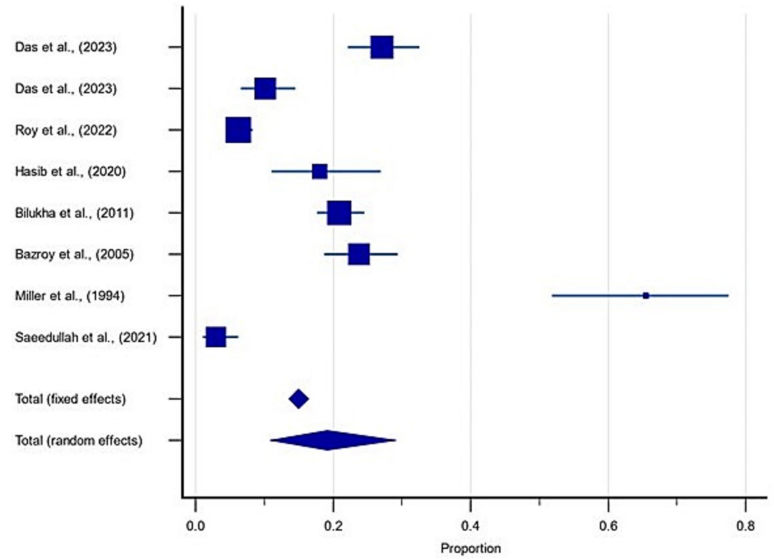


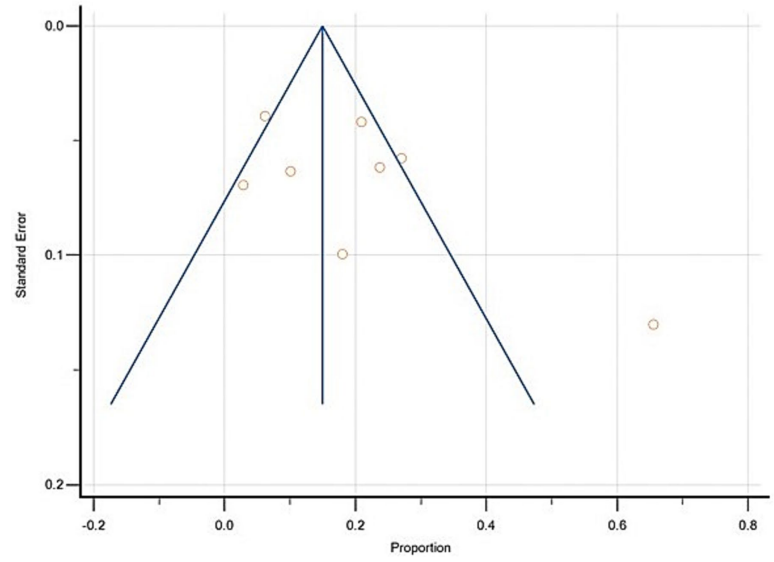
FIGURE 4
Funnel Plot showing publication bias for included studies of stunting among refugee children dwelling in South Asian countries.



Test for heterogeneity

Q	223.8067
DF	7
Significance level	P < 0.0001
I^2 (inconsistency)	96.87%
95% CI for I^2	95.39 to 97.88

FIGURE 5
Forest plot for estimates of pooled prevalence of underweight in refugee children dwelling in South Asian Countries.



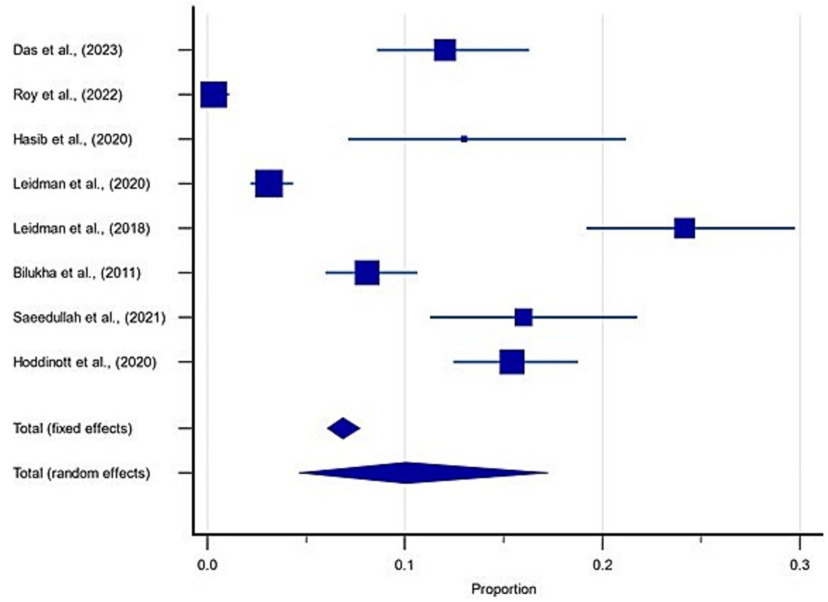
Publication Bias

Egger's test	
Intercept	6.9410
95% CI	-7.5558 to 21.4379
Significance level	P = 0.2858
Begg's test	
Kendall's Tau	0.1429
Significance level	P = 0.6207

FIGURE 6
Funnel Plot showing publication bias for included studies of underweight among refugee children dwelling in South Asian countries.

Most of the refugee children were found to be concentrated in Bangladesh and Pakistan. Around 500,000 Rohingya children sought refuge in camps in Bangladesh. Similarly, it was reported that 90% of refugees in South Asia were originally from Afghanistan (36). A majority of the literature reported on children under five years, and information on the nutritional status of refugee children between five and nineteen was underreported, or the availability of factual data was limited. UNICEF (35) reported a 7.5% prevalence of severe acute malnutrition among Rohingya refugee children, which was double the rate compared to their six-month prior reports (35). The opportunity to corroborate of the prevalence results from original studies with that from the gray literature was limited as the comparable data was unavailable.

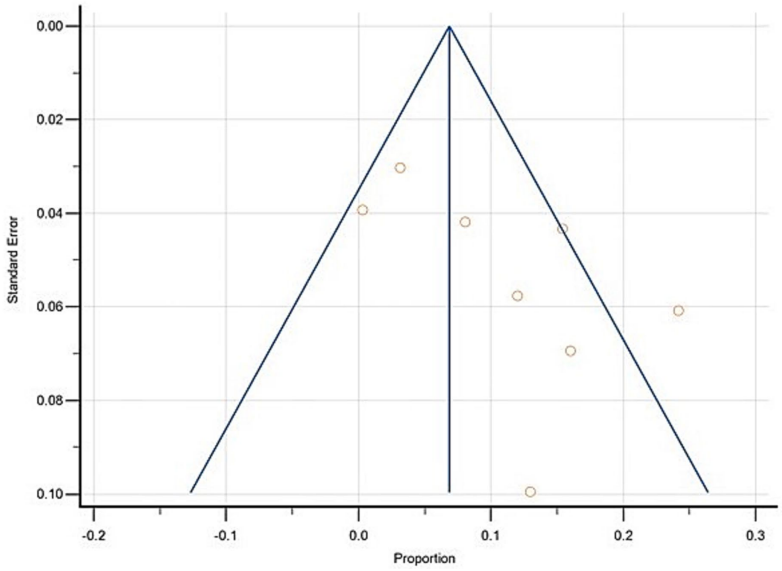
Additionally, the Kutupalong and Nayapara camps of Bangladesh reported high wasting and stunting in the under-five children. Overall, the reports focused on the social, demographic, and other related challenges and implications of malnutrition in refugee children of South Asia. However, information (data) on the prevalence of malnutrition was limited in the gray literature that otherwise addressed the challenges of refugee children, including food insecurity (Table 5).



Test for heterogeneity

Q	282.2145
DF	7
Significance level	P < 0.0001
I^2 (inconsistency)	97.52%
95% CI for I^2	96.45 to 98.27

FIGURE 7
Forest plot for estimates of pooled prevalence of wasting in refugee children dwelling in South Asian Countries.



Publication Bias

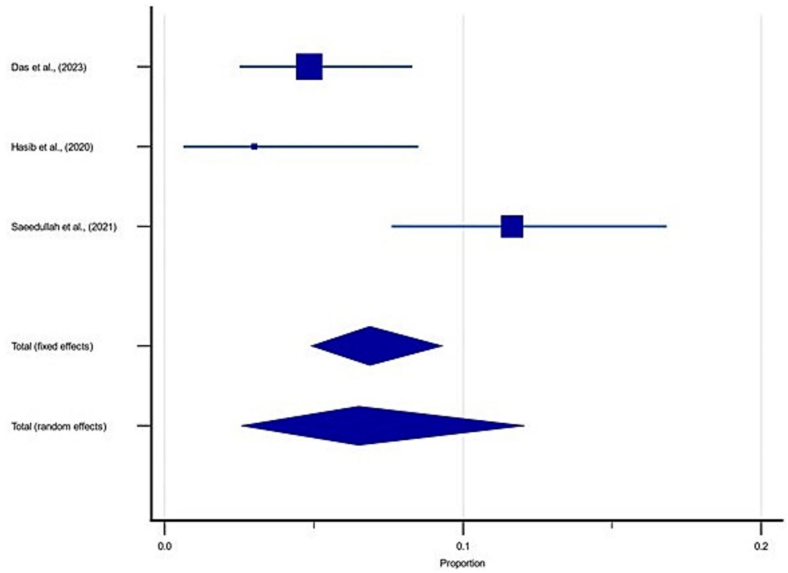
Egger's test	
Intercept	11.8132
95% CI	-2.7789 to 26.4054
Significance level	P = 0.0949
Begg's test	
Kendall's Tau	0.4286
Significance level	P = 0.1376

FIGURE 8
Funnel plot showing publication bias for included studies of wasting among refugee children dwelling in South Asian countries.

4 Discussion

The present study proposed estimating malnutrition prevalence in refugee children living in South Asian countries. The silent findings of the present systematic review and meta-analysis were: (1) the studies reported predominantly from Bangladesh, especially post 2017 Myanmar crisis; (2) wide variations existed in the prevalence of malnutrition indicators and pooled prevalences are estimated; (3) most of the studies reported undernutrition than overnutrition status; and (4) the pooled estimates indicated double burden of malnutrition among the refugee children of South Asia. All the studies used valid, standard, and consistent measures of malnutrition in children, and studies were of high quality.

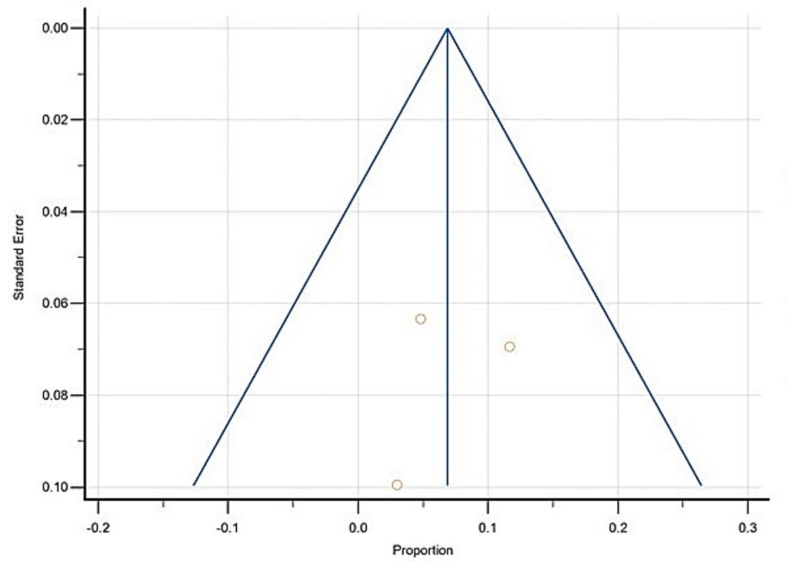
Evidence on the prevalence of malnutrition in refugee children predominantly was from Bangladesh. Although Pakistan hosts the highest number of refugees in South Asia (~19,88,231) than Bangladesh (9,71,984), most of the studies in the present review were from Bangladesh (3). Post 2017 refugee related publications in South



Test for heterogeneity

Q	10.1430
DF	2
Significance level	P = 0.0063
I^2 (inconsistency)	80.28%
95% CI for I^2	37.85 to 93.74

FIGURE 9
Forest plot for estimates of pooled prevalence of over nourishment in refugee children dwelling in South Asian Countries.



Egger's test	
Intercept	-3.6989
95% CI	-125.4087 to 118.0109
Significance level	P = 0.7654
Begg's test	
Kendall's Tau	-0.3333
Significance level	P = 0.6015

FIGURE 10
Funnel plot showing publication bias for included studies of over nourishment among refugee children dwelling in South Asian countries.

Asia were predominantly from Bangladesh due to the Rohingya refugee crisis. Bangladeshi researchers have published several research articles on refugees, their food insecurity, nutritional status, and other diet-related challenges over the last 7 years, especially post the influx of about one million Rohingya refugees from Myanmar. Many researchers have probably had the opportunity to study refugees and report on the nutritional status of children to improve their lives and address their nutritional challenges. Also, children remain a vulnerable, dependent group- more than 60% of the refugees- and are most affected during their critical phase of growth and development (33).

The available evidence indicated wide variations in the prevalence rates of reported indicators such as stunting, underweight, and wasting, which made it necessary to have pooled estimates for the prevalence of malnutrition. The studies showed a higher prevalence of stunting than wasting (33.3% vs. 11.1%) among refugee children in South Asian countries. The present findings are identical to those of Skinner et al. (13), who evaluated the undernutrition among children under five living in refugee camps. According to the authors, severe wasting remains a significant problem in camps that needs urgent attention; often, persistent chronic malnutrition (stunting) is not well-addressed. Additionally, the stunting present in the children before

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TABLE 5 Prevalence of overweight and obesity in refugee children living in South Asian countries.

No	Source (Year)	Title of report	Age (Years)	Under weight (%)	Over nutrition (%)	Stunting (%)	Wasting (%)
1	UNHCR/UN Women (42)	Afghanistan Crisis Update- Women and Girls in Displacement - Factsheet III	<5	–	–	–	–
2	UNICEF (36)	Children on the Move in South Asia Regional Brief	<5	▲	–	▲	–
3	iDMC, IMPACT, Plan International (31)	Women and girls in internal displacement	<5	–	–	–	–
4	(29)	Emergency nutrition assessment final report Nayapara and Kutupalong registered refugee camps and makeshift settlements. (Kutupalong)	<5	▲	–	▲	▲
		Emergency nutrition assessment final report Nayapara and Kutupalong registered refugee camps and makeshift settlements. Nayapara	<5	▲		▲	▲
5	UNICEF (35)	Malnutrition rates among Rohingya refugee children in Bangladesh appear to be at least double earlier estimates	<5	–	–	▲	–
6	UNHCR (33)	Solutions Strategy for Afghan Refugees	<5	–	–	–	–
7	UNHCR (33)	UNHCR Operational Guidance on the Use of Fortified Blended Foods in Blanket Supplementary Feeding Programs	<5	▲	–	▲	–
8	CDC (28)	Malnutrtion and Micronutrient Deficiencies Among Bhutanese Refugee Children- Nepal 2007	<5	▲	–	▲	▲
9	UNHCR/WHO (32)	The road to health and the road to Afghanistan	<5	▲	–	▲	▲
10	UNICEF (37)	Children affected by armed conflict in South Asia: A review of Trends and issues identified through secondary research	<5	–	–	–	–
11	CDC (30)	Nutritional Assessment of Adolescent Refugees- Nepal 1999	10–19	▲	–	–	–

CDC, Centre for Disease Control and Prevention; UNHCR, United Nations High Commissioner for Refugees; iDMC, Internal Displacement Monitoring Centre; UNICEF, United Nations International Children's Emergency Fund.

they arrive in the refugee camps may not be amenable to the interventions offered in the camps (13).

Etiology of malnutrition in refugee children is multifactorial. A high rate of malnutrition is primarily attributed to the dependency of refugees on the humanitarian assistance with limited source or no livelihood (38). Additionally, poor access to good nutrition, the exposure to weather-related hazards such as flooding, cyclones, extreme heat and landslides; and unhygienic and congested living expose children to infectious disease that leads to the vicious cycle of malnutrition. Although the international agencies support the children with nutrition services for prevention and treatment of malnutrition, the impact remains modest in the crisis scenario (39).

Also, most of the studies in the present review reported undernutrition than overnutrition status, as most refugee camps have food insecurity and challenges of inadequate nutrition. However, two studies in the present review reported overweight and obesity among adolescent refugees in South Asia. The present study reported a pooled prevalence of 6.5% overweight. Similar results were reported among adolescents from refugee camps in high-income countries such as Korea (40) or upper-middle-income Turkey (9). Although the scenario is uncommon in South Asian countries, the high carbohydrate-rich diets with less diversified diets may have contributed to overweight and obesity among adolescents (6). Certainly, the rising trend needs attention to reduce the risk of non-communicable diseases.

The pooled estimates indicated a double burden of malnutrition among the refugee children of South Asia. Co-existing under and overnutrition indicate the need for programs to prevent and provide health care for nutrition-related comorbidities in the future. In their systematic review, Ankomah et al. (41) found a high prevalence of double the burden of malnutrition among migrants and refugees in developed countries (41). The effect was attributed to the double burden due to acculturation and the prevalence of unhealthy eating behaviors (4). The shift from a limited food environment for

consumption in the home country to camps with near-adequate amounts of food in the host country improves the food intake. Further, physical inactivity and increased consumption of unhealthy or less diversified diets may lead to a double burden of malnutrition in refugee children (8).

There are a few strengths and limitations to the present work. The strengths include the inclusion of both research articles and gray literature on malnutrition of refugee children to provide a comprehensive overview of the scenario of South Asia. Also, the present study reported on the double burden of malnutrition in refugee children of South Asia – both undernutrition and overnutrition. The limitations include the risk of publication bias due to the inclusion of only articles published in English. However, a comprehensive search strategy and search of most of the electronic databases were conducted to capture most of the literature.

5 Conclusion

Most studies that evaluated the nutritional status of refugee or refugee children from Asian or developing countries reported severe undernutrition, as expected of the scenario in many settings. However, the present review reports the pooled prevalence of double burden of malnutrition in refugee children of South Asia. Further studies are needed to elucidate the potential predictors of the double burden of malnutrition and regular appropriate nutritional screening and focused nutrition education programs considering the potential implications in their adulthood.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

PP: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MU: Data curation, Formal analysis, Methodology, Software, Validation, Visualization. TL: Data curation, Formal analysis, Methodology, Writing – original draft. RB: Data curation, Methodology, Writing – original draft. MNK: Data curation, Formal analysis, Methodology, Software, Validation, Visualization. SR: Conceptualization, Formal analysis, Investigation, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. KM: Conceptualization, Formal analysis, Investigation, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2024.1480319/full#supplementary-material

SUPPLEMENTARY FIGURE S1
(A-D) Time trend analysis of stunting, underweight, wasting, and overweight in refugee children dwelling in South Asian countries.

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Kitchen garden, dietary diversity, and women's health in rural eastern India: a mixed method study

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Background: Nutrition and food security have been a development priority for decades and remain a major challenge for developing nations like India. Although agriculture is the dominant occupation in India, the rural populations experience poor nutritional outcomes and lag in socio-economic progress. More than half of the Indian women (15–49 years) are anaemic & one-third of the children are stunted. Nutrition-sensitive agricultural practices such as kitchen garden have proven as sustainable methods for reducing undernutrition at affordable costs in different regions. This study aimed to see the relationship between kitchen garden and dietary diversity by using DDS (Dietary Diversity Score) scale in Odisha, India.

Objectives: To assess the relationship between dietary diversity score (DDS) and backyard kitchen garden & other socio-economic (SE) factors and to explore the enablers & barriers associated with developing a kitchen garden (KG) in rural households of Odisha, India.

Methods: The study used simple random sampling to select 150 participants (WRA group: women of reproductive age) from the eligible household lists. The outcome variable for the investigation was DDS, whereas KG and SE indicators served as predictors/exposure variables. Furthermore, the study used purposive sampling to choose members for FGDs (Focus Group Discussions) to explore enablers and constraints related to growing a KG.

Results: Women who did not have a household kitchen garden, had poor dietary outcomes, with DDS <5 (OR: 0.163, $p = 0.001$). Furthermore, a lack of agricultural land lowered DDS (OR: 0.176, $p = 0.008$) as well. The remaining SE parameters did not demonstrate a statistically significant relationship with DDS/diet quality. The enablers and constraints to building a KG were synthesised from 2 FGDs & further classified into four themes: seasonal fluctuation, local government's initiatives, men's engagement, and challenges.

Conclusion: Kitchen garden can improve DDS and nutritional outcomes for the WRA group in rural Odisha. However, the distribution of seeds/saplings and small financial assistance from the local government can help with sustainability, particularly in the lower SE strata.

KEYWORDS

kitchen garden, dietary diversity score, women of reproductive age group, nutrition, food security

Introduction

Nutrition and food security have been a development priority for decades worldwide and remain a major challenge for developing nations like India. In the Global Hunger Index-2023, India ranks 111th out of 121 qualifying countries with a score of 28.7 (1). Evidence also suggests that two-thirds of India's current workforce is undernourished, and because of the enormous economic costs incurred it has reduced the country's future per capita income (2, 3). Furthermore, undernutrition also accounts for 20% of maternal deaths either directly or indirectly (4). In India, undernutrition is more prevalent in rural than urban areas presumably due to poor socio-economic conditions, lack of resources, religious taboos, limited education & awareness etc. (3, 5, 6). Although agriculture is the dominant occupation in rural India, dietary quality of the rural populations remains poor which includes cheap, starchy foods and limited consumption of micro-nutrient-rich foods (fruits, vegetables and animal protein) (7). There is no exception in Odisha, an eastern Indian state. The prevalence of various nutritional deficiencies is quite high in the state (5). For example, 32% of children aged 0 to 5 are stunted and 66% of WRA (non-pregnant) are anaemic (5). Furthermore, 30% of men (15–49 years) are also anaemic in the state (5). The data presented above highlights the severity of the undernutrition issue in Odisha, which has persisted for many generations. The state is also battling poverty and a low female literacy rate (67% in rural) (5, 8) which are two predominant social determinants of undernutrition among women & children. A study conducted in Namibia and Ghana found that women of middle- or high-income households had better nutritional outcomes (4). Another study from rural West Bengal, India reiterates the similar conclusion that undernutrition is adversely correlated with factors such as the mother's education, father's occupation, economic status, and sanitation (9). Educational status plays an important role, possibly due to better awareness.

Different studies from around the globe have suggested tailored approaches to combat undernutrition which include nutrition-specific & nutrition-sensitive interventions (10). Nutrition-specific interventions include nutritional supplements and behavior change communication and on the /other hand, nutrition-sensitive interventions include sustainable agricultural practices at affordable cost for the community (10). Most of the Indian states have adopted interventions related to supplementary nutrition programs and awareness campaigns (11) which are mostly nutrition-specific interventions (12). However, notably, the state of Odisha had initiated an additional nutrition-sensitive intervention: 'kitchen garden' which primarily aimed to provide a diversified menu to the household along with reducing expenses for food and preventing those vulnerable families from falling further into the poverty trap (13). The role of small scale agriculture like kitchen garden in reducing undernutrition is undisputable across the globe (14). Furthermore, small-scale fruit and vegetable production via kitchen garden projects were identified as nutrition-sensitive agriculture interventions having the highest success rate due to their ease of adaptability (14). Another study from Melghat, India showed positive association between dietary diversity & kitchen garden and reiterated it as a sustained method for reducing malnutrition (15). Similarly, a study from rural Rwanda, Africa concluded that kitchen garden along with nutrition education can bring remarkable increase in DDS (16). The kitchen garden initiative by the local government in Odisha, included the provision of financial support & capacity building support to vulnerable households for growing their backyard kitchen garden (13).

Although several studies published in the last 15 years have focused on agriculture interventions and their impact on nutrition-related outcomes, the states of India primarily focused on awareness generation programs rather than leveraging the huge agriculture resources to combat undernutrition in rural areas. Secondly, only a handful of studies were found in rural India which strengthens the case for continued research. Our study intended to examine the relationship between kitchen garden and DDS among the WRA of rural Odisha. The previous studies suggested using DDS as a proxy indicator in resource-poor settings for measuring undernutrition since it could be used without any tools or trained professionals, making it feasible to use in rural India (17). Thus, this study aimed to address the empirical question of the "relationship between kitchen garden & dietary diversity score and does it vary across the different socio-economic factors". Furthermore, it is also critical to comprehend the viability of kitchen garden in rural areas among low socio-economic strata. However, there is almost non-existent literature in India to assess the feasibility & sustainability of kitchen garden. This study intended to examine the different enablers and barrier factors for growing and maintaining a backyard kitchen garden in rural Odisha (see Figure 1).

Methodology

Study settings

The study employed original data from Odisha's Angul district. We had planned to select 2–3 additional districts from various sections of the state, but due to logistical constraints, only one district could be picked on purpose. Since the data collection took place in January–February 2022, soon after India's second wave of COVID-19, there were travel restrictions and limited community involvement. Under such circumstances, only one district was picked, which is closer to the state capital (130 kilometres). However, despite its proximity to the capital, Angul is one of the districts with high undernutrition burden. According to the NFHS-5 (National Family Health Survey-4), approximately 44% of WRA women (15–49 years, non-pregnant) and 36% of children (6–59 months) are anaemic (18). In rural Angul, about 22% of children under the age of five are diagnosed with wasting (15).

Sampling technique

In this study, we have taken women of reproductive age group (WRA, 15–49 years) as the study unit. The households which had at least one member of the WRA group were already enlisted by their respective Gram Panchayat (local self-government), hence sampling frame was available with the respective department of Govt. of Odisha. A simple Random sampling method was used to select the sample. Firstly, 10 Gram Panchayats (GP) were randomly selected from the GP list and those GPs are dispersed over 4 blocks of Angul: Talcher, Kishorenagar, Angul Sadar and Athamalik.

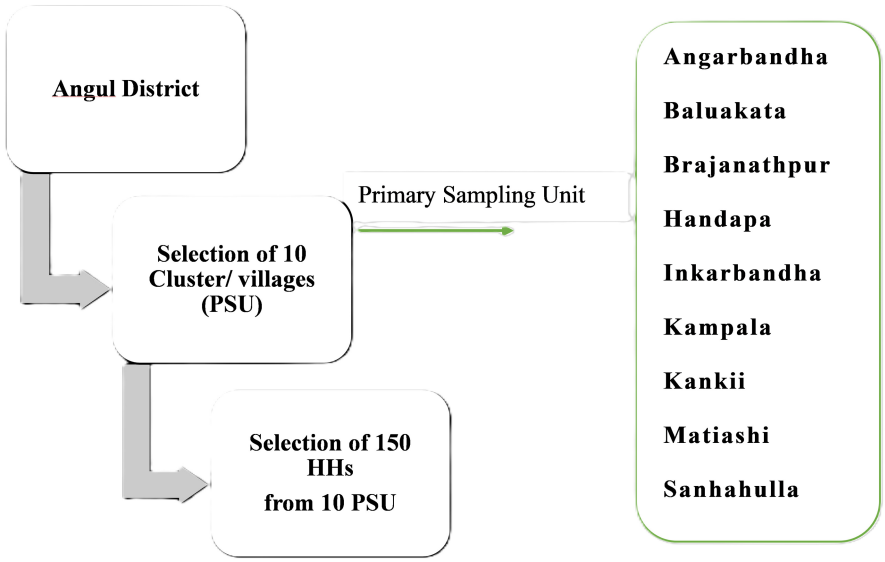

FIGURE 1
Sampling technique for quantitative data collection.

Following that, 15 households were selected from each GP randomly from the eligible household list. In total, 150 WRA households were selected and identified for data collection (: sampling technique). The primary data acquired directly from beneficiaries of chosen households (HH) in Odisha's Angul district.

Sample size

The sample size required for the beneficiaries was calculated using a population proportion with a specified relative of the main predictor variable, around 55% (19). The reference proportion is available from an adjacent block of the same district which has similar demography and geographical pattern.

The sample size was calculated by using the formula: $n = 4pq/d^2$, where p (population proportion) = 55% & d (error of margin) = 8.5. Hence, total is 132; considering non-responses & to round up the figure, a total of 150 samples was taken.

Data source and study participants for qualitative data collection

The government of Odisha has been implementing a special program to promote kitchen garden in rural Odisha for combating undernutrition among vulnerable groups (adolescent girls, pregnant women, lactating mothers & children under 5 years of age) (13). The program includes cash assistance, provision of sapling/seed & capacity building for eligible households for WRA. The inclusion criteria were set accordingly to include the Women of the reproductive age group who have/had a backyard kitchen garden in any of the last three seasons (summer/monsoon/winter). According to the inclusion criteria, households were selected purposively from the Angul district's two GPs (Angarbandha & Khalari). Two focus group discussions (FGDs) were held with 16 participants from the selected households, 8 for each FGD, to investigate enablers & barriers for sustaining a kitchen garden.

Measures

Outcome variables

The Dietary Diversity Score (DDS) was the only outcome variable used in this study. The DDS was captured as a numerical variable during the data collection, but it was later classified as a binary variable based on the score. DDS was captured using the dietary recall method by a 10-point MDD-W (Minimum Dietary Diversity for Women) scale developed by the FAO and USAID. This pre-validated, easy-to-use, quick, low-cost indicator which counts the food groups consumed by women of reproductive age over the previous 24 h (20). The food groups include (1) Cereals, roots & tubers, (2) Pulses, (3) Nuts & seeds, (4) Milk and milk products, (5) Fish and meat, (6) Eggs, (7) Dark green leafy vegetables, (8) Vitamin A rich vegetables and fruits, (9) Other vegetables, (10) Other fruits. Scoring is done on a 10-point scale, with each food group receiving 1 point for consumption within the last 24 h. Each food group bears one mark for consumption within last 24 h during any meal by the respondent, thereby, the total score was calculated. The dietary diversity was considered as poor/unsatisfactory, in case DDS < 5 and if DDS > =5, categorised as satisfactory dietary quality/diversity. The cut-off marks are pre-decided and validated for pregnant and non-pregnant women (15–49 years) by FAO during this tool's development, indicating consumption of > = 5 food groups is dietary adequacy (21).

Exposure variables

The major independent variables were the presence of a kitchen garden, the HH's income, the respondent's occupation, the availability of agricultural land, meat consumption & meal frequency of the participant. The kitchen garden was defined as a small space/land

around a homestead, where several species of plants are grown, and their products are primarily intended for family consumption. The variables which showed *p* value <=0.25 during the construction of unadjusted OR, were only considered for further adjustment in the regression model.

Analytical strategy

Quantitative strategy

SPSS 23 was used to conduct the analysis, which included descriptive statistics and multinomial logistic regression. The descriptive analysis examined the sample's characteristics followed by logistic regression to determine the relationship between the predictor variables and a single outcome variable. The regression was after categorising the outcome variable (DDS) into binary variables based on the DDS score: poor (DDS < 5) and adequate dietary diversity (DDS > = 5). The major independent variables were the presence of a kitchen garden, the HH's income, the respondent's occupation, the availability of agricultural land, meat consumption & meal frequency. The variables which showed *p* value <=0.25 during the construction of unadjusted B (OR), were only considered for further adjustment in the regression model.

Qualitative strategy

We audio-recorded & transcribed the verbatim and analysed the data. We asked the participants to avoid using names or personally identifying information. Qualitative data were segregated, coded, and analysed through an open coding method manually. Following coding, the data was grouped and checked for emerging patterns to identify themes which led to exploring the enablers & barriers of having a kitchen garden in a rural setting.

Result

Quantitative result

A total of 150 samples of the WRA group were taken and their mean age was 31 (Std. Dev. 8.52) (Table 1). The families were largely joint, with 5–6 individuals (mean 5.65) and an average of 0.3 children (under 10 years) per family (Table 1). Most of the beneficiaries interviewed were included (84%) in the SHG (Self Help Group), meaning that at least one member of those HHs used to receive financial assistance from the SHG. A SHG is a community-based group primarily comprised of women from lower socioeconomic backgrounds. They used to borrow from their collective funds in times of urgency or financial constraint, for major life events, or to buy assets. However, most of the families had income below rupees 10,000/− (122$) per month, i.e., meaning that 45% of them were classified as BPL (Below the Poverty Level), with 6% of those being severely poor, meaning that their monthly income was less than rupees 5,000/− (61$) (Table 1). Most of the respondents were homemakers 74.7% (frequency: 112), followed by community cadres 13.3% (frequency: 20) and students 10.7%(frequency: 16) (Table 1). Most of the families owned agricultural land (86%) and almost all of them had their own household toilet/latrine (98%) (Table 1). Furthermore, all the HHs were entitled to receive support from Panchayats for developing KG, but only 67.3% of the HHs had kitchen garden during the previous three seasons (Table 1). To meet their daily vegetable needs, 34 % (34%) of HHs relied mostly on the market, whereas 66% of HHs relied primarily on their kitchen garden (Table 1). Twenty-three per cent of HHs relied only on their agricultural land for their grain needs but most of the HHs relied on PDS (Public Distribution System/Ration: 65%). Ninety-three per cent of the respondents ate at least three times a day, and most of them (95%) were non-vegetarians. The mean DDS was 6.69 with a standard deviation of 7 (Table 1).

The multinomial logistic regression model was used after the categorisation of the outcome variable (DDS score) into binary variables based on the DDS score: poor/unsatisfactory (DDS < 5) & satisfactory dietary diversity (DDS > =5). The relevant variables were taken as predictors which include (1) availability of kitchen garden, (2) agricultural land, (3) income, (4) meal frequency, (5) meat consumption and (6) occupation of the respondents. Those variables, which showed *p* value <=0.25 during the construction of unadjusted OR, were only considered for further adjustment in the regression model (Table 2). The result shows absence of backyard kitchen garden is negatively associated with satisfactory dietary diversity (OR: 0.163, $p = 0.001$). In other words, it simply implies that backyard KG is positively associated to satisfactory dietary diversity (Table 2). Further, not having or lack of own Agricultural land also showed a negative association with satisfactory dietary diversity (OR: 0.176, $p = 0.008$) (Table 2). Furthermore, the higher income group demonstrated a positive correlation with satisfactory dietary diversity, i.e., with an increase in income, the DDS also increased. However, statistical significance is absent (Table 2). Three broad occupational categories were used to classify the respondents: students, community workers, and housewives/homemakers. These groups had no discernible impact on the dietary diversity score. Additionally, there was no statistically significant correlation found between the frequency of meals, meat/egg consumption and dietary diversity. Apart from the backyard KG and own agricultural land, the standardised odds ratio (OR) of these SE predictors did not demonstrate a statistically significant correlation. This might explain why having a kitchen garden was strongly associated with increased DDS and not confounded by all these SE predictors.

Qualitative result (thematic analysis)

The FGDs were conducted to identify the factors that enable and hinder rural households' efforts to grow and manage a kitchen garden in their backyard. Two focus group discussions (FGDs) were held in the Angarbandha and Khalari GPs of the Angul Sadar block on 9.4.22 from 11 AM to 11.45 AM and 14.5.22 from 4 PM to 5 PM, respectively. Every FGD lasted between forty-five and sixty minutes. The criteria for inclusion were used to choose the participants. A total of sixteen women of reproductive age took part in the conversations. The age range of the majority of FGD participants was 25–35 years old. All of them received seed support & cash grants from the local government to develop their kitchen garden. Two FGDs were translated and scripted for thematic analysis. There are 4 major themes identified from arranging the quotes: seasonal variability, initiative of local government, men's engagement, and challenges (Table 3).

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TABLE 1 Socio-demographic characteristics of study participants.

Variable	Frequency	Percent	Variable	Frequency	Per cent
Household questions			Food security questions		
Whether the respondent is a SHG member			Is an individual kitchen garden available		
No	24	16.0	No	49	32.7
Yes	126	84.0	Yes	101	67.3
Total	150	100.0	Total	150	100.0
Total family income			The major source of vegetables for the HH		
<5,000	6	4.0	Kitchen garden	99	66.0
>10,000	44	29.3	Market	51	34.0
5,000–10,000	61	40.7	Total	150	100.0
Not responded	39	26.0	The major source of cereals for the HH		
Total	150	100.0	Agricultural land	35	23.3
Occupation of the respondent			Market	17	11.3
Community cadre (ASHA/AWW/ANM/CRP)	20	13.3	PDS*	98	65.3
Homemaker	112	74.7	Total	150	100.0
honey bee maker	1	0.7	Whether consume non-vegetarian food		
Student	16	10.7	No	7	4.7
Ward member	1	0.7	Yes	143	95.3
Total	150	100.0	Total	150	100.0
Availability of agricultural land			Meal frequency		
No	21	14.0	1–2 times	10	6.7
Yes	129	86.0	3 times or more	140	93.3
Total	150	100.0	Total	150	100.0
Availability of HH toilet			*N* = 150	Mean	Std. Deviation
No	3	2.0	Age of the respondent	31.01	8.252
			Total family members	5.65	1.835
Yes	147	98.0	Number of children	0.33	0.564
Total	150	100.0	DDS**	6.69	7
Availability of nearby marketplace					
No	1	0.7			
Yes	149	99.3			
Total	150	100.0			

*PDS, Public Distribution System; **DDS, Dietary Diversity Score.

Theme 1: variability in kitchen garden produce throughout the seasons

The FGD analysis showed that most participants agreed that the kitchen garden was seasonal and did not produce adequate vegetables to feed the entire family throughout the year, specifically if the family was large. As per them, the kitchen garden was like agricultural crop production. The number of products was higher during winter and less in harsh summer. Almost all the FGD participants agreed that vegetables like potatoes, onion, ginger etc. had to be bought from the market. Only a few families had sufficient financial resources to support the water requirement of the kitchen garden throughout the year, especially during summer.

One of the respondents of FGD: 1 said "Yes, it remains throughout the year but does not yield the same quantity. Summertime sees a decrease, whereas winter and monsoon see a rise." Another respondent from FGD: 2 said, "It is not possible to grow all varieties of vegetables at the same time, such as potato, tomato, chilli, lemon, and other green vegetables and spinaches together".

Theme 2: initiatives and active support provided by the state and local government

The support of local government was identified as one of the important facilitators in developing & maintaining a kitchen garden. This comprised financial assistance, seed distribution, and capacity building for the designated households and eligible beneficiaries. The vulnerable target groups which included

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TABLE 2 Association between kitchen garden & other socio-demographic parameters with DDS.

Parameter estimates				
Dependent variable (binary): satisfactory dietary diversity (DDS > =5)				
Parameter	Unadjusted odds ratio with CI	*p*-value of unadjusted OR	Adjusted odds ratio with CI	*p*-value of adjusted OR
1. Lack or absence of household kitchen garden	0.097 (0.41–0.23)	0.00	0.163 (0.061–0.435)	0.001
2. Lack or absence of own agricultural land	0.103 (0.037–0.28)	0.0	0.176 (0.049–0.630)	0.008
3. Monthly Incomes				
Income= > 10,000	4.44 (1.29–15.24)	0.18	NA**	
Income = 5,000–10000	1.15 (0.47–2.77)	0.755		
Income = <5,000	Ref			
4. Frequency of meal intake				
Meal frequency = 1–2 times	0.182 (0.048–0.68)	0.12	0.538 (0.099–2.91)	0.472
Meal frequency = 3 times or more	Ref		Ref	.
5. Consumption of non-vegetarian food				
Vegetarian	0.780 (0.142–4.2)	0.77	NA**	
Non-vegetarian	Ref			
6. Occupation of the respondent				
Working (community cadre) (ASHA/AWW/ANM/CRP)	0.633 (0.052–7.6)	0.72	0.211 (0.013–3.48)	0.277
Homemaker	0.162 (0.02–1.27)	0.08	0.147 (0.015–1.49)	0.1
Student	Ref		Ref	

**If p < =0.25 in unadjusted OR, that variable was considered for further adjustment.

TABLE 3 Thematic tree analysis of responses from FGD.

Themes	Variability in kitchen garden produce throughout the seasons	Initiatives & active support provided by the state & local government			Engagement of male members in developing the KG	Challenges in developing & maintaining the KG
Sub-theme		Hands-on training for beneficiaries	Seed provision to eligible beneficiaries	Cash Grants to eligible beneficiaries		
	Seasonal change	Training & Demonstration	Indigenous seed	Nominal cash	Husbands helped	Water Constraint
	Favourable in winter	Bed rising & mulching	Not hybrid	Cover extra expenses	Coordinated with GP	Lack of land
	Market bought herbs	Organic Fertiliser	Locally grown seeds	Credited as tranche	Heavy work by men	Delay in seed distribution
	Water shortage	Organic Pesticides	Mixing of various plants	Credited to women	Men became accountable	Delay in cash credit
	Drought in summer	Handholding support	Easy to get		Field cleaning	Irregularities in cash grant
		CRP-CM's role	No extra cost		Manure preparation	
			Good quality			

adolescent girls, pregnant women & lactating mothers were entitled to receive a packet of indigenous seeds of different plants along with cash assistance. Every participant acknowledged that they received assistance from community volunteers. Additionally, each entitled HH received instruction on how to prepare beds for KG, apply fertiliser, etc.

As per one of the respondents from FGD: 1, "We have received seeds & money. We were given training on how to prepare the bed, do mulching, use pesticides, prepare organic fertilizer etc." Another respondent from FGD: 2 added, "The provision of seeds is a great help for us. Otherwise, it would not be possible to find quality seeds in the market at a reasonable price." Many of the

participants from both the FGDs said that "receiving all the necessary benefits from Gram Panchayat and the cash grant were helpful to cover expenses for developing our kitchen garden".

Theme 3: engagement of male members in developing the kitchen garden

Every participant acknowledged that their husbands had assisted them in growing the kitchen garden. The work done by men was field cleaning, manure pit preparation, "Ranja" preparation, etc. Men's participation significantly lessened the physical strain placed on women. Being responsible to their female members also aided them. Additionally, according to the respondents, GP's choice of women as beneficiaries guaranteed their empowerment by granting them nominal cash and directly depositing the money to their bank accounts, which also decreased the likelihood of misappropriation by male members.

One of the respondents from FGD: 1 shared, "Yes, men do help us in preparing this kitchen garden & they used to play an active role in preparing this." Another respondent from FGD: 2 added, "Men used to take charge of labour-intensive work which needs more physical strength such as field cleaning, manure preparation etc."

Theme 4: challenges in developing and maintaining the kitchen garden

The respondents discussed a variety of difficulties they faced while growing their kitchen garden. First, labour-intensive tasks that were impossible for a single person to finish alone. It was particularly challenging for a woman who was pregnant or nursing to continue doing such demanding work. Second, most families did not have a piped water supply, and the kitchen garden used to require a lot of water, which was challenging to provide without one, especially in the summer. Thirdly, the region is surrounded by an industrial belt, and summertime water shortages were typical. Fourth, the respondents also revealed that many of them had not yet received financial assistance and that it used to take a long time to be credited. Lastly, the timing of seed distribution was not appropriate and most of the time they received it after the harvesting period.

One respondent from FGD: 1 said, "I am not able to grow it during the summer because of water constraints." Another one from FGD: 2 said, "We have received the seed support and training. But there is a problem with crediting the cash." One of them from FGD: 2 also added, "Seed should be distributed in the proper time just before the season so that harvesting can be done properly".

Discussion

This study investigated the relationship between DDS and kitchen garden. A few significant characteristics of rural living standards that had an impact on DDS directly or indirectly were also highlighted in the study. All the respondents were women aged between 15–49 years from the selected HHs. Most of the participants were from lower- or middle-income families, earning less than 10,000 rupees (<$118) a month. The earlier study also showed similar data on the socio-economic status of rural families in India or in Odisha, which used to have several consequences on the nutritional status of women & children (3). The association between poverty and stunting is evident from the significant difference noted in the undernutrition rate among women and children in the lower wealth quintile compared to the higher wealth quintile. In India, the proportion of women with low BMI is 51.5% and stunted children is 59.9% in the lowest wealth index compared with 18.2% of women with low BMI and 25.3% of stunted children in the highest wealth index (NFHS-32006). Regarding occupation, most of the women—roughly 75%—were homemakers, which is precisely in line with the data on women's employment in rural Odisha (5). This study also tried to clarify the issue of a rural household's food security. Odisha is a state where agriculture is a predominant profession and this study confirms the same. Eighty-six per cent of the households owned land for farming. But even with their farm, most of the people still got their cereals from PDS (Public Distribution System) which underlines the continued importance of the social protection programmes in rural India. Additionally, this research revealed that 67.3% of homes had backyard kitchen garden, and 66% of those families sourced most of their vegetables from their KG. According to previous studies, a well-developed kitchen garden has the capability of fulfilling the daily dietary requirements of a family by producing nutritionally rich foods such as vegetables, roots, tubers, fruits, legumes, spices etc. (15). Based on previous studies, it was hypothesized that this nutrition-sensitive kitchen garden intervention would be associated with a sustained increase in household dietary diversity leading to better food security, thus indicating an improvement in dietary patterns aimed at reducing undernutrition. Even after standardisation, the KG revealed a statistically significant positive association with good/satisfactory dietary diversity (DDS > =5). This outcome is consistent with earlier research conducted in various contexts, which similarly explains why people who have a kitchen garden have a lower prevalence of inadequate dietary diversity (3, 6). Although no biomarker data were collected on actual micronutrient levels in participants, no conclusions can be reported on the actual nutrient status of participants or household members—a limitation that could be addressed in future studies. The variety of vegetables offered by kitchen garden is likely to contribute to household dietary diversity both directly and indirectly, which is consistent with other researches in similar populations (7, 14–16). Previous research has demonstrated that owning agricultural land is crucial in lowering food insecurity in a variety of contexts (7) and this study's DDS results were consistent with those of previous studies. Further, another critical predictor 'income' had not shown a statistically significant relation with dietary diversity even though earlier research has shown a negative correlation between low income and good dietary outcomes (18, 19). This might be due to the small sample size (only 111 samples) for the correlating income group with dietary diversity (Table 1) i.e. 39 respondents did not answer this question among a total 150 samples. Furthermore, there was no positive correlation observed between DDS and occupation. Based on their responses, the respondents (WRA group) were divided into three occupational categories: homemaker, student, and community worker, indicating that none of them worked in the organised sector and had a fixed source of income. As a result, it was unable to determine how the women's occupations affected their DDS through

accurate comparison. Nonetheless, past research has consistently shown that working women's greater knowledge leads to improved nutritional outcomes (4, 9).

The qualitative findings are consistent with the quantitative findings regarding the kitchen garden. There were four major themes identified: (1) variability in kitchen garden produce throughout the seasons, (2) initiatives & active support provided by the state & local government, (3) engagement of male members in developing the KG and (4) challenges in developing & maintaining the KG. These themes helped to determine the enablers and barriers associated with KG. Although the kitchen garden is considered as most cost-effective, traditional & sustainable method (3) for ensuring food security, there was hardly any research done previously to examine facilitators or hurdles in the context of Odisha or India. This study clarified important facets of raising a KG. Every participant in the focus group discussion (FGD) concurred that the kitchen garden was seasonal and did not provide enough produce, especially in the summer. However, few families combated it as they were financially stable and had enough resources to support the garden even during the lean season. A study conducted in different developing countries showed how seasonal variation is associated with food production. Second, the support of local government was very significant, which mainly included: capacity building, cash grants and seed support. These things enabled a family to grow a garden easily without financial strain. However, there were certain challenges, such as irregularities in cash grants, delays in seed distribution, and water shortage which demotivated the community members towards this initiative. The men of the HHs actively participated in the growth and upkeep of the kitchen garden, even though its primary beneficiaries were women. Additionally, the financial reward was typically credited to women's bank accounts, which lessened the likelihood that men would misuse or engage in unethical behavior those are common in rural India.

Strength and limitation

This study showed the association between different socio-economic factors of rural life and DDS which was largely unexplored in the Odisha context. It also explored the enablers and barriers to developing a KG. This assessment was necessary which may aid in future recommendations & policy formulation. The limitations of this study include direct nutritional status measurement was not taken into consideration. Further, the study did not include the women who did not have kitchen garden in qualitative analysis, which could have given a different perspective on the challenges.

Areas for further research

Further studies may be carried out measure the diet quality of rural women by using raw food weighment method & biomarker which are more sensitive to measure undernutrition. Research may also be carried out to address the problem of water shortage during summer through innovative agricultural practices so that seasonal food insecurity can be addressed.

Conclusion

The literature summarised how kitchen garden might enhance Dietary Diversity Score and raise household food security. There are two universal approaches to addressing undernutrition: nutrition-specific or BCC (Behavior Change Communication) intervention and nutrition-sensitive or agricultural intervention. A kitchen garden serves the second approach and increases the accessibility and availability of vegetables at a much lower cost for a family. The support of the local government had played an important role which enabled many of the households to grow a scientifically designed kitchen garden. As the government is focusing on improving the nutritional status of women along with ensuring household food security, it is necessary to put effort into bringing a sustainable solution specifically for rural households & marginalized communities. In this sense, the Kitchen Garden is a cost-effective intervention that can be adopted by the government for nationwide implementation with minimal resources. However, irregularities in cash payment should be addressed for the sustainability of such an initiative. This research will help in generating the evidence which is necessary for policy framing and will help in correcting the loopholes. To summarise, kitchen garden is proving to be a cost-effective approach to increase Dietary Diversity Score. However, for sustainability, support of seed kits and cash assistance is useful.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by All India Institute of Medical Sciences, Bhubaneswar. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

SP: Conceptualization, Supervision, Writing – review & editing. PG: Writing – review & editing. BB: Writing – review & editing. SH: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2025.1465169/full#supplementary-material

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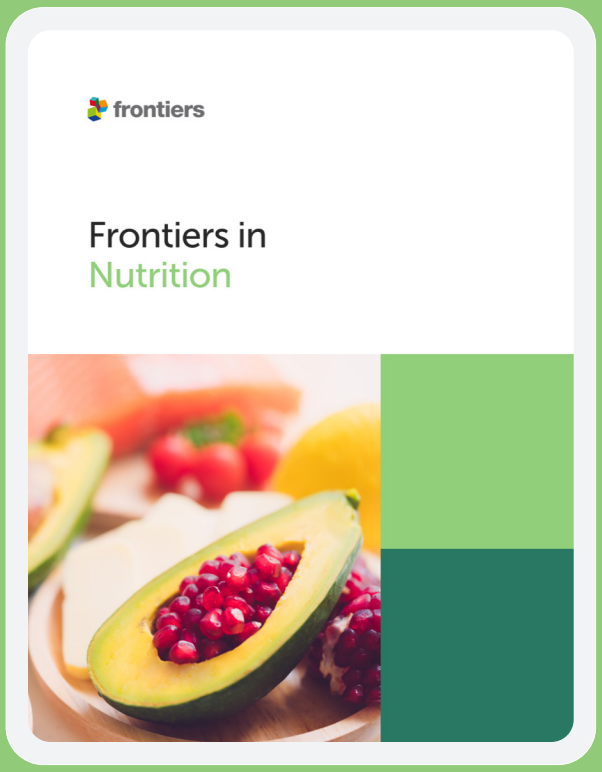

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