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Scoping Review

A Scoping Review of Nutrition-Specific and Nutrition-Sensitive Interventions Addressing All Forms of Malnutrition in Nepal

Sharada Prasad Wasti *,[1]; Sudip Ale[2]; Prajal Pradhan[3,4]; Vijay Singh GC [5]; Shrijana Vaidya[6,7]; Biwash Ghimire[8]; Kiran Kumari Bhattarai[9]; Laxmi Prasad Pant[10]

[1]School of Human Sciences, University of Greenwich, London, SE10 9LS, United Kingdom; [2]Department of Health Services, Ministry of Health and Population, Kathmandu, 44600, Nepal; [3]Integrated Research on Energy, Environment & Society, Energy and Sustainability Research Institute Groningen, University of Groningen, Groningen, 9747 AG, the Netherlands; [4]Potsdam Institute of Climate Impact Research (PIK), Member of Leibniz Association, Potsdam, 14473, Germany; [5]Centre for Health Economics, University of York, York, YO10 5DD, United Kingdom; [6]International Livestock Research Institute (ILRI), Livestock Climate and Environment, CGIAR, Nairobi, 00100, Kenya; [7]Leibniz Center for Agricultural Landscape Research (ZALF), Research Area 1 Landscape Functioning, Müncheberg, 15374, Germany; [8]College of Pharmacy, Idaho State University, Pocatello, 83209, United States; [9]Ontario Public Interest Research Group, University of Guelph, Guelph, N1G 2W1, Canada; [10]Natural Resources Institute, University of Greenwich, Chatham Maritime, ME4 4TB, United Kingdom
*Corresponding Author: Sharada Prasad Wasti, School of Human Sciences, University of Greenwich, Royal Naval College, Park Row, London, SE10 9LS, United Kingdom (s.wasti@greenwich.ac.uk).

The main objective of our scoping review was to synthesize the research evidence on the outcomes of interventions seeking to address all forms of malnutrition in Nepal. Globally, the triple burden of malnutrition—encompassing undernutrition, micronutrient deficiency, and overnutrition leading to overweight or obesity—poses a significant risk to health and well-being. In Nepal, various nutrition-related interventions have been implemented, but the evidence on the outcomes remains scattered. We used Arksey and O'Malley's 5-stage framework and synthesized the existing interventions addressing all forms of malnutrition in Nepal. Three major databases (Medline, Scopus, and Web of Science) were searched up to December 2024, and the search results were screened using the Rayyan screening tool. The findings are presented as a narrative synthesis. Our review included 58 studies, the majority of which focused on pregnant women and children under the age of 5, with most interventions lasting from 1 to 3 years. Most interventions ($n = 48$) were nutrition-specific, 3 were nutrition-sensitive, and 7 were both. Nutrition-specific interventions primarily targeted micronutrient supplementation, whereas nutrition-sensitive interventions addressed broader structural inequalities, such as financial support; access to water, sanitation, and hygiene; and provision of a maternal influenza vaccine. Surprisingly, none of the interventions addressed overweight and obesity, the nutritional needs of adult males and elderly populations, digital applications to reach remote communities, or the promotion of nutrient-rich forgotten foods such as iron-rich minor millets, buckwheat, and beans. The government of Nepal prioritizes a multisectoral nutritional policy; however, our findings indicate

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that implementation consists largely of sectoral nutrition-specific interventions, with unclear mandates across federal, provincial, and local levels. Implementing multisectoral nutrition-sensitive interventions by prioritizing localized production, promoting behavioral change strategies, and integrating nutrition security programs might help Nepal to address all forms of malnutrition and achieve long-term nutritional outcomes.

Key words: Triple burden of malnutrition, nutrition-sensitive, nutrition-specific, intervention, social safety nets, Nepal.

INTRODUCTION

Malnutrition is no longer limited to what was once called the "double burden," undernutrition and micronutrient deficiency, as in the early 1990s.[1] Since 2010, the concept of double burden has been replaced by the term "triple burden of malnutrition" (TBM), which refers to the coexistence of undernutrition, overnutrition, and micronutrient deficiencies during the life course of an individual, as well as within households and communities.[2,3] For example, maternal or childhood undernutrition can increase the risk of obesity and type 2 diabetes in adult life.[4] Individuals in the same household or community may have experienced different forms of malnutrition simultaneously. The United Nations Sustainable Development Goal (SDG) 2: "End Hunger, Achieve Food Security and Improved Nutrition and Promote Sustainable Agriculture" recognizes the interlinkages between supporting sustainable agriculture and ensuring healthy lifestyles.[5] SDG 2, target 2.2, focuses explicitly on ending all forms of malnutrition, including the triple burden.

Despite successes in decreasing maternal mortality and maternal and child malnutrition in recent decades, Nepal continues to face a complex malnutrition burden characterized by TBM. Nepal falls behind in key nutrition indicators such as undernourishment (5.7%), severe food insecurity (13.5%), wasting (7%), stunting (26.7%) in children under 5, obesity in adults (7%), anemia in women aged 15–49 years (35.7%), infants 0–5 months not exclusively breastfed (44%), and low birth weight (19.7%).[6] Children from the poorest households are nearly 3 times more likely to be stunted than those from the wealthiest families (36.9% vs 13.1%), while the figure is double in Karnali, a remote province (35.8%), compared with Bagmati, a province in which the federal capital area lies (17.6%).[7] More than half (52%) of women aged 15 to 49 in Madhesh province in the southeastern plains are anemic, which is much higher than the national average.[7]

Our scoping review aims to synthesize evidence on both nutrition-specific and nutrition-sensitive interventions. While the former addresses specific dietary needs, nutritional outcomes, and nutritional behavioral change, the latter focuses on overcoming structural barriers to food and nutrition security.[8,9] In low- and middle-income countries such as Nepal, nutrient supplementation and food fortification have been prioritized to treat persistent micronutrient deficiencies, such as deficiencies in Vitamin A, Iron, Folic Acid, Zinc, and Iodine.[10,11] Although these interventions have been successful under external support, government subsidies, or project-based interventions, the cost of certain fortification technologies and overlooking the distributed and localized nature of food security limit their success and long-term sustainability.[12] More technologically advanced nutrition-specific interventions, such as biofortification through conventional breeding (eg, iron-rich beans, orange-fleshed sweet potato, yellow cassava) and genetic engineering (eg, golden rice, iron-fortified transgenic banana, transgenic yellow cassava), are available.[13] However, the success has been limited in terms of (1) mainstreaming of biofortified traits into public plant breeding programs, (2) building consumer demand, and (3) integrating biofortification into public and private sector policies, programs, and investments. Other nutrition-specific interventions include school meal programs,[14] school gardens, home gardens, and sourcing locally grown produce in school meals.[15–18] These latter examples are often referred to as nutrition-sensitive agriculture, which does not necessarily address structural barriers to achieving nutritional outcomes.[19] The government of Nepal has developed and implemented several policies and initiatives to promote nutrition security, which may have a direct or indirect impact on improving nutrition security and combating malnutrition.[9,20] The successive iterations of the Multi-Sector Nutrition Plan (MSNP), the third iteration running from 2023 to 2030, shows Nepal's ongoing commitments to eliminate all forms of malnutrition.[20] However, existing evidence of the effectiveness of nutrition-specific and nutrition-sensitive interventions is scattered, and a comprehensive synthesis is lacking, which is critical for informing nutrition strategies. Understanding the implemented interventions and their effectiveness is critical to guiding policy and achieving national nutrition targets by 2030.[21] Therefore, we aimed to synthesize the research evidence on the outcomes of interventions targeting all forms of malnutrition in Nepal.

METHODS

The scoping review was developed and reported in compliance with the Preferred Reporting Items for Systematic and Meta-Analysis Extension for Scoping Reviews (PRISMA-ScR).[22] We employed Arksey and O'Malley's (2005) 5-step scoping review framework: (1) identifying the review question; (2) identifying the relevant studies; (3) selecting the relevant studies; (4) charting the data; and (5) collating, summarizing, and reporting the results.[23]

Stage 1: Identifying the Review Question

The overall review question was: What were the outcomes of nutrition-specific and nutrition-sensitive interventions aimed at addressing the triple burden of malnutrition in Nepal? This review question was refined using the Population, Intervention/Exposure, Comparator, and Outcome (PI/ECO) framework to enhance clarity and focus in the research questions[24] (Table 1).

Stage 2: Identifying the Relevant Studies

A search strategy was formulated using the PI/ECO framework,[24] as stated in Table 1, in accordance with the review question and the delineation of key concepts. Our scoping review searched 2 interdisciplinary databases (Web of Science and Scopus) and a health sciences database (Medline) to identify potential studies. In addition, the reference lists of relevant studies, including related reviews and those of the included studies, were further screened to identify potentially eligible studies. Therefore, the search strategy and interdisciplinary coverage allowed us to identify a comprehensive set of potential studies for this review (Table 2).

Stage 3: Selecting the Relevant Studies

All search results were exported to EndNote reference management software, and duplicates were removed. The final set of studies was then exported into Rayyan, an online screening tool, for double-blind screening and selection.[25] The remaining studies were independently screened by 2 authors (S.P.W. and L.P.P.) based on titles and abstracts from the database search. A third author (V. S.G.C.) was consulted to resolve any disagreement between the 2 independent reviewers. The full-text of eligible studies was then assessed before proceeding to data

Table 1. Framework Components

Components	Explanation
Population	Individuals of any age (children, adolescents, adults, and the elderly)
Intervention/ exposure	Interventions for addressing the triple burden of malnutrition, both nutrition-specific (supplementation, food fortification and nutrition literacy) and nutrition-sensitive, especially the underlying barriers to achieving nutritional outcomes (deworming, access to water, sanitation and hygiene [WASH], infrastructure, and social safety nets)
Comparison/ context	Effectiveness of these interventions in improving nutrition status (undernutrition, micronutrient deficiency [anthropometric indices, micronutrient biomarkers, diet-related behaviors, and overnutrition], overweight and obesity) and health outcomes (maternal, neonatal, child health, infectious disease, and noncommunicable diseases)?
Outcomes	Outcomes of interventions associated with improved nutrition status (undernutrition—stunting, wasting, and underweight; micronutrient deficiency; and overnutrition—overweight and obesity)

Table 2. Search Terms

Components	Search terms
Population	"child" OR "children" OR "adolescent" OR "elderly" OR "pregnant women" OR "maternal" OR "neonatal" OR "child health" OR "reproductive age"
Intervention	"nutrition intervention" OR "supplement*" OR "fortification" OR "school feeding" OR "school meal" OR "FCHV" OR "female community health volunteer" OR "m-health intervention" OR "mobile app*" OR "voucher" OR "cash transfer" OR "peer group"
Outcomes	"nutrition" or "undernutrition" OR "malnutrition" OR "overnutrition" OR "food security" OR "nutrition security" OR "food availability" OR "food accessibility" or "food supply" OR "reduce stunting" OR "wasting" OR "overweight" OR "obesity" OR "low birth weight" OR "anemia" OR "health" OR "wellbeing" OR "well-being"
Study design	"RCT" OR "randomized controlled trial" OR "quasi-experiment" OR "controlled before and after study" OR "cohort study" OR "case–control" OR "program evaluation"
Setting	"Nepal" OR "Nepalese" OR "Nepali"

extraction and charting. The final screening was based on fulfilment of all the following inclusion criteria: (1) intervention-related studies addressing any health and well-being outcomes (such as malnutrition, stunting, wasting, overweight/obesity, low birth weight, anemia, exclusive breastfeeding practices, cognitive development, and the overall morbidity and mortality rates); (2) studies conducted among the Nepali population; (3) studies published up to December 2024; and (d) primary, peer-reviewed studies published only in the English language. Any studies published in local languages (such as Nepali) may have been excluded, which is further discussed under the Strengths and Limitations of the Review section.

Stage 4: Charting the Data

Once the list of included studies was finalized, 2 authors (S.P.W. and B.G.) extracted information from each study using a data extraction Excel spreadsheet. The information extracted from each study included: study reference (authors, publication year), province and district where the study was conducted, study design, settings, sample size, intervention duration, study populations, key interventions, and results. The data extraction tables were circulated to all authors for review and subsequent discussions to ensure the completeness and accuracy of the evidence synthesis.

Stage 5: Collating, Summarizing, and Reporting the Results

The data analysis and interpretation were performed using a 2-stage approach. First, we conducted a narrative analysis to categorize and synthesize the data extracted from included studies systematically. Initially, data were coded in an inductive approach to identify the types, patterns, similarities, and effectiveness of nutrition-specific and nutrition-sensitive interventions to combat the TBM in Nepal. In the second step, the interventions were grouped into 2 categories: nutrition-specific and nutrition-sensitive interventions, the former seeking to address the immediate causes of malnutrition, and the latter seeking to address the underlying determinants and the contributing factors,[9] as stated in Table 3.

A narrative synthesis approach was used for the final data analysis. This strategy was chosen because it enabled a clear explanation of the nature of the data, which varied in content, intervention implementation modalities, and intervention duration. Such variations could not be sufficiently captured by other evidence synthesis approaches.[26] Our review did not assess the methodological quality of the included studies, as its primary objective was to include a broad range of studies to capture valuable insights and perspectives that might have been overlooked if strict methodological rigor had been applied, and it is not mandatory in scoping reviews.[23,27]

FINDINGS

Study Selection

Our search identified 1401 records. After removing 461 duplicates, 940 titles and abstracts were screened. After screening the titles and abstracts, 114 full texts were retained and assessed for eligibility, of which 58 articles were included in the review (Figure 1).

Characteristics of the Included Studies

Almost ¾ of the published studies ($n = 42$) were RCTs, 6 were before-and-after studies,[28–33] 4 were case–control studies,[34–37] 4 were quasi-experimental studies,[38–41] and 2 were cohort studies.[42,43] The majority of the studies ($n = 42$) were conducted in the community, 10 were conducted in health facilities[34,41,44–50,55] 5 were conducted in schools ($n = 5$),[36,39,40,51,52] and 1 was conducted in a day-care center.[37] More than half of the studies conducted in

Table 3. Nutrition-Specific and Nutrition-Sensitive Interventions

Nutrition-specific intervention	Nutrition-sensitive intervention
• Micronutrient supplementation (eg, iron, folic acid, iodine, vitamin A, zinc) • Food fortification (eg, iron, zinc, and iodine fortification of flour, oil, and salt) • Biofortification (conventional breeding and genetic engineering) • Nutrition behavior change communication (eg, nutrition counseling, keep-fit programs, lifestyle change interventions) • School gardening, home gardening, and homestead production • School meal program (on-site canteen, external catering)	• Cash transfer (unconditional or conditional) • Water, sanitation, and hygiene (WASH), immunization • Community empowerment platforms (saving groups, school clubs, mothers' clubs) • Access to land and other resources (legal ownership, management, rights, and economic rights) • Governance, policies, and institutions to enable long-term sustainable interventions in food and agriculture • Governance, policies and institutions to improve the food environment (eg, ban on industrially produced trans fats, restrictions on children's access to unhealthy foods and beverages)

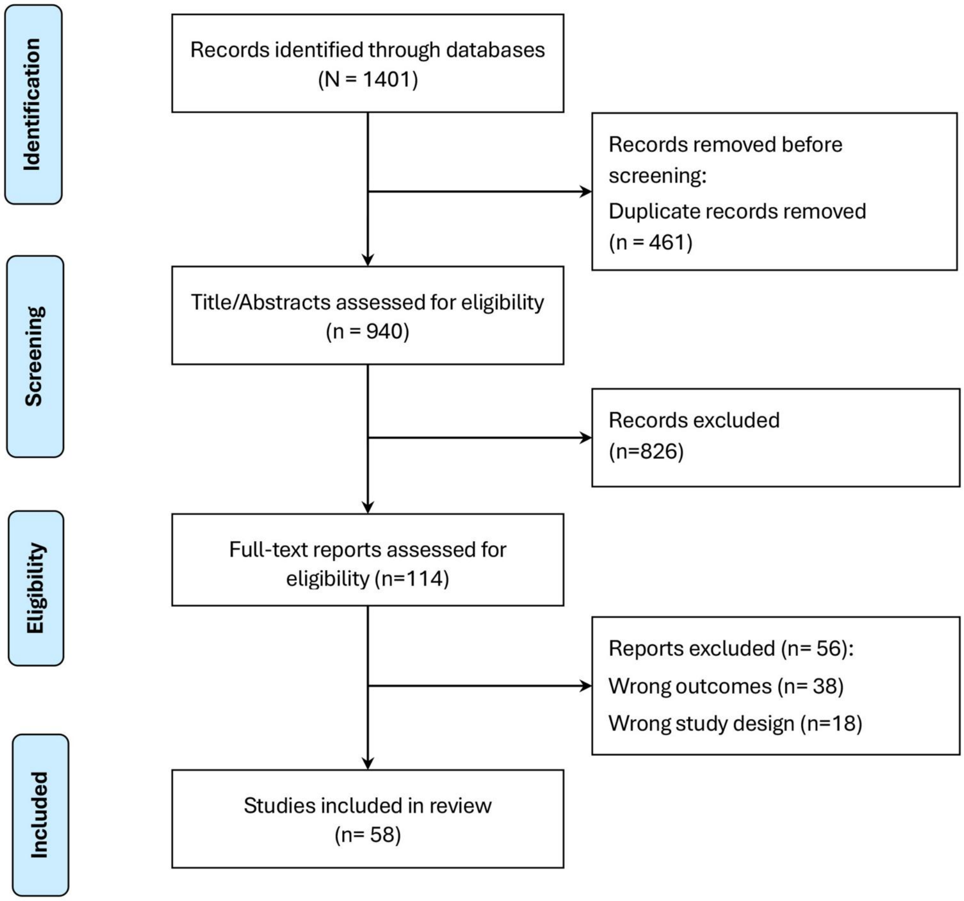

Figure 1. PRISMA Flow Diagram of Literature Search.

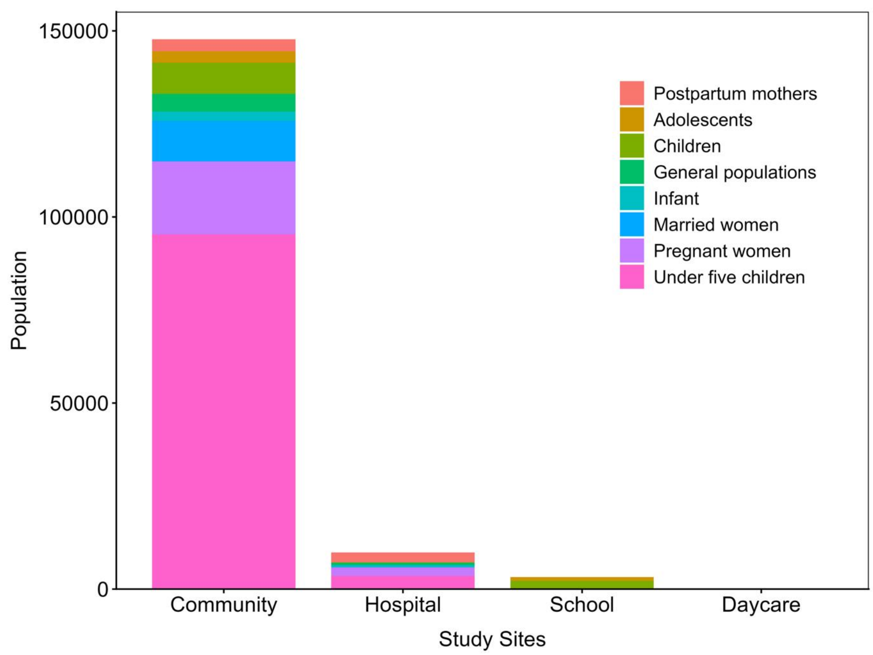

Figure 2. Distribution of Population Across Various Study Sites.

the community were on children under 5, and the next most frequent population studied was pregnant women (Figure 2). The total sample size of all the included studies was 160 863 respondents, ranging from the smallest sample size of 46[37] to the largest of 41 276.[53] The interventions primarily targeted perinatal women ($n = 19$), followed by children under 5 ($n = 15$), older children ($n = 8$),[28,31,40,43,52,54–56] adolescents ($n = 6$),[36,39,51,57–59] infants ($n = 6$),[48,60–64] general populations ($n = 3$),[34,38,65] and married women ($n = 1$)[66] (Figure 2). Table 4 provides the details of the included studies.

Geographical Location

The largest number of the studies ($n = 22$) were conducted in the Sarlahi district, followed by Kathmandu ($n = 5$), Bhaktapur ($n = 5$), Dhanusha ($n = 4$), Baitadi ($n = 2$) and Sunsari ($n = 2$). In addition, 6 studies were conducted in a single district, while. A 9 studies were conducted in 2 districts,[31–33,35,40,52,66–68] and 3 in more than 2 districts[28,29,46] (Figure 3). Similarly, among Nepal's 7 provinces, more than ½ of the studies ($n = 31$) were conducted in the Madhesh province, followed by the Bagmati ($n = 12$), Lumbini ($n = 3$), Koshi ($n = 2$), Sudurpaschim ($n = 2$), and Gandaki ($n = 1$) provinces, and the remaining studies ($n = 7$) were conducted in 2 or more provinces (Table 4).

Duration of Interventions

The duration of interventions varied greatly, ranging from 10 days[37] to 12 years.[47] The majority of the studies ($n = 24$) lasted 1–3 years, followed by 12 months or shorter ($n = 19$). Furthermore, 6 studies reported a duration ranging from 4 to 5 years,[43,50,57,58,69,70] with 3 lasting more than 5 years.[29,46,47] Six studies failed to report the duration of the intervention (Table 4).[36,40,56,71–73]

Intervention Types Based on Nutrition Specificity

Over ¾ (83%) of the interventions were nutrition-specific, while 12% were both nutrition-sensitive and nutrition-specific, and nutrition-sensitive interventions alone accounted for 5% of the interventions (Figure 4). Nutrition-specific interventions focused primarily on micronutrient supplements (capsules, tablets, syrup, and powder formulations of iron and folic acid [IFA], vitamin A, vitamin B12, zinc), school meals, school gardening, home gardening, nutrition literacy, and dietary counseling. The nutrition-sensitive interventions were primarily focused on financial support, water, sanitation, and hygiene (WASH), and the maternal influenza vaccination (Table 4).

REPORTED OUTCOMES AND THE EFFECTIVENESS AND IMPACT OF INTERVENTIONS

This review identified a wide range of interventions aimed at improving the nutritional status in Nepal, which were categorized into 3 broad types: (1) nutrition-specific, (2) nutrition-sensitive, and (3) interventions that combined nutrition-sensitive and nutrition-specific interventions, as described in the following sections:

1. Nutrition-specific interventions

Almost ¾ ($n = 43$) of the studies examined nutrition-specific interventions. These were broadly related to (i) micronutrient supplementation, (ii) social and nutrition behavior change, and (iii) gardening, homestead production, and school meal–related interventions.

i. Micronutrient supplementation-related interventions. *Iron and Folic Acid Supplementation.* Weekly IFA supplementation was found to be significant in reducing the prevalence of anemia among school-going adolescent girls (14% vs 20.9%),[36] increasing mean birth weight, reducing the percentage of low birth weight babies (<2500 g) from 43% to 34%,[74] increasing infants' sleep hours,[60] and improving temperament scores.[75] Daily supplementation of young children with IFA with or without zinc was found to be a protective factor against diarrhea, dysentery, and acute respiratory illness.[53] Receiving a daily combination of 350 mg ferrous sulfate and 1.5 mg folic acid for 90–100 days significantly raised the mean hematocrit (ie, the proportion of red blood cells per unit of blood volume) in the supplemented group.[51] Maternal supplementation with IFA and zinc increased mean height, reduced mean triceps skinfold thickness, subscapular skinfold thickness, and arm fat area[56] and also reduced anemia, compared with supplementation with multiple micronutrients.[74] Infants whose mothers received folic acid alone or with iron or iron plus zinc had 15% to 20% reduced mortality in the first 3 months of life.[76] Iron and folic acid supplementation with zinc also increased their temperament scores by 0.37 points over 5 visits and improved eating behaviors of babies.[75] Furthermore, iron supplementation alone increased hemoglobin and ferritin levels, and reduced iron deficiency anemia by 59% in the nutrition education group of mothers compared with the control group.[44] However, studies on IFA supplementation did not find a significant difference in maternal or child hemoglobin, maternal or child anemia, exclusive breastfeeding, early initiation of breastfeeding, or the introduction of complementary feeding practices.[29] Daily supplementation of young children with IFA without zinc did not impact their risk of death.[77] The iron pill count method to enhance dose

Table 4. Characteristics of Included Studies

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
Adhikari et al, 2009[44]	Randomized controlled trial	Kathmandu/ Bagmati	Hospital	≤12 months	320/Pregnant women	I: Iron supplementation plus education concerning iron and anemia, pill count to assess compliance, or both education and pill count; C: Iron supplementation with a ferrous sulfate tablet (60 mg of elemental iron)	**Micronutrient supplementation with literacy**	Hb was significantly higher in the education-only group than in the control group (OR 0.23, 95% CI 0.07–0.39 and OR 0.26, 95% CI 0.10–0.42, respectively). Anemia was reduced by 59% (95% CI 0.18–0.91) in the education group and by 65% (95% CI 0.16–0.78) in the education with pill count group, compared with the control group. Pill count alone did not improve Hb (OR 0.07, 95% CI 0.09–0.23) or anemia (OR 0.93, 95% CI 0.45–1.191).
Arguello et al, 2015[79]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	589/Pregnant women	I: Weekly supplement containing vitamin A, beta-carotene; C: Placebo	**Micronutrient supplementation**	Hb increased with each quartile of IGF-1, and the odds of anemia declined 68.8% from the first to the fourth quartile. Improved iron status indicators explained only 29.1% of the association between IGF-1 and Hb, while IGF-1 explained 25.6% of the association between retinol and Hb.
Basnet et al, 2020[34]	Case–control study	Kathmandu/ Bagmati	Hospital	≤12 months	612/General populations	Patients with more than 70% stenosis in any main coronary artery branch in angiography were defined as cases; C: Those presenting normal coronary angiography, or negative for stressed exercise test were considered controls.	**Micro/macronutrient supplementation**	There was a negative relationship between CAD and dietary intake of β-carotene (OR 0.54; 95% CI 0.34–0.87) and between CAD and vitamin C (OR 0.96; 95% CI 0.93–0.99), but a positive association between CAD and carbohydrates (OR 1.16; 95% CI 1.10–1.24), total fat oil consumption (OR 1.47; 95% CI 1.27–1.69), saturated fatty acid intake (OR 1.2; 95% CI 1.11–1.30), cholesterol (OR 1.01; 95% CI 1.01–1.14), and iron intake (OR 1.11; 95% CI 1.03–1.19). The daily average dietary intakes of saturated fatty acid, vitamin A, total fat/oil, β-carotene, and cholesterol were among the top 5 nutrients (out of 12 nutrient variables) of relative importance associated with CAD.
Buckley et al, 2013[57]	Randomized controlled trial	Sarlahi/Madhesh	Community	37–60 months	390/Adolescents	I: Children born to women randomly assigned by a village to receive supplemental vitamin A (7000 Âµg retinol equivalents); C: Placebo	**Micronutrient supplementation**	Children born to mothers receiving vitamin A vs placebo were not significantly different between the groups (MD = −1.07, 95% CI −7.10 to 9.26). MABC scores were similar for children born to mothers exposed to vitamin A and placebo: MD = 0.15 (95% CI −0.43 to 0.08). More children in the placebo group repeated a

(continued)

Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
								grade in school (28% of placebo group vs 16.7% of vitamin A group)
Chandyo et al, 2010[45]	Randomized controlled trial	Bhaktapur/ Bagmati	Hospital	≤12 months	2628/Under-5 children	I: Zinc administration 10 mg/ day for children of 2–11 months and 20 mg/day for children of 12 months of age for 14 days to prevent diarrheal and respiratory illnesses; C: Placebo	**Micronutrient supplementation**	After 2 weeks of administering zinc, plasma zinc significantly increased in the zinc group. The number of hospital visits and median days to first pneumonia, diarrhea, or dysentery did not differ between the groups and there was also no difference in rates of diarrheal or respiratory illness.
Chandyo et al, 2023[69]	Randomized controlled trial	Bhaktapur/ Bagmati	Community	37–60 months	800/Pregnant women	I: Vitamin B12; C: Placebo	**Micronutrient supplementation**	Infant death or stillbirth was reported in 3 (1%) of 374 women in the vitamin B12 group and 9 (2%) of 379 women in the placebo group. Vitamin B12 supplementation from early pregnancy improved vitamin B12 status but did not affect infant growth or neurodevelopment.
Christian et al, 2001[78]	Randomized controlled trial	Sarlahi/Madhesh	Community	NS	202/Pregnant women	I: Vitamin A, or B-carotene supplementation; C: Placebo	**Micronutrient supplementation**	Zinc treatment improved serum zinc concentrations, but the zinc-alone group failed to restore night vision or to improve dark adaptation among pregnant women. Pregnant women in the vitamin A + zinc group who had baseline serum zinc concentrations of <9.9 micromole/L were 4 times more likely to have their night vision restored (95% CI: 1.1–17.3) than similar women in the control group.
Christian et al, 2003[76]	Randomized controlled trial	Sarlahi/Madhesh	Community	≤12 months	426/Pregnant women	I1: Daily supplements of FA; I2: IFA; I3: IFA + zinc; I4: MMNs all given with vitamin A; C: Vitamin A alone	**Micronutrient supplementation**	Regular IFA supplement use during pregnancy increased mean birth weight by 37 g (95% CI −16 g to 90 g) and reduced the percentage of low-birth-weight babies (<2500 g) from 43% to 34% (16%; RR 0.84, 95% CI 0.72–0.99). MMN supplementation increased birth weight by 64 g (12–115 g) and reduced the percentage of low-birth-weight babies by 14% (RR 0.86, 95% CI 0.74–0.99).
Christian et al, 2003a[74]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	1028/Pregnant women	I1: FA; I2: IFA; I3: IFA + zinc; I4: MMNs; C: Vitamin A alone	**Micronutrient supplementation**	IFA was found to be effective in reducing the burden of anemia in the third trimester by 54% with IFA when compared with MMNs (ie, by 48% with IFA + zinc, and by 36% with IFA + zinc + MMN supplementation, relative to the control ($P < .05$).
Christian et al, 2003 b[76]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	4122/Pregnant women	I1: FA; I2: IFA; I3: IFA + zinc; I4: MMNs; C: Vitamin A alone	**Micronutrient supplementation**	Infants whose mothers received FA alone, IFA, or IFA + zinc had a consistent pattern of a 15% to 20% lower 3-month mortality. RR for mortality was close to 1 for all supplements

(continued)

Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
								except micronutrients (RR 1.74; 95% CI 1.00– 3.04)
Christian et al, 2006[83]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	740/Pregnant women	I1: FA; I2: IFA; I3: IFA + zinc; I4: MMN supplement containing IFA + zinc, and 11 other nutrients plus vitamin A; C: Vitamin A alone	**Micronutrient supplementation**	MMN supplementation in pregnant women decreased the deficiency of serum riboflavin, vitamin B6, vitamin B12, folate, and vitamin D but did not affect the infection rate. Supplementation with FA alone or IFA decreased folate deficiency.
Christian et al, 2008[80]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	3927/Perinatal women	I1: Daily supplements of vitamin A alone; I2: Vitamin A with FA; I3: IFA; I4: IFA + zinc; 15: MMN supplement containing these and 11 other nutrients; C: Vitamin A alone	**Micronutrient supplementation**	Maternal micronutrient supplementation had no effect on morbidity assessed at 6 weeks of age. Symptoms of birth asphyxia increased by ∼60% ($P < .05$) in infants of women who received the MMN supplement compared with infants of women in the control group. Symptoms of combinations of sepsis, preterm birth, and birth asphyxia were associated with 8- to 14-fold increased odds of 6-month infant mortality.
Christian et al, 2011[54]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	780/Children	I1: Daily FA: I2: IFA; I3: IFA + zinc; I4: IFA + zinc and cholecalciferol, tocopherol, thiamine, riboflavin, niacin, pyridoxine, vitamin B-12, ascorbic acid, phylloquinone, copper, and magnesium; C: Vitamin A alone	**Micronutrient supplementation**	Preschool IFA + zinc supplementation to children exposed to IFA in utero, or the addition of zinc to maternal IFA conferred no additional benefit to cognitive outcomes of early-school-age children.
Darrouzet-Nardi et al, 2016[28]	Before-and-after study	Three districts—Chitwan, Nuwakot, Nawalparasi/ Bagmati and Lumbini	Community	13–36 months	1213/Children	I: Participatory community-level activities (nutrition literacy)—focus on poverty alleviation, citizen empowerment, community development, composting, and pest management techniques. Kitchen gardens and goat donations	**Nutrition literacy with financial support**	Children who had received a comprehensive intervention of nutrition literacy and financial support for 2 years were 2.2 times as likely to have consumed food from an additional food group, 1.27 times as likely to have achieved minimum dietary diversity, and 1.38 times as likely to have consumed animal-sourced foods as compared with children who received the intervention for only 1 year.
Dulal et al, 2018[46]	Randomized controlled trial	Four districts—Dhanusha, Mahottari, Sarlahi, Siraha/ Madhesh	Hospital	≥61 months	813/Pregnant women	I: Antenatal micronutrient supplementation, comparing the effects on birth weight and gestational duration of antenatal MMNs; C: IFA supplementation	**Micronutrient supplementation**	There was no evidence of benefit from antenatal MMN supplements compared with IFA supplements on children's overall intelligence and executive function at 12 years.
Frongillo et al, 2024[29]	Before-and-after study	8 districts—Sindhupalchowk, Syangja, Rupandehi, Darchula,	Community	10 years	4520/Under-5 children	I: Nutrition literacy, family planning services, health and hygiene behaviors, multiple social and behavior change communication	**Multiple interventions—literacy, micronutrient supplementation, mass media, m-**	A comprehensive intervention reduced maternal underweight by 8.4% points ($P < .001$) and improved complementary feeding practices with children between 6 and

(continued)

Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
		Ramechhap, Tanahu, Chitwan and Jumla/5 provinces- Bagmati, Gandaki, Lumbini, Sudurpaschim and Karnali				interventions—interpersonal communication, community events, mass media and m-health—to improve household behaviors, complemented with capacity building to strengthen nutrition, health, WASH and agricultural services and governance, particularly at local levels.	**health, hygiene promotion, and governance**	23.9 months: improving child dietary diversity by 0.294 food groups ($P = .072$), minimum dietary diversity by 9.5% points ($P = .028$), feeding of sick children ($P = .002$) by ∼17% points, administering of oral rehydration solution and zinc for diarrhea ($P = .057$) by ∼17% points, minimum meal frequency ($P = .004$) by ∼15% points, and minimum acceptable diet ($P = .022$) by ∼15% points. Child stunting was reduced by 21%, underweight by 19%, and wasting by 9.1% points, but there was no significant difference in reduction between groups. Adequate IFA supplementation during pregnancy (≥180 days) increased by 18% in comparison group and 23% points in intervention group. No significant impacts on child or maternal Hb, maternal or child anemia, exclusive breastfeeding, early initiation of breastfeeding, or introduction of complementary feeding were observed.
Grubesic et al, 2004[35]	Case–control study	Two districts—Doti and Dhading/ Sudurpaschim and Bagmati	Community	≤12 months	876/Under-5 children	I: Vitamin A supplementation and consumption of vitamin A–rich foods (both plant and animal sources) supplemented only once; C: Never-supplemented children	**Micronutrient supplementation**	There was a protective effect among the vitamin A–supplemented children for all 3 disease outcomes (malnutrition PR 0.52, 95% CI 0.39–0.69; diarrhea PR 0.75, 95% CI 0.67–0.83; acute respiratory infection PR 0.60, 95% CI 0.53–0.69). In the supplemented-only-once group, there was a significant protective effect for malnutrition (PR 0.68; 95% CI 0.49–0.94), but not for diarrhea (PR 0.94; 95% CI 0.84–1.05) or acute respiratory infection (PR 1.03, 95% CI 0.92–1.16).
Harris-Fry et al, 2018[67]	Randomized controlled trial	Two districts—Dhanusha and Mahottari/ Madhesh	Community	13–36 months	805/Pregnant women	I1: PLA monthly women's groups; I2: PLA with transfers of 10 kg of fortified flour ("Super Cereal"); I3: PLA plus transfers of 750 Nepalese rupees (∼US$7.5) to pregnant women; C: Usual government services	**Nutrition literacy with financial support**	Dietary iron intake was higher in cash transfer interventions than in the control arm (PLA plus cash = coefficient of 0.06; 95% CI 0.01–0.11; PLA plus food: 0.07; 95% CI 0.01–0.12). The odds of pregnant women consuming IFA supplements were 2.5–4.6 times higher; the odds of pregnant women consuming more animal-sourced foods than the household head were 1.7–2.4 times

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
								higher. The odds of pregnant women consuming more animal-sourced foods (flesh foods and dairy) than the household head were higher than in the control arm, with the largest effect being observed in the PLA-only arm (flesh foods OR 2.4; 95% CI 1.09–5.10).
Haskell et al, 2005[30]	Before-and-after study	Saptari/Madhesh	Community	≤12 months	494/Pregnant women	Night-blind pregnant women were randomly assigned to 1 of 6 retinol equivalents I1: High-dose vitamin A; I2: Low-dose vitamin A; I3: Vitamin A-fortified rice; I4: Goat liver; I5: Amarnath greens; I6: Carrots	**Micronutrient supplementation**	A vitamin A–fortified rice supplement administered to night-blind pregnant women significantly improved the mean pupillary threshold ($P < .0001$). Improvement in dark adaptation was greater in the liver group than in the vitamin A–fortified rice group ($P < .02$). Plasma retinol concentrations increased significantly ($P < .0001$), and the plasma retinol response was greater in the higher-dose capsule and liver groups than in the vegetable groups and significantly greater in the liver group than in the vitamin A–fortified rice group ($P < 0.05$).
Hindle et al, 2006[84]	Randomized controlled trial	Dhanusha/ Madhesh	Community	13–36 months	1200/Pregnant women	I: 15 micronutrient supplementation; C: IFA supplementation	**Micronutrient supplementation**	Plasma C-reactive protein and AGP were higher in women who had a preterm delivery, and AGP was higher in women who delivered a low-birth-weight term infant than in women who delivered a normal-birth-weight term infant.
Katz et al, 2010[70]	Randomized controlled trial	Sarlahi/Madhesh	Community	37–60 months	3264/Under-5 children	I1: Zinc; I2: IFA; I3: Zinc + IFA; C: Placebo	**Micronutrient supplementation**	IFA was associated with an adjusted mean delay of 28.0 days (95% CI 11.3–44.7) in time to walking among infants, and the delay was more pronounced with mid-upper arm circumference (MUAC) of <9.5 cm at 60.6 days, (95% CI 28.5–92.6).
Katz et al, 2017[85]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	2526/Post-partum mothers	I: Influenza vaccine; C: Placebo	**Maternal influenza immunization**	Prevalence of stunting (ie, 13.6% vs 14.8%) and wasting (10.3% vs 11.0%) was slightly lower in the treatment group than in the control group. The impact of the maternal influenza vaccine on wasting was significant (RR 0.66, 95% CI 0.44–0.99) for any wasting, but was not found to be significantly different in reducing wasting between groups. Maternal immunization increased birth weight by 15%.

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
Khanal et al, 2016[42]	Cohort study	Rupandehi/ Lumbini	Community	≤12 months	735/Post-partum mothers	I1: Complete formula feeding; I2: Nutrition literacy	**Nutrition literacy**	Infant formula was commonly used as top-up food. Infants born by cesarean section (aOR 1.96; 95% CI 1.21–3.18) were more likely to be formula-fed. Health workers support improved initiation of and exclusive breastfeeding after cesarean deliveries.
Khanal et al, 2024[36]	Case–control study	Kathmandu/ Bagmati	School	NS	602/Adolescents	I: Proper counseling and promotion of utilization of weekly IFA supplementation implemented; C: No service	**Micronutrient supplementation with literacy**	The prevalence of anemia among adolescent girls receiving weekly IFA was 17.4%, 14% and 20.9% of which were from intervention and control groups, respectively. IFA supplementation at schools (aOR 3.1, 95% CI 1.7–5.7) and recommended dietary diversity (aOR 12.1, 95% CI 6.9–20.8) were significantly associated with anemia reduction among school-going adolescent girls.
Kordas et al, 2009[60]	Randomized controlled trial	Sarlahi/Madhesh	Community	≤12 months	567/Infants	I: Micronutrient supplementation with community health workers' doorstep nutritional advice; C: Usual care	**Micronutrient supplementation with literacy**	Infants receiving IFA supplements slept 0.3 hours more at night ($P < .01$) and 0.4 hours more overall per 24 hours ($P < .01$) than infants not receiving any iron. Zinc supplements also positively affected sleep duration.
Kulkarni et al, 2009[72]	Randomized controlled trial	Sarlahi/Madhesh	Community	NS	4080/Pregnant women	I1: FA; I2: IFA; I3: IFA + Zn; I4: IFA + Zn plus 11 other micronutrients (vitamin D, E, B6, B12, C, K, thiamine, riboflavin, niacin), all with vitamin A; C: Vitamin A alone	**Micronutrient supplementation**	A large proportion of pregnant women (91%) perceived a health benefit from taking the combinations of micronutrients (ie, FA; FA + ferritin [FE]); IPA + Zn; IFA + Zn + 11 other micronutrients.
Locks et al, 2018[31]	Before-and-after study	Two districts—Kapilvastu and Achham/ Lumbini and Sudurpaschim	Community	13–36 months	5121/Under-5 children	I: Integrated IYCF and 60 sachets MNPs (Baal Vita) free of charge to all children aged 6–23 months every 6 months through local health facilities and through FCHVs	**Micro/macronutrient supplementation with literacy**	Integrated IYCF–MNP program children were significantly less likely to be stunted in both districts (aPR 0.77, 95% CI 0.69–0.85) and (aPR 0.82, 95% CI 0.75–0.91) in the Kapilvastu and Achham districts, respectively. Only Achham district had significantly lower prevalences of underweight (aPR 0.82, 95% CI 0.71–0.93), moderate/severe anemia (aPR 0.67, 95% CI 0.46–0.99), iron-deficiency (aPR 0.85, 95% CI 0.77–0.94), and iron deficiency anemia (aPR 0.78, 95% CI 0.64–0.95) compared with children in the baseline. Frequent maternal–FCHV interactions were associated with a reduced risk of stunting (aPR 0.87, 95% CI 0.77–0.99) and underweight in the children (aPR 0.84, 95% CI 0.72–0.99) compared with the children whose

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/Study population	Description of interventions	Key domain	Findings
								mothers saw their FCHV less than once a month. The children of mothers who reported receiving at least 2 sachets of MNP for their child had a significantly reduced risk of anemia (aPR 0.79, 95% CI 0.65–0.96) and iron deficiency anemia (aPR 0.75, 95% CI 0.58–0.95) compared with children whose mothers never received MNP.
Locks et al, 2018[32]	Before-and-after study	Two districts—Kapilvastu and Achham/Lumbini and Sudurpaschim	Community	13–36 months	5120/Under-5 children	I1: Integrated MNPs (Baal Vita) in IYCF programs; I2: Distributed free MNP sachets to all children through local health facilities and FCHVs and health workers counseling	**Micro/macronutrient supplementation with literacy/counseling**	Mothers who received MNPs from their FCHV were more likely to initiate and feed their children so as to maintain their minimum dietary diversity (aPR 1.27, 95% CI 1.14–1.40), minimum meal frequency (aPR 1.31, 95% CI 1.19–1.44), and minimum acceptable diet (aPR 1.41, 95% CI 1.21–1.64). Mothers who received IYCF counseling from a health worker were significantly more likely to identify pulses as a source of iron than were mothers who did not receive IYCF counseling (aPR 1.13, 95% CI 1.01–1.27).
Locks et al, 2019[33]	Before-and-after study	Two districts—Kapilvastu and Achham/Lumbini and Sudurpaschim	Community	13–36 months	2578/Children	I: Children received 60 MNP sachets every 6 months from a FCHV or health center	**Micronutrient supplementation with nutrition counseling**	FCHV-delivered IYCF-MNP counseling was associated with significant improvement in knowledge, receiving MNP sachets at least once (aPR 2.97, 95% CI 2.55–3.47), and correctly answering questions on appropriate use of MNPs (aPR 1.99, 95% CI 1.72–2.31). Counseling from a health worker was also associated with a significant improvement in individual knowledge on appropriate use of MNPs and coverage of MNPs ser.
Marphatia et al, 2020[47]	Randomized controlled trial	Dhanusha/Madhesh	Hospital	12 years	1069/Pregnant women	I: Women were randomly allocated and received either a daily multivitamin and mineral supplement; C: IFA supplement	**Micronutrient supplementation**	Improving maternal nutrition and education is known to improve the timely progression of children in school education. It was found that antenatal micronutrient supplementation marginally increased children's birth weight, protected against late pre-primary entry, and increased child school attendance but did not affect over-age attendance.

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
Mehta et al, 2013[48]	Randomized controlled trial	Sunsari/Koshi	Hospital	≤12 months	614/Infants	I: Received 1 mg/kg/day of elemental zinc, in addition to antibiotic therapy and supportive care; C: Placebo	**Micronutrient supplementation**	There were no statistically significant differences between zinc supplement treatment and control groups in reducing the mortality rate (9.77% vs 7.81%), mean duration of hospital stay (142.85 ± 69.41 hours, vs 147.99 ± 73.13 hours), and requirement of higher lines of antibiotic (13.35% vs 12.05%).
Miller et al, 2020[43]	Cohort study	Banke/Lumbini	Community	37–60 months	269/Children	I1: Full heifer intervention package—community development, livestock management training, and nutrition education (full package); I2: livestock management training and nutrition education only (partial package); C: Usual care	**Nutrition literacy with financial support**	Greater consumption of eggs (aOR 0.80, $P = .04$) or dairy products (aOR 0.95, $P = .05$) over the previous 7 days was associated with a significant reduction in the odds of a low total ASQ score. In the longitudinal sample, only egg consumption and cumulative Dietary Diversity and Animal-Sourced Food scores were associated with significantly reduced odds of a low total ASQ score (aORs 0.59–0.89) and overall improved child development.
Morrison et al, 2023[38]	Quasi-experimental study	Kapilbastu/ Lumbini	Community	≤12 months	55/General populations	I: Nutrition counseling programs; C: Usual care	**Nutrition counseling**	Dietary analysis showed that optimized diets did not achieve 100% of recommended iron intakes, but increasing green leaf, egg, and meat intake could double iron intake. Families often struggle to address anemia through food-based strategies due to perceived expense and religious or cultural taboos. Food taboos for eating buffalo, pork, and snails were found in religious and cultural beliefs, which have social consequences for Muslims and Hindus.
Osrin et al, 2005[73]	Randomized controlled trial	Dhanusha/ Madhesh	Community	NS	1200/Pregnant women	I1: Routine IFA supplements; I2: MMN supplement providing a recommended daily allowance; C: Usual care	**Micronutrient supplementation**	The mean birth weight was 2733 g (SD 422) in the control group and 2810 g (SD 453) in the treatment group, representing a mean difference of 77 g (95% CI 24–130) and a relative fall in the proportion of low birth weight by 25%. No difference was recorded in the duration of gestation (0.2 weeks, 95% CI −0.1 to 0.4), infant length (0.3 cm, 95% CI −0.1 to 0.6), or head circumference (0.2 cm, 95% CI −0.1 to 0.4).
Osei et al, 2015[61]	Randomized controlled trial	Baitadi/ Sudurpaschim	Community	13–36 months	335/Infants	I1: EHFP; I2: EHFP plus MNP. The EHFP + MNP group received 60 sachets of MNP for flexible consumption at the start and 6 months later for a total supplementation	**Micronutrient supplementation with literacy and home gardening**	The mean Hb concentration increased in both intervention groups and in the control group, but the difference in adjusted mean Hb concentration was not statistically significant between groups. Anemia decreased

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
						period of 11 months. The MNP contained 15 micronutrients, including iron (10 mg encapsulated ferrous fumarate); C: Usual care		at a slightly higher magnitude in the EHFP + MNP intervention group (51.5 percentage points [PPs]) than in the EHFP group (48.6 PPs) and the control group (39.6 PPs), and combining the EHFP and MNP programs yielded a marginally significant reduction in anemia among children.
Osei et al, 2017[65]	Randomized controlled trial	Baitadi/ Sudurpaschim	Community	13–36 months	4720/General populations	I: EHFP program consisting of home garden, poultry raising, and nutrition education. Each woman was given a 1-time free supply of seeds, saplings, and locally bred chicks to establish their home gardens and poultry production. Vegetables and fruits promoted in the program included kangkong (*Ipomea aquatica*), amaranth, carrots, spinach, bitter gourd, bottle gourd, orange-fleshed sweet potato, papaya, and mango; C: Usual care	**Nutrition literacy with home gardening**	Anemia was significantly lower among children (OR 0.76, 95% CI 0.59–0.98) and mothers (OR 0.62, 95% CI 0.48–0.82) in the treatment group receiving literacy programs and home gardening support compared with those in the control group. Underweight was lower among mothers in the treatment group compared with those in the control group (OR 0.61, 95% CI 0.46–0.82).
Palmer et al, 2015[58]	Randomized controlled trial	Sarlahi/Madhesh	Community	37–60 months	290/Adolescents	I: Weekly supplementation with vitamin A or beta carotene; C: Usual care	**Micronutrient supplementation**	Maternal vitamin A supplementation was associated with a 0.39 SD increase in natural antibody (Nab) concentrations ($P = .02$). Girls had 1.4-fold higher NAb concentrations ($P < .001$), but the child's sex did not modify the vitamin A effect.
Poudel et al, 2004[37]	Case–control study	Kaski/Gandaki	Day-care centre	≤12 months	46/Under-5 children	I: 2 day-care centers—light meal at noon and snacks in the afternoon; C: Usual care	**School meals**	School meals at the day-care centers improved nutritional status, particularly the height-for-age *z*-score among attendees who had been fed for longer.
Raut et al, 2024[39]	Quasi-experimental study	Kavreplanchock/ Bagmati	School	≤12 months	226/Adolescents	I: 1 hour of nutrition education in the form of mini-lectures and interactive discussions; C: No additional class	**Nutrition literacy**	The health education intervention was found to be effective in increasing nutritional knowledge and improving attitude towards nutrition score among school-going adolescents. The magnitude of the difference in knowledge score was OR 1.80 (95% CI 1.11–2.49), in emotional eating was OR 0.98 (95% CI 0.42–1.54), in uncontrolled eating was OR (3.60, 95% CI 2.10–5.09), and in cognitive restraint of eating was OR 2.26 (95% CI 1.51–3.01) between the intervention and control groups.

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
Saville, et al. 2018[66]	Randomized controlled trial	Two districts—Dhanusha and Mahottari/ Madhesh	Community	13–36 months	10 936/Married women	I1: PLA; I2: PLA + food supplement, I3: PLA + cash transfer; C: No additional program	**Nutrition literacy with financial support**	Mean birth weight was significantly higher in the community-based PLA + food supplement arm by 78.0 g (95% CI 13.9–142), and there was significantly reduced colostrum discarding (OR 0.71, 95% CI 0.54–0.93), and increased breastfeeding (35.1% vs 52.5%) (OR 1.53, 95% CI 1.10–2.14).
Saville et al, 2022[68]	Randomized controlled trial	Two districts—Dhanusha and Mahottari/ Madesh	Community	13–36 months	25 090/Under-5 children	I1: PLA; I2: PLA + food supplement; I3: PLA + cash transfer; C: No additional program	**Nutrition literacy with financial support**	Mothers of male children had higher MUAC and BMI at around 36 weeks gestation after receiving dietary education and financial support; in addition, the odds of wasting were higher in boys at 10–12 months post-intervention (aOR 1.56, 95% CI 1.08–2.25), but there were no differences at any other time points after receiving education and financial assistance.
Schmitz et al, 2012[59]	Randomized controlled trial	Sarlahi/Madhesh	Community	≤12 months	2378/Adolescents	I: Every 4 months for 16 months, preschool children were visited at home, given an oral 200 000 IU dose of vitamin A (half dose at age 1–11 months, quarter dose at <1 month); C: Placebo	**Micronutrient supplementation**	Vitamin A supplementation was associated with a 42% lower risk of hearing loss (OR 0.58, 0.37–0.92) compared with the control.
Shah et al, 2002[51]	Randomized controlled trial	Sunsari/Koshi	School	≤12 months	209/Adolescents	I1: Received a 350-mg ferrous sulfate and 1.5-mg FA combination tablet once daily for 90–100 days; I2: received the tablet under supervision once a week for 14 weeks; C Usual care	**Micronutrient supplementation**	In intervention groups 1 and 2, respectively, the prevalence of anemia decreased from 68.6% and 70.1% to 20% and 13.4% post-supplementation, respectively. In addition the proportion of red blood cells was significantly higher (32.9% ± 3.5% to 41.0% ± 5.6%; 33.2% ± 3.6% to 40.4% ± 4.9%, respectively).
Shah et al, 2012[55]	Randomized controlled trial	Kathmandu/ Bagmati	Hospital	13–36 months	117/Children	I: Received supplementation with elemental zinc; C: Placebo	**Micronutrient supplementation**	Daily zinc supplementation with standard antimicrobial therapy did not significantly reduce severe pneumonia duration or hospital stay duration.
Shrestha et al, 2020a[52]	Randomized controlled trial	Two districts—Dolakha and Ramechhap/ Bagmati	School	13–36 months	682/Children	I1: School garden program; I2: school garden with WASH conditions at schools and in households. Dietary intake program with complementary WASH, health and nutrition interventions; C: No additional program	**Nutrition, WASH, and school gardening**	An integrated intervention consisting of school gardening (SG), WASH, nutrition, and health components (ie, SG+) increased children's fruit and vegetable consumption, decreased intestinal parasitic infections, and improved hygiene behaviors. Stunting was slightly reduced in the SG + group post-intervention (19.9% to 18.3%; $P = .92$) and in the

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
								control group (19.7% to 18.9%). Anemia was slightly decreased in the SG + group post-intervention (33.0% to 32.0%; $P < .01$), and a minor decline in anemia was observed in the control group (43.9% to 42.4%) group. Handwashing with soap before eating strongly increased in the SG + group (from 74.1% to 96.9%; $P = .01$), and a similar observation was made for handwashing after defecation (increase from 77.2% to 99.0% in the SG + group vs 78.0% to 91.9% in the control group, $P = .15$).
Shrestha et al, 2020[40]	Quasi-experimental study	Two districts—Sindhupalchok and Bardiya/ Bagmati and Lumbini	School	NS	1512/Children	I: Home-grown school feeding; C: Usual care	**School meal**	School meal programs significantly increased midday meal provision (19%; $P < .01$), dietary diversity (44%; $P < .01$), and consumption of vitamin A–rich fruits and vegetables (21%; $P < .01$).
Siegel et al, 2011[62]	Randomized controlled trial	Sarlahi/Madhesh	Community	≤12 months	367/Infants	I1: Daily supplementation with 5 mg of zinc, 6.25 mg of iron with 25 Âμg of FA; I2: Zinc + IFA; C: Placebo	**Micronutrient supplementation**	Neither the combined nor the individual micronutrient supplements improved the performance of infant intelligence ($P > .05$).
Stewart et al, 2009[56]	Randomized controlled trial	Sarlahi/Madhesh	Community	NS	3524/Children	I: Mothers received 1 of 5 micronutrient supplements plus daily FA; I2: IFA; I3: IFA + zinc; I4: MMNs; C: Usual care	**Micronutrient supplementation**	Maternal supplementation with IFA + zinc resulted in an increase in a child's mean height (0.64 cm; 95% CI: 0.04–1.25), and a reduction in their mean triceps skinfold thickness (−0.25 mm; 95% CI: −0.44 to −0.06), subscapular skinfold thickness (−0.20 mm; 95% CI: −0.33 to −0.06), and arm fat area (−0.18 cm^2; −0.34 to −0.01).
Strand et al, 2020[63]	Randomized controlled trial	Bhaktapur/ Bagmati	Community	13–36 months	600/Infants	I: Vitamin B12, corresponding to approximately 2–3 recommended daily allowances; C: Placebo.	**Micronutrient supplementation**	Vitamin B12 supplementation in young children at risk of vitamin B12 deficiency resulted in an improved metabolic response. Children who received vitamin B12 supplementation mean difference in Hb concentration was 0.02 g/dL (95% CI −1.33 to 1.37), and the difference in the cognitive scaled scores was 0.16 (95% CI −0.54 to 0.87). The methylmalonic acid concentrations were 23% (95% CI 17–30) and 30% (95% CI 15–46) higher in the placebo group than in the vitamin B12 group.

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
Sunuwar et al, 2019[41]	Quasi-experimental study	Kathmandu/ Bagmati	Hospital	≤12 months	107/Pregnant women	I: Nutrition education and iron-rich-food-based diet plan; C: Usual care	**Nutrition literacy**	Maternal nutrition education significantly increased the Hb level in the intervention group [0.56 ± 0.40 g/dL vs 0.16 ± 0.82 g/dL]. The change in the maternal nutritional knowledge score for anemia and iron-rich foods was significantly higher in the intervention group (8.26 ± 4.57 vs 1.05 ± 6.59). Consumption of iron-rich food was significantly higher in the intervention group ($P < .05$).
Surkan et al, 2012[81]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	569/Under-5 children	I1: Children received zinc; I2: IFA; I3: Zinc plus IFA; C: Placebo	**Micronutrient supplementation**	Children in the zinc treatment group showed smaller decreases in head circumference *z*-score compared with children in the placebo group (adjusted $\beta = 0.13$, 95% CI 0.03–0.23). Zinc supplementation was found to be effective for improving head growth (head circumference *z*-score 0.11, (95% CI 0.05–0.17) as compared with placebo in Nepali infants.
Surkan et al, 2013[82]	Randomized controlled trial	Sarlahi/Madhesh	Community	≤12 months	544/Under-5 children	I1: IFA; I2: Zinc; I3: Zinc plus IFA supplementation; C: Placebo	**Micronutrient supplementation**	Children receiving zinc had a 0.8 lower mean change in language score 5 compared with children not receiving zinc (95% CI −1.3 to −0.3). Neither zinc nor IFA supplementation improved the attainment of motor or language milestones.
Surkan et al, 2015[75]	Randomized controlled trial	Sarlahi/Madhesh	Community	≤12 months	569/Under-5 children	I: Zinc and IFA supplementation (observing early child temperament and eating behaviors); C: Usual care	**Micronutrient supplementation**	Children receiving supplements increased temperament scores by 0.37 points over 5 visits (95% CI 0.02–0.7). The temperament scores comparing the effects of IFA with and without zinc ($\beta = -0.03$, 95% CI −0.3 to 0.2) and comparing iron with and without FA ($\beta = 0.08$, 95% CI −0.2 to 0.3) were significantly different. Children with iron-deficiency anemia at baseline showed improved eating behaviors when supplemented with zinc ($\beta = -0.3$, 95% CI −0.6 to −0.01).
Tielsch et al, 2006[77]	Randomized controlled trial	Sarlahi/Madhesh	Community	13–36 months	8337/Under-5 children	I1: IFA; I2: Zinc alone: I3: IFA and zinc; C: Placebo	**Micronutrient supplementation**	There was no difference in mortality between the groups who took IPA without or with zinc when compared with placebo (HR 1.03, 95% CI 0.78–1.37, and 1.00, 0.74–1.34, respectively). Daily supplementation of young children with IPA with or without zinc has no effect on their risk of death but might protect against diarrhea, dysentery, and acute respiratory illness.

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Table 4. Continued

Author(s), year	Study design	Study district/Province	Study sites	Intervention duration	Sample size/ Study population	Description of interventions	Key domain	Findings
Tielsch et al, 2007[53]	Randomized controlled trial	Sarlahi/Madhesh	Community	≤12 months	41, 276/Under-5 children	I1: IFA; I2: Zinc; I3: IFA with zinc; (all intervention group children received vitamin A supplementation twice per year); C: Placebo	**Micronutrient supplementation**	There was no significant difference in mortality between the zinc and placebo groups (316 vs 333 deaths; hazard ratio 0.92, 95% CI 0.75–1.12). Zinc did not affect mortality in children younger than 12 months (181 vs 168 deaths; 1.04, 0.83–1.31); mortality was lower, but not statistically significantly so, in older children receiving zinc (135 vs 165; 0.80, 0.60–1.06).
Ulak et al, 2023[64]	Randomized controlled trial	Bhaktapur/ Bagmati	Community	13–36 months	600/Infants	I: Paste containing vitamin B12; C: Placebo	**Micronutrient supplementation**	Vitamin B12 supplementation had no effect on the neurodevelopmental outcomes and beneficial effect for infants at risk of vitamin B12 deficiency, ie, in improving preschool cognitive function.
Vaidya et al, 2008[49]	Randomized controlled trial	Dhanusha/ Madesh	Hospital	13–36 months	917/Under-5 children	I: Women received either IFA or a supplement that provided the recommended daily allowance of 15 vitamins and minerals, over the second and third trimesters of pregnancy; C: Usual care	**Micronutrient supplementation**	Children of women who had taken MMN supplements during pregnancy were 204 g (95% CI 27–381) heavier than controls. They also had greater measurements than controls in the circumference of the head (2.4 mm [95% CI 0.6–4.3]), chest (3.2 mm [0.4–6.0]), and mid-upper arm (2.4 mm [1.1–3.7]), and in triceps skinfold thickness (2.0 mm [0.0–0.4]). Effects of maternal MMN supplementation on the fetus persisted into childhood, with increases in both weight and body size.
Valentiner-Branth et al, 2010[50]	Randomized controlled trial	Bhaktapur/ Bagmati	Hospital	37–60 months	2628/Under-5 children	I: Zinc; C: Placebo	**Micronutrient supplementation**	There was no difference in time to recovery between zinc and placebo groups for women with nonsevere or severe pneumonia. Regurgitation or vomiting ≤15 minutes after supplementation was observed more frequently among children in the zinc group than among those in the placebo group during the supplementation period (37% compared with 13%; OR: 0.25; 95% CI: 0.20–0.30). Adjuvant treatment with zinc neither reduced the risk of treatment failure nor accelerated recovery in episodes of nonsevere or severe pneumonia.

Abbreviations: AGP, alpha-1-acid glycoprotein; aOR, adjusted odds ratio; aPR, adjusted prevalence ratio; ASQ, Ages and Stages Questionnaire; C, control; CAD, coronary artery disease; EHFP, enhanced homestead food production; FA, folic acid; FCHV, female community health volunteer; Hb, hemoglobin; I, intervention; IFA, iron and folic acid; IGF, insulin-like growth factor; IYCF, infant and young child feeding; MABC, Movement Assessment Battery for Children; MD, mean difference; MMNs, multiple micronutrients; MNP, micronutrient powder; MUAC, mid-upper arm circumference; NS, not stated; OR, odds ratio; PLA, participatory learning and action; PR, prevalence ratio; RR, relative risk; WASH, water, sanitation, and hygiene.

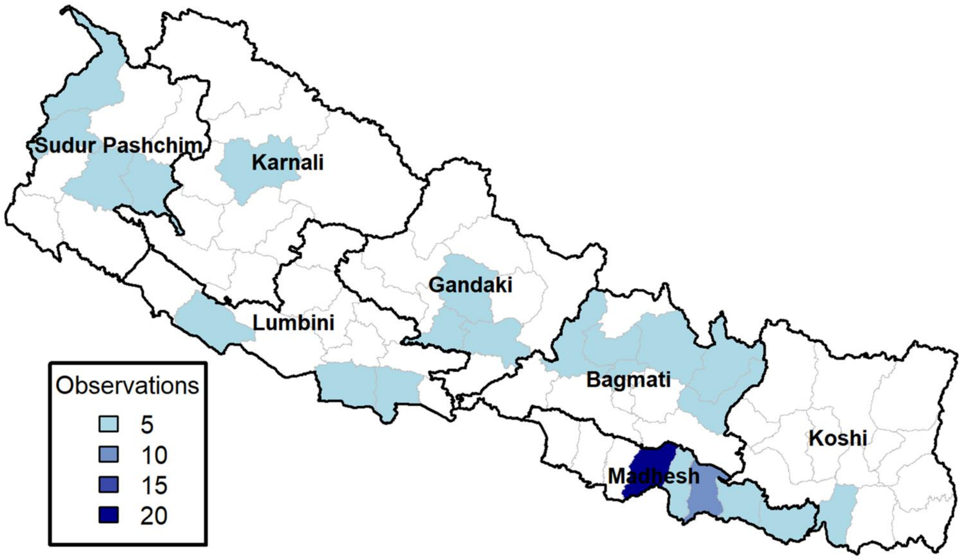

Figure 3. Map of Nepal Showing Study Locations.

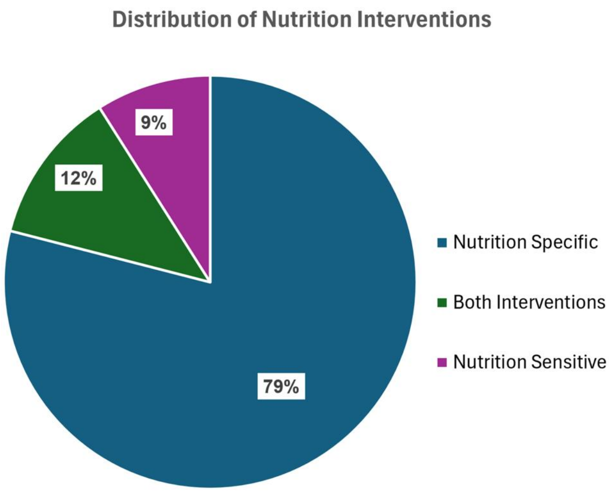

Figure 4. Pie Chart Illustrating the Three Studied Intervention Types: Nutrition-Specific, Nutrition-Sensitive, and combined Interventions (both). Each segment represents the proportion of studies falling into each category.

compliance alone did not increase hemoglobin or reduce anemia among mothers.[44] Iron, folic acid and zinc supplementation for preschool children had no additional benefit on cognitive outcomes[54] or infant intelligence[62] (Table 4).

Vitamin A Supplementation. Vitamin A and zinc supplementation have been shown to be effective in restoring the night vision of pregnant women with reduced night vision.[78] Supplementation of Vitamin A-rich foods (both plant and animal sources) was also found to protect against malnutrition (PR 0.68) among pregnent women.[35] Pregnant women who received a weekly vitamin A supplement had increased hemoglobin and reduced risk of anemia,[79] their children performed better in school,[57] and it also improved maternal, fetal, and infant health and survival.[58] Daily vitamin A supplements and multiple micronutrient supplements were effective in reducing birth asphyxia symptoms[80] and also reduced the risk of hearing loss.[59] Night-blind pregnant women were given retinol through various sources, including vitamin A–fortified rice, goat liver, amaranth leaves, or carrots. The liver group showed significantly improved dark adaptation, while the vitamin A–fortified rice group showed less improvement. Plasma retinol concentrations increased significantly, with the higher-dose capsules and liver groups showing greater response than the vegetable groups.[30] However, Vitamin A supplementation was ineffective in treating diarrhea or severe respiratory infections[35] (Table 4).

Vitamin B12 Supplementation. Vitamin B12 supplementation in young children resulted in an improved metabolic response.[63] However, 2 studies on vitamin B12 supplementation in pregnant women had no effect in reducing neonatal death or stillbirth, or in improving infant growth, or neurodevelopment[64,69] (Table 4).

Zinc Supplementation. Zinc supplementation in infants increased sleep duration and growth,[60] serum zinc concentration,[78] temperament scores,[75] and plasma zinc levels.[45] Zinc supplementation in children increased head growth but decreased head circumference *z*-score,[81] and lowered mean language score.[82] However, the zinc supplementation timing (whether in infants or in children) both showed similar beneficial effects with respect to reducing the mortality rate and the duration of hospitalization,[48] preventing diarrheal and respiratory illnesses,[45] reducing hospital visits[45] and restoring night vision.[78] Similarly, zinc supplementation during the severe health conditions had no effect in terms of reducing mortality rates, mean hospital stays, or the need for further antibiotic medication, and or in reducing severe pneumonia[48,55] (Table 4).

Micronutrient powders and multivitamins. A total of 11 studies reported on micronutrient powder (MNP)- and multivitamins-related studies. Dietary interventions were found to reduce the risk of anemia (aPR 0.79) and iron-deficiency anemia (aPR 0.75).[32] Mothers who received MNPs from female community health volunteers (FCHVs) were more effective in initiating to feed the children (aPR 1.27) and increasing the diversity in their children's diet (aPR 1.31).[33] Women who received either daily multivitamin or mineral supplementation improved their nutritional status and their children's school progression.[47] Multiple micronutrient supplements providing 15 vitamins and minerals daily during the 12 weeks of gestation preceding delivery significantly increased baby birth weight by 25%.[73] Women who took multiple micronutrient supplements (IFA with 15 vitamins) during pregnancy delivered babies who weighed 204 g (95% CI 27–381) more than those of women in the control group, had greater measurements for the circumference of the head, chest, mid-upper arm, and triceps skinfold thickness, and had decreased systolic blood pressure.[49] The effects of maternal multiple micronutrient supplementation on the fetus persisted into childhood, with increases in both weight (average 2% greater) and body size, compared with the control group children,[49] improved overall health status,[72] and reduced rates of early neonatal morbidity and low birth weight.[76,80,83] However, multiple micronutrient supplementation did not impact gestation duration, infant length, or head circumference,[73] birth weight,[46] or rate of neonatal morbidity[80] (Table 4).

ii. Social and nutritional behavior change interventions. *Nutrition Counseling.* Three studies reported on infant and young child feeding (IYCF) counseling interventions,[31–33] with significant reduction in stunting (aPR 0.82), underweight (aPR 0.82), anemia (aPR 0.67), and iron deficiency anemia (aPR 0.85), compared with baseline.[32] Mothers who received IYCF counseling and met their FCHV more than once per month were more likely to feed their children home-made "super flour" (aPR 1.47), meet their minimum recommended meal frequency (aPR 1.18), and achieve the minimum acceptable diet for their children (aPR 1.47). Infant and young child feeding counseling from a health worker was also found to be effective in helping mothers identify sources of iron-rich foods (aPR 1.13)[31] and increased their knowledge on the appropriate use of nutrient-rich foods compared with those who did not receive counseling (aPR 1.19).[33] Regular interaction of mothers with FCHVs was effective in reducing stunting (aPR 0.87) and underweight (aPR 0.84) in their children, compared with the children whose mothers saw their FCHV less than once a month. The children of mothers who reported receiving MNPs for their child also showed reduced risk of anemia (aPR 0.79) and of iron-deficiency anemia (aPR 0.75) compared with children whose mothers never received MNPs[31] (Table 4).

Nutrition Literacy. Thirteen studies reported on nutrition literacy–based interventions, 10 in combination with other interventions, but 3 of them focused on literacy-only interventions. The 10 studies on nutrition literacy–based interventions in combination with other interventions, reported on the efforts of nutrition literacy programs in association with micronutrient supplementation ($n = 8$), macronutrient and micronutrient supplementation ($n = 2$), counseling ($n = 2$), and/or home gardening ($n = 2$). Nutrition literacy programs improved nutritional knowledge (OR 1.80), reduced uncontrolled eating (OR 3.60), and increased cognitive restraint of eating (OR 2.26).[39] Maternal nutrition literacy increased the hemoglobin level, knowledge of anemia and iron-rich foods, and the consumption of iron-rich foods ($P < .05$).[41] Maternal nutrition literacy programs alone were found to be effective in reducing anemia in their children by 59% compared with the control group children.[44] Nutritional counseling programs increased iron intake by encouraging individuals to eat more leafy greens, eggs, and meat. However, some foods, such as pork for Muslims and buffalo meat for Hindus,[38] are considered taboo due to religious and cultural restrictions (Table 4).

iii. Gardening, homestead production, and school meal programs. *Home Gardening.* Three studies reported that home gardening–based interventions significantly increased the level of hemoglobin[61] and decreased the level of anemia in children (OR 0.76), mothers (OR 0.62), and underweight mothers (OR 0.61) in the treatment group.[65]

Homestead Food Production. Helen Keller International (HKI) implemented homestead food production through multiple interventions, such as home gardening, poultry raising, and nutrition education. The interventions were found to be effective in reducing the prevalence of underweight mothers (OR 0.61), anemic children (OR 0.76), and anemic mothers (OR 0.62).[65]

School Gardening. One comprehensive study on a school gardening intervention supplemented with WASH, nutrition, and health components showed significantly reduced anemia in children (from 33.0% to 32.0%; $P < .01$), increased fruit and vegetable consumption (OR 6.08), and reduced prevalence of intestinal parasitic infections (OR 0.16). The school gardening programs also contributed to reductions in stunting, and improvements in handwashing after defecation, but these changes were not statistically significant[52] (Table 4).

School Meal Programs. Two studies examined the impact of school meal programs and their influence on increased quality of dietary diversity and higher consumption of vitamin A–rich fruits and vegetables, which overall improved the nutritional status of the children.[37,40] The study duration was short and the sample size was small, so further large-scale research is needed to better understand the programmatic interventions that improve the nutritional status of school children (Table 4).

2. Nutrition-sensitive interventions

Social Safety Nets. Safety net programs, including direct cash/voucher transfers or in-kind food assistance, were found to be effective in addressing malnutrition. A total of 5 studies reported on safety net–based interventions (cash or food assistance) in combination with nutrition literacy programs. Community-based participatory learning and action with financial support for pregnant women resulted in the women being 2.5–4.6 times more likely to use IFA supplements, and women who received food assistance consumed 0.7–2.4 times more animal-sourced foods.[67] Community-based PLA women's groups with food support had children with higher mean birth weight (78.0 g vs 28.9 g) and a higher proportion of early initiation of breastfeeding (52.5% vs 35.1%) between the intervention and control groups.[66] Women who received nutrition literacy with financial support consumed 1.38 times more animal-source foods, and were 1.27 times more likely to achieve the minimum recommended dietary diversity for thier children compared with control group.[28] A comprehensive intervention package for children whose families were enrolled in community development, livestock management training, and nutrition education significantly increased the consumption of eggs (aOR 0.80) and dairy products (aOR 0.95) among children and improved their overall child development. Greater egg consumption (aOR 0.59), higher cumulative dietary diversity score (aOR 0.89), and higher animal-sourced food scores (aOR 0.86) for children were associated with reduced odds of them having a low ASQ score and better overall child development.[43] Nutrition literacy with financial support provided to pregnant women at around 36 weeks of gestation reduced food restriction during pregnancy and increased their children's mid-upper arm circumference (MUAC) and BMI[68] (Table 4).

WASH and Maternal Immunization. The influenza vaccine for pregnant women reduced wasting (relative risk 0.66) and low birth weight in babies of the vaccinated group at 6 months of age.[85] Comprehensive interventions, including literacy, WASH, mass media, and nutrition security, reduced child stunting by 21%, underweight by 19%, and wasting by 9.1 points.[29] School garden programs in combination with a WASH program reduced stunting and increased handwashing after defecation, but the effects were not statistically significant[52] (Table 4).

3. Combination of nutrition-specific and nutrition-sensitive interventions

A total of 7 studies reported on combined nutrition-specific and nutrition-sensitive interventions. Among these, 3 studies focused on the provision of nutrition literacy and financial support,[43,66,68] while 2 studies combined micronutrient supplementation with nutrition literacy and home gardening.[61,65] The promotion of homestead food production through integrated approaches, such as home gardening, poultry raising, and nutrition education, significantly reduced the prevalence of underweight mothers (OR 0.61), anemic children (OR 0.76), and anemic mothers (OR 0.62).[65] Additionally, 2 studies implemented comprehensive intervention packages that included nutrition literacy, micronutrient supplementation, a WASH program, and school gardening strategies.[29,52] These interventions reduced child stunting (by 21%), underweight (by 19%), and wasting (by 9.1 points), but the differences between the intervention and control groups were not statistically significant (Table 4).

DISCUSSION

The review included 58 studies that evaluated the outcomes of interventions aimed at addressing all forms of malnutrition in Nepal. These included 2 broad categories of interventions (nutrition-specific and nutrition-sensitive interventions) and a combination of the 2 categories. This section discusses the key findings on how these interventions may address the TBM: undernutrition (stunting, wasting, and underweight), micronutrient deficiencies, and overnutrition (overweight or obesity).

Nutrition-Specific Interventions

Notably, a large proportion ($n = 43$) of the included studies primarily focused on nutrition-specific interventions. Receiving micronutrient supplements reduced rates of early neonatal morbidity and low birth weight, and improved complementary feeding practices. Interventions such as MNPs, locally available protein-based homemade super flour, and Baal Vita for infant feeding significantly reduced the risk of iron-deficiency anemia and met the children's minimum dietary diversity requirements. Studies from other low- and middle-income countries (LMICs) confirm our findings for Nepal. A similar study in Bangladesh found that micronutrient supplementation significantly increased the weight gain of children aged 6–24 months.[86] A study in China found that soybean-based supplementary food supplements, along with other micronutrient supplementation, reduced underweight and stunting.[87] Another study showed that multiple micronutrient supplements improved birth outcomes for pregnant women in LMICs.[88] Our findings revealed that consuming eggs improved children's weight, height, and dietary intake.[38,43] A study in Ecuador also reported that the consumption of 1 egg per day by babies aged 6–9 months for a 6-month intervention period had increased length-for-age, weight-for-age, and dietary intake of eggs, and reduced stunting (by 47%), underweight (by 74%), and intake of sugar-sweetened foods.[89]

Iron and FA supplementation significantly reduced the prevalence of anemia among school-going adolescent girls, increased infant sleep time, and increased birth weight.[36,51,60] As found in this review for Nepal, earlier systematic reviews conducted elsewhere found that weekly IFA supplementation improved hemoglobin concentration and iron status while lowering the risk of iron-deficiency anemia.[90,91] Furthermore, our finding that zinc supplementation serves as a protective factor against diarrhea, dysentery, and acute respiratory infections, and improves child growth is consistent with the findings of other global systematic reviews.[91,92] Although several zinc supplementation studies did not show short-term clinical recovery from the need for acute care, zinc supplementation was shown to reduce the mortality rate and duration of hospitalization,[48] reduce diarrheal and respiratory illnesses,[45] decrease hospital visits,[45] and help restore night vision.[78] The findings revealed that Infant and Young Child Feeding and counseling were effective in reducing stunting, underweight, anemia, and iron deficiency anemia among children, and are in line with those of a systematic review conducted in the context of LMICs, in which IYCF counseling was found to increase early initiation of breastfeeding, exclusive breastfeeding, and to decrease stunting and diarrhea.[93] Our review in the Nepali context suggests that regular nutrition counseling from health workers or FCHVs improves nutrition indicators.

Home gardening and homestead food production interventions increased hemoglobin levels and reduced anemia among children, mothers, and underweight people, while combining school gardening with WASH, nutrition, and health interventions increased children's fruit and vegetable consumption, decreased intestinal parasite infections, and improved personal hygiene practices. This finding is in concordance with the findings of a similar study in Caribbean and Pacific countries, which showed that home gardens encouraged better diets by re-emphasizing local foods and ensuring access to fresh, nutrient-rich produce, often leading to long-term changes in dietary behaviors and weight management.[94] Our findings support the expansion of community-based agriculture, which is pragmatic for agrarian countries like Nepal, where agriculture employs over ⅔ (67%) of the population.[95] All 753 local governments in Nepal should take the lead in the effective implementation of the federalized system by prioritizing local production, equitable access to food and nutrition,[96] and strengthening community links to get fresh and nutritious produce.[97]

Nutrition-Sensitive Interventions

Community-based participatory learning and action regarding food, agriculture, and nutrition education and growth monitoring have significantly reduced undernutrition among children under 5 in Nepal. This finding aligns with the findings of a recent systematic review, that integrating social and behavioral change communication strategies reduced the prevalence of stunting, wasting, and underweight in children and improved knowledge and practices regarding minimum meal frequencies, maternal and child dietary diversity, and household food consumption, including exclusive breastfeeding practices.[98,99] Similarly, health promotion, along with improving health legislation, such as increasing taxation on sugary foods and/or soft drinks, has been found to be effective in addressing sugary foods for children.[100] Empowering mothers in planning and preparing healthy, nutritious diets, providing timely care, gaining an understanding and knowledge of nutritional status, and regular home-based diet preparation, was associated with improvement in the nutritional status of underweight preschool children in India.[101] Most health promotion interventions have traditionally focused on changing individual behavior as an immediate determinant of ill health, rather than targeting the broader socio-political or environmental determinants that influence behavior—which is crucial in combating the various forms of malnutrition in Nepal. This knowledge provides a great opportunity for the integration of nutrition-sensitive interventions into Nepal's current federalized health system, in which all local governments must empower local communities and vulnerable groups to implement long-term sustainable interventions to remove structural barriers to nutritional outcomes through regular public health, food, and agricultural extension services.[102]

Female Community Health Volunteers deployed across the community have played an important role in managing several government initiatives, including community-based integrated management of neonatal and childhood illness, and of IYCF, facilitation of timely referrals, assistance in overcoming sociocultural barriers to seeking services, and the provision of education on healthy behaviors.[103–106] Our review revealed that mothers who received IYCF counseling and saw their FCHV more than once a month were more likely to feed their children homemade "super flour," to maintain a minimum meal frequency, and to follow the minimum acceptable diet. The literature shows that FCHVs have played crucial roles in the community-wide dissemination of health information and the distribution of health commodities at doorsteps.[104] Nepal is well known for its highly diverse society, with over 100 caste and ethnic communities, each with distinct health-seeking behaviors.[107] Integrated primary healthcare, including that provided by the FCHVs, could play an important role in providing nutrition services—for example, the successful vitamin A program in Nepal was managed by FCHVs.[108]

A total of 7 studies investigated combinations of both nutrition-specific and nutrition-sensitive interventions, including school gardening alongside WASH, immunization, nutrition, and social safety nets, which markedly showed improved child nutrition indicators, including decreased anemia, increased fruit and vegetable intake, and reduced intestinal parasite infections. Our findings are consistent with a recent systematic review undertaken in the global context showing that gardening programs combined with nutrition education had a positive impact on children's attitudes toward eating fruits and vegetables, as well as on their nutritional understanding.[109] However, our findings indicate that future gardening interventions should be more pragmatic, focusing on the empowering of children, parents, and the community to support healthy eating behaviors. Our findings also reported that comprehensive interventions involving both nutrition-specific and nutrition-sensitive measures reduced underweight, wasting, and stunting in children, but the findings were not statistically significant. This evidence highlights the fact that implementing multiple interventions does not always guarantee significant improvement in addressing malnutrition— for long-term sustainable outcomes, the interventions need to be pragmatic and tailored to the specific underlying causes of malnutrition, while taking into account Nepal's fragmented socio-cultural diversity.[107]

Current Evidence Gaps and Implications for Research and Practice

The present review has primarily identified nutrition-specific interventions that have focused on micronutrient supplementation or diet-related behaviors; the number of reports on nutrition-sensitive interventions was very limited. Limited nutrition-specific interventions included food literacy and nutritional counseling, which could have been framed as social and nutritional behavioral change communication. Despite the large number of intervention studies, there is a lack of empirical research in key areas, such as the use of digital applications in the delivery of nutrition interventions, and the promotion of neglected and underutilized forgotten foods, food environment research, marketing and consumption of ultra-processed foods, and dietary needs of aging populations. First, the available studies were mostly conducted in 1 of the 7 provinces (Madhesh province, in the southeastern plains), while Karnali province in the western high mountains had no targeted interventions; nonetheless, current statistics suggest that Karnali province has the highest malnutrition burden compared with other provinces.[7] Malnutrition can be caused by multiple etiologies, including macro- and micro-nutrient deficiencies and lack of access to healthcare and sanitation. The review did not identify interventions that specifically focused on nutrient-rich forgotten foods, such as iron-rich minor millets and beans, which can also build food system resilience in adverse conditions. Particularly in remote areas, the use of digital communication can bridge the spatial divide. However, there is a lack of evidence of the use of digitally devised interventions, such as m-health– or e-health–based interventions, to address malnutrition in rural and urban Nepal and its impact. These interventions are crucial for future efforts to support hard-to-reach communities, enabling them to access health information and influencing their behavior to improve nutrition literacy. Further research should be conducted to delve deeper into the effectiveness of the such interventions through subgroup analyses, with particular focus on vulnerable groups.

Second, none of the studies focused on interventions for the elderly population, although the Nepali population is gradually aging; the average life expectancy at birth has reached 70.6 years, and the proportion of the population aged 60 years and over (older adults) was 10.2% in the most recent census report.[110] Similarly, the high rate of youth migration for foreign employment and the declining birth rate present a significant demographic shift that must be considered in the development of personalized interventions. These changes highlight the importance of tailoring dietary services to Nepal's aging populations to improve nutritional health and overall well-being. Home-delivered ready-made meals,[111] lifestyle interventions focusing on diet (such as high-protein intake or restriction of calorie intake),[112] exercise, and self-management (including self-monitoring),[113] as well as combined approaches, have been shown to improve the nutritional status of older adults.

In addition, none of the studies in our review reported interventions for men in Nepal, although evidence elsewhere shows nutrition education, digital tools, supplementation, and behavior change programs effectively reduce undernutrition and micronutrient deficiencies in men.[114,115]

Third, of the 58 included studies, none examined the food environments implicated in increasing consumption of ultra-processed foods and beverages, which is a major burden of overnutrition leading to overweight and obesity as risk factors of noncommunicable diseases. Recent South-Asian research has found that a higher number of fast-food outlets was associated with increased obesity among women and low-income groups[116] and also with an increase in the number of diabetics.[117] On the other hand, obesity and overweight are becoming more prevalent in Nepal, with a significantly higher prevalence among urban women aged 20–49 years (38%) and the poorest households (53%), compared with the richest.[7] Therefore, it is imperative to implement targeted interventions to combat overweight and obesity in Nepal's geographically and culturally varied communities. For example, consuming fresh food fosters an adequate dietary intake of calcium, iron, and zinc. However, the interventions should incorporate nutrition education and encourage the use of locally available food options, making these foods and supplements affordable and accessible along with adequate nutrition literacy. Likewise, the health status of children with obesity needs interventions, with dietary considerations including limiting of sugar-sweetened drinks, consuming meals with portions of fruits and vegetables, avoiding fast foods and processed foods, and increasing the consumption of healthy foods.

The rapid dietary shifts toward ultra-processed foods are inadequately addressed by current interventions, necessitating dual-focused strategies (eg, integrating obesity prevention into severe acute malnutrition treatment protocols). Another concerning gap is the lack of intervention to assess nutritional patterns as a risk factor for noncommunicable diseases, particularly among women, leading to obesity and overweight, and subsequently to type-2 diabetes, hypertension, heart diseases, liver cancer, colon cancer, and dementia. There has been gross neglect in addressing the TBM, with intervention biases toward the classical intervention involving vitamin and micronutrient supplementation. The current challenge is to provide enough calories and proteins to combat hunger and recurring famines in remote areas and informal urban settlements, micronutrient deficiency among certain groups, such as infants, children, adolescent girls, women of reproductive age, and elderly people, and excessive consumption of energy-dense ultra-processed foods high in salt, sugar, and trans-fats in urban and peri-urban areas.

Finally, yet another important policy priority area is economic empowerment and food security. Financial obstacles to food security and nutrition are critical. Therefore, providing social safety nets (eg, conditional cash transfers or food assistance supports), and long-term support through income-generating activities can empower family members from low-income homes to secure food and nutrition. Targeted social and behavioral change interventions are critical for promoting nutrition literacy and reducing TBM, but more importantly, for removing structural barriers. Nutrition intervention programs should be integrated with routine public health programs, including community stakeholders such as FCHVs and schoolteachers (including health and school nurses), provide social safety nets, and empower women in health decision-making.

Strengths and Limitations of the Review

To the best of our knowledge, this is the first scoping review to summarize the available and up-to-date intervention studies on addressing the TBM in Nepal. The strengths of this review are unraveling the research gaps discussed above, such as bridging rural–urban divides through the use of digital technologies, engaging in co-designing approaches to address the rising TBM in Nepal, particularly the increasing consumption of ultra-processed foods and beverages and the growing burden of noncommunicable diseases, while the country still grapples with communicable diseases. The use of the PRISMA-ScR guidelines ensures a robust and replicable process, and the use of Arksey and O'Malley's (2005) scoping review framework[23] guides appropriate reporting and analysis. All possible terms were included in the search strategy using different databases, ensuring that all studies addressing the TBM were identified. This review identified critical evidence gaps that should guide future research, and identified programs showing early evidence of addressing the TBM in Nepal.

This review also has some limitations. We did not include gray literature; as a result, some intervention studies not published in peer-reviewed academic publications may have been potentially excluded from this review. The current government has implemented several interventions, such as school meal programs, school nurses, nutrition committees, increased maternity leave, and expanded immunization and nutrition support programs. The evaluation of these programs could provide a more comprehensive picture of long-term effects on combating TBM, but none were included due to a lack of published data. However, we handpicked a modest number of studies to address this limitation. Additionally, our search was linguistically constrained; we used only English-language publications, which may have led to the omission of important studies conducted and published in Nepali. However, we are confident that Nepali scholars normally publish in English and policy documents are published in English as well as Nepali. Furthermore, some studies included in this review had small sample sizes and short intervention periods, making it difficult to provide a complete picture of the intervention's effectiveness in addressing all forms of malnutrition, which might have influenced the study outcomes. Since this is a scoping review, the findings were not weighted or stratified by methodological quality or study design; therefore, we interpreted the findings with extra caution.

CONCLUSION

This review of nutritional interventions shows that, over the last 2 decades, research priorities have excessively focused on nutrition-specific interventions, and short-term and project-led experiments, regardless of the emerging challenges to address the TBM and the progressive shift toward multi-sectoral policies. Nevertheless, a limited number of more recent interventions have explored sustainable alternatives, such as school gardening, home gardening, homestead production, and homegrown school meal programs, which focus on nutrition-specific interventions rather than addressing structural barriers to nutritional outcomes. Rapid dietary shifts toward the marketing and consumption of energy-dense ultra-processed foods are inadequately countered by the existing intervention studies, however, overlooking food as a risk factor for non-communicable diseases, such as obesity, type 2 diabetes, hypertension, certain cancers, and dementia among the elderly population. Multi-sectoral interventions can lead to innovations in dietary diversification, bringing a shift away from costly micronutrient supplements, food fortification, and nutrition interventions to address micronutrient deficiencies. Stakeholders may need to prioritize localized production, behavioral change strategies, and integrated nutrition security programs, alongside nutrition-sensitive interventions to address structural barriers. It is critical to scale up nutrition-specific initiatives (community-led nutrition literacy, including mobilization of FCHVs, schoolteachers, and school nurses; homestead food production; income-generating activities or economic livelihoods) and promote nutrient-rich forgotten foods (eg, iron-rich minor millets and beans) to ensure the long-term sustainability of food and nutrition security. To address the structural determinants of malnutrition, nutrition-sensitive interventions (eg, cash transfers, and group-based empowerment and capacity building) should be prioritized, alongside nutrition-specific interventions (eg, folic acid and iron supplementation, and nutrition counseling). Research must shift from documenting prevalence to informing context-specific, equity-driven interventions that simultaneously address the underlying causes of undernutrition, obesity, and micronutrient deficiencies. Nepal is a newly federalized country with 753 local governments with devolved decision-making powers. This structure creates opportunities to promote nutrient-rich forgotten foods, such as iron-rich minor millets and beans, through multi-sectoral interventions at the local level. These initiatives can build health co-benefits while strengthening food system resilience against climate change and other adverse conditions.

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Conflicts of Interest

None declared.

Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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