Who is the Woman in Women's Nutrition? A Narrative Review of Evidence and Actions to Support Women's Nutrition throughout Life

Elizabeth L Fox,[1] Claire Davis,[1] Shauna M Downs,[2] Werner Schultink,[3] and Jessica Fanzo[1,4,5]

[1]Berman Institute of Bioethics, Johns Hopkins University, Baltimore, MD; [2]Department of Health Systems and Policy, School of Public Health, Rutgers University, New Brunswick, NJ; [3]UNICEF Kenya, UNICEF, Nairobi, Kenya; [4]Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD; and [5]Nitze School of Advanced International Studies, Johns Hopkins University, Washington, DC

Abstract

Nutrition interventions that target mothers alone inadequately address women's needs across their lives: during adolescence, preconception, and in later years of life. They also fail to capture nulliparous women. The extent to which nutrition interventions effectively reach women throughout the life course is not well documented. In this comprehensive narrative review, we summarized the impact and delivery platforms of nutrition-specific and nutrition-sensitive interventions targeting adolescent girls, women of reproductive age (nonpregnant, nonlactating), pregnant and lactating women, women with young children <5 y, and older women, with a focus on nutrition interventions delivered in low- and middle-income countries. We found that although there were many effective interventions that targeted women's nutrition, they largely targeted women who were pregnant and lactating or with young children. There were major gaps in the targeting of interventions to older women. For the delivery platforms, community-based settings, compared with facility-based settings, more equitably reached women across the life course, including adolescents, women of reproductive age, and older women. Nutrition-sensitive approaches were more often delivered in community-based settings; however, the evidence of their impact on women's nutritional outcomes was less clear. We also found major research and programming gaps relative to targeting overweight, obesity, and noncommunicable disease. We conclude that focused efforts on women during pregnancy and in the first couple of years postpartum fail to address the interrelation and compounding nature of nutritional disadvantages that are perpetuated across many women's lives. In order for policies and interventions to more effectively address inequities faced by women, and not only women as mothers, it is essential that they reflect on how, when, and where to engage with women across the life course.
Curr Dev Nutr 2019;3:nzy076.

Introduction

Women's nutrition is often eclipsed by maternal nutrition. There are important linkages between maternal nutrition and the health, cognitive development, and earning potential of future generations (1). However, with reduced childbearing and longer life spans, women's experiences extend beyond motherhood (2). Interventions and policies that target women solely as mothers fail to account for women before they conceive, after they no longer engage with programs targeting maternal–child health, as well as those who never have children (3, 4). A woman's nutrition should matter not (only) because of her reproductive potential, but because it is fundamental to her rights as a person and to her well-being and ability to thrive (5–7). With increasing attention to the nutritional needs of adolescent girls (8, 9), in addition to the rising prevalence of overweight, obesity, and noncommunicable disease affecting women later in life (10), it is becoming more imperative that interventions reach women at all life stages.

Keywords: women, maternal, adolescent, life course, nutrition-specific, nutrition-sensitive, delivery platforms, equity

Manuscript received June 19, 2018. Initial review completed August 23, 2018. Revision accepted September 11, 2018. Published online September 21, 2018. doi: https://doi.org/10.1093/cdn/nzy076
The authors reported no funding received for this study.
Author disclosures: ELF, CD, SMD, WS, and JF, no conflicts of interest.
Supplemental Table 1 is available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/cdn/.

Address correspondence to ELF (e-mail: efox15@jhu.edu).

Abbreviations used: CCT, conditional cash transfer; EHFP, Enhanced Homestead Food Production; LNS, lipid-based nutrient supplement; WASH, water, sanitation, and hygiene.

The extent to which interventions target women more generally, as opposed to just mothers, is not well documented. It requires reflecting on "Who is the woman in women's nutrition?" to identify which women are actually targeted in nutrition interventions, which are not, how they are reached, and gaps in policies and interventions to reach women who are missed. To address this, in this comprehensive narrative review, we *1*) summarize existing knowledge about interventions targeting women's health and nutrition in low- and middle-income countries, *2*) identify gaps in current delivery platforms that are intended to reach women and address their health and nutrition, and *3*) determine strategies to reshape policies and programs to reach all women, at all stages of their lives, with a particular focus on women in low- and middle-income countries.

Current Status of Knowledge

Methods

We conducted a comprehensive narrative review to synthesize the existing literature on interventions targeting women's nutrition (11). We searched the PubMed database and Google Scholar from 1990 to December 2017 for peer-reviewed articles, systematic reviews, and grey literature that reported on a set of nutrition-specific and nutrition-sensitive interventions, outlined in what follows. We also reviewed the cited sources of key articles. When available, we used existing reviews to identify studies. Some of the review articles that emerged from our search included both high-income countries and low- and middle-income countries. When possible, we specified the delivery platforms for low- and middle-income countries. For review articles that did not explicitly describe the intervention delivery platforms, we reviewed the cited primary sources to identify the delivery platform for the discussed interventions.

We only included studies that reported on women's health and nutrition outcomes, and excluded studies that were targeted to women but that reported only on health and nutrition outcomes of children (including birth outcomes). We included outcomes for adolescent girls ages 10–19 y, pregnant and lactating women, nonpregnant and nonlactating women of reproductive age (>19 y), and older women. Studies that described interventions targeting a wider age range of adolescent girls (e.g., ages 8–24 y) were also included but adolescent girls aged >19 y were reported in this review as nonpregnant and nonlactating women of reproductive age. Although many adolescents in low- and middle-income countries are married and bearing children, adolescents (10–19 y) as reported in this review reflect girls who are nonpregnant and nonlactating. The few interventions in low- and middle-income countries that target pregnant and lactating adolescents are reported under pregnant and lactating women. A description of the articles included in this review can be found in **Supplemental Table 1**.

For this comprehensive narrative review, we evaluated both nutrition-specific and nutrition-sensitive interventions. Nutrition-specific approaches are those that address the immediate determinants of nutrition (e.g., food and nutrient intake, diet-related practices and behaviors, disease, etc.), whereas nutrition-sensitive approaches are those that address the underlying determinants of nutrition (e.g., food security, access to resources, safe and hygienic environments, adequate health services, etc.) (5, 12). We evaluated the following nutrition-specific interventions described by Bhutta et al. (13, 14): nutrition counseling and education, micronutrient supplementation and fortification, protein and energy supplementation, and lipid-based supplementation. We also included the following nutrition-sensitive approaches described by Ruel and Alderman (5) and Bhutta et al. (14): health care; family planning; water, sanitation, and hygiene (WASH); empowerment; income-generation; education; and social protection. For each intervention, we *1*) described the scale and coverage of the intervention, when available; *2*) summarized the evidence of effectiveness for women's health and nutrition outcomes; and *3*) described and evaluated the target population and delivery platforms, as described in the published articles and as summarized in **Table 1**. The delivery of interventions included the physical platforms, as well as the adherence and the implementation challenges of the different interventions.

Nutrition-specific interventions

Nutrition counseling and education. Nutrition education, including communication and counseling to raise awareness and promote nutrition-related knowledge and behaviors aligned with public health goals, was found to increase women's knowledge and improve women's dietary diversity and protein intake (15–21). It also reduced energy intake of overweight women over a 9-mo period (22). However, evidence for the effectiveness of nutrition education interventions showed mixed impact on biological and anthropometric markers of women's nutritional status (14–16, 18, 23–29). This could be due to lack of statistical power given the small sample sizes of the reviewed studies. For adolescent girls, nutrition education was found to reduce odds of overweight, and improve knowledge, dietary intake, physical activity, and sedentary behavior (27, 29, 30). This was particularly true for nutrition education that lasted longer than 12 mo (29). Nutrition education was also more strongly associated with changes in health outcomes in studies evaluating childhood obesity treatment, rather than childhood obesity prevention (29).

Nutrition education interventions were often implemented in conjunction with other programs, and it was difficult to identify the effects of nutrition education alone. In addition, many studies reported on one-on-one counseling and group education, and it was not possible to differentiate the impact. The effects of nutrition education were often greater when combined with other resource-based interventions, such as micronutrient supplementation (31, 32), home gardening (28), food supplementation (33), and water provision (22). For nutrition education programs targeting mothers, those who were more educated or of higher socioeconomic status more often translated the intervention to nutritional outcomes (33). This suggests that the effectiveness of nutrition education might relate to individuals' ability to access resources and implement information received.

The delivery of nutrition education reached women across all life stages and through many platforms. Many nutrition education studies that targeted pregnant and lactating mothers reported on women's outcomes, but the primary focus of many of these studies was child health outcomes (13, 14, 19, 21, 24, 28); few studies focused on dietary outcomes and behaviors of pregnant and lactating women themselves (17, 20, 23). There were some studies evaluating the impact of nutrition education on the practices and outcomes of school-age children and adolescent girls (15, 18, 27, 29, 34), as well as older women

TABLE 1 Interventions, delivery platforms, and outcomes addressing women's nutrition across the life course[1]

Interventions	Delivery platforms	Outcomes			
		Adolescent girls	Women of reproductive age (nonpregnant, nonlactating)	Pregnant and lactating women; women with young children <5 y	Older women
Nutrition-specific interventions					
Nutrition education	Health clinics	↑ knowledge, NC Hgb, ↑ intake of fruits and vegetables, ↓/NC intake of fats, sweets, and sugar-sweetened beverages	↑ knowledge, NC Hgb, ↑ intake of fruits and vegetables, ↓/NC intake of fats, sweets, and sugar-sweetened beverages	↑ knowledge, NC urinary iodine, ↑ intake of nutrient-rich foods, ↑ intake of protein, ↑ weight gain, ↑/NC weight loss postpartum (obese women) with diet and exercise	
	Home visits			↑ knowledge, ↑ dietary diversity, ↓ underweight	↓ bone loss, ↑ intake dietary calcium
	Community centers	↑ knowledge, NC anemia, ↑ intake of Fe and ascorbic acid		↑ knowledge, ↑ dietary diversity, ↓ underweight	↓ bone loss, ↑ intake dietary calcium
	Community outreach				↓ bone loss, ↑ intake dietary calcium
	Worksites		↑ knowledge		↑ knowledge
	Schools	↑ knowledge, ↑/NC Hgb, ↓ intake of junk foods and sugar-sweetened beverages, ↓/NC BMI (↓ in Tx setting), NC weight loss, ↑ physical activity			
Micronutrient supplementation	Health clinics	↓ anemia and Fe-deficiency anemia, ↑ Hgb, ↓ soil-transmitted helminth infection, ↑ cognitive function	↓ anemia and Fe-deficiency anemia, ↑ Hgb, ↑ serum ferritin, ↓ soil-transmitted helminth infection	↓/NC anemia, ↑/NC MN status (Hgb, folate, zinc, retinol), ↑ MN status [ferritin, B-12, 25(OH)D], ↓/NC gestational hypertension and pre-eclampsia, NC gestational diabetes, ↓/NC hyperthyroidism, ↓/NC night blindness, ↓ bone mineral content, ↑ weight gain (among underweight women), ↓ maternal mortality, ↓/NC placental malaria, NC parasitemia, NC maternal infection, ↓/NC depression and perceived stress	
	Home visits	↓ anemia, ↑ Hgb, ↑ food consumption, ↑ weight gain (underweight adolescents), NC mortality, ↓ fatigue	↓ anemia, ↑ serum folate, ↑ serum B-12, NC mortality, NC depression	↓ anemia, ↑ MN status (Hgb, ferritin, folate, B-12, zinc, riboflavin), ↑/NC serum retinol, ↓/NC night blindness, ↑ weight gain, NC maternal mortality, NC depression	
	Community centers	↓ anemia and Fe-deficiency anemia, ↑ Hgb, ↓ soil-transmitted helminth infection	↓ anemia and Fe-deficiency anemia, ↑ Hgb, ↓ soil-transmitted helminth infection	↑ serum ferritin, ↑ serum folate, ↑ serum B-12	

(*Continued*)

TABLE 1 (*Continued*)

Interventions	Delivery platforms	Outcomes			
		Adolescent girls	Women of reproductive age (nonpregnant, nonlactating)	Pregnant and lactating women; women with young children <5 y	Older women
	Pharmacies		↓ anemia	↓ anemia	
	Schools	↓ anemia, ↑/NC MN status [Hgb, retinol, 25(OH)D], ↑ MN status (ferritin, zinc, vitamin C, riboflavin), ↑/NC PTH, ↑ weight gain, ↑ cognitive function			
	Workplace	↓ anemia, ↑ Hgb, ↓ vitamin A deficiency	↓ anemia, ↑/NC Hgb, ↑ physical energy		
Food fortification	Health clinics	↓ anemia and Fe-deficiency anemia, ↑ MN status (Hgb, total body Fe, iodine, retinol)		↓ anemia and Fe-deficiency anemia, ↑ MN status (Hgb, ferritin, retinol, calcium), ↓ iodine deficiency, ↓ night blindness	↑ 25(OH)D concentrations, ↓ PTH, ↓ bone loss, ↓ bone turnover
	Home visits	↓/NC anemia, ↑/NC Hgb, ↑ serum ferritin, ↑/NC serum retinol, ↓ vitamin A deficiency	↓/NC anemia and Fe-deficiency anemia, ↑/NC Hgb, ↑/NC serum ferritin, ↑ serum folate, ↑ serum zinc, NC serum retinol	↓ anemia, ↑ Hgb, ↑ serum ferritin, ↑/NC serum retinol, ↑ erythrocyte thiamine diphosphate concentrations, ↓ night blindness, ↑/NC weight gain	↓ anemia, ↑/NC Hgb, ↑ serum ferritin, NC serum retinol, ↑ serum calcium, ↑ 25(OH)D concentrations, ↓ PTH, ↓ bone turnover
	Community centers	NC anemia, ↑ Hgb, ↑ serum retinol, ↑ urinary iodine, ↓ vitamin A deficiency	NC anemia, ↑/NC Hgb, ↑ MN status (folate, zinc, retinol, iodine), NC weight gain/BMI	↑ Hgb, NC serum retinol, ↑ urinary iodine, ↑ intake vitamin A, ↑ weight gain	NC anemia, ↑ MN status (Hgb, folate, zinc, retinol, iodine), NC weight gain/BMI
	Water points	↑ urinary iodine, ↓ goiter prevalence	↑ urinary iodine, ↓ goiter prevalence	↑ urinary iodine, ↓ goiter prevalence	↑ urinary iodine, ↓ goiter prevalence
	Schools (and universities)	↓/NC anemia, ↓ Fe-deficiency anemia, ↑/NC MN status [Hgb (↑ if anemic), ferritin, zinc, retinol], ↑ MN status [folate, riboflavin, 25(OH)D, iodine], ↓ PTH, ↓ goiter prevalence, ↓ MN deficiency (vitamin A, B-12, C), ↑ bone mineral accretion, ↑/NC weight gain/BMI, ↑ MUAC, ↑ gut inflammation, ↓/NC respiratory symptoms and diarrheal morbidity, ↑ fitness (for Fe-deficient subjects), ↑/NC short-term cognitive function	↑ Hgb (↑ if anemic), ↑ serum ferritin, ↑ total body Fe, ↑ urinary iodine concentration, ↑ serum zinc, ↑ aerobic power, NC net energetic efficiency		

(*Continued*)

TABLE 1 (*Continued*)

Interventions	Delivery platforms	Outcomes			
		Adolescent girls	**Women of reproductive age (nonpregnant, nonlactating)**	**Pregnant and lactating women; women with young children <5 y**	**Older women**
	Markets and retail	↓/NC anemia, ↑ MN status (Hgb, Fe stores, ferritin, folate, iodine), ↓/NC goiter prevalence, ↓ folate deficiency, NC retinol-binding protein, ↑ dietary adequacy, ↑ intake of nutrient-rich foods (vitamin A, vitamin B-6, thiamin, iodine, riboflavin, niacin, folate, and Fe)	↓/NC anemia, ↑ Hgb, ↑/NC Fe stores, ↑/NC serum ferritin, ↑ serum folate, ↑ urinary iodine, ↓ goiter prevalence, ↓ folate deficiency, NC retinol-binding protein, ↑ dietary adequacy, ↑ intake of nutrient-rich foods (vitamin A, vitamin B-6, thiamin, iodine, riboflavin, niacin, folate, and Fe)	↓/NC anemia, ↑ serum folate, ↓ folate deficiency, ↑ urinary iodine concentration, ↓ goiter prevalence, ↑ mean adequacy ratio of diet, ↑ dietary adequacy, ↑ intake of nutrient-rich foods (vitamin A, vitamin B-6, thiamin, iodine, riboflavin, niacin, folate, and Fe)	↑/NC Fe stores, ↑/NC serum ferritin, ↑ serum folate, NC B-12 deficiency, ↑ dietary adequacy, ↑ intake of nutrient-rich foods (vitamin A, B-6, thiamin, iodine, riboflavin, niacin, folate, and Fe)
	Workplace		↓ anemia and Fe-deficiency anemia, ↑/NC Hgb (↑ if anemic), ↑ total body Fe, ↑ serum ferritin, ↑ serum zinc		
Energy and protein supplementation	Health clinics			NC pre-eclampsia, NC BMI, ↑/NC gestational weight gain, ↓ weight gain in overweight women, ↑ ANC coverage	
	Home visits			NC BMI, ↑/NC gestational weight gain, ↑ food consumption, ↑ intake of protein and fat	
	Community centers	↓/NC anemia, ↑/NC food consumption, ↑ intake of Fe-rich foods	↑/NC food consumption, ↑ intake of fruits and vegetables, and ASF, ↑ BMI, ↑ weight (particularly among women with BMI >25)	↑ nutrition knowledge and practices, ↑/NC BMI, ↑/NC gestational weight gain, ↑ ANC coverage	↑/NC food consumption
	Schools	↑ BMI, ↑ weight, ↑ MUAC, ↑ body fat, ↑ work capacity, ↑ school attendance, ↑ cognitive function	↑ BMI, ↑ weight, ↑ body fat, ↑ work capacity		
	Markets and retail		↑ food consumption, ↑ intake of fruits and vegetables, and ASF, ↑ weight (particularly among women with BMI >25)	↓ HH food insecurity, ↑ BMI	
Lipid-based nutrient supplements	Health clinics			↑ serum α-linolenic acid concentrations, ↑/NC gestational weight gain (↑ among multiparous women ≥25 y of age), ↑/NC MUAC (↑ among multiparous women and women ≥25 y of age), NC anti-malarial antibody response	

(*Continued*)

TABLE 1 (*Continued*)

Interventions	Delivery platforms	Outcomes			
		Adolescent girls	Women of reproductive age (nonpregnant, nonlactating)	Pregnant and lactating women; women with young children <5 y	Older women
	Home visits			↑ serum α-linolenic acid concentrations, ↑/NC gestational weight gain (↑ among multiparous women ≥25 y of age), ↑/NC MUAC (↑ among multiparous women and women ≥25 y of age), NC anti-malarial antibody response	
Nutrition-sensitive interventions[2]					
Integrated health care	Health clinics	↑ knowledge about FP, NC use of FP	↑ knowledge about diabetes, ↓ incidence of diabetes, ↑ glycemic control, ↑ hypertension screening and Tx, ↓ hypertension, NC mortality (from coronary artery disease), ↓ depression, ↑/NC health care utilization, ↑ knowledge about FP, ↑/NC use of FP, ↑/NC STI screening, NC STI incidence, ↑ cervical cancer screening, ↑ mammography	↓/NC anemia, ↑ Hgb, ↑ glycemic control, ↑ hypertension screening and Tx, ↓ hypertension, ↓ pre-eclampsia, ↓ maternal mortality, ↓/NC placental malaria, ↓ parasitemia, ↓/NC depression, NC health care utilization, ↑/NC hospital deliveries, NC cesarean delivery, ↑/↓ knowledge about FP, ↑/NC use of FP, ↑ STI screening, ↓ STI incidence, ↑ cervical cancer screening, ↑ mammography	↑ knowledge about diabetes, ↓ diabetes, ↑ glycemic control, ↑ hypertension screening and Tx, ↓ hypertension, NC mortality (from coronary artery disease), ↑ health care utilization, ↓ depression, ↑ mammography, ↑ cervical cancer screening
	Home visits	↑ MN provision, ↑ knowledge about FP, NC use of FP	↑ MN provision, ↑ knowledge about FP, NC use of FP	↑ MN provision, ↓ maternal mortality, ↓ placental malaria, ↓ parasitemia, ↓ depression, ↑ hospital deliveries, ↑ knowledge about FP, ↑/NC use of FP, ↑ STI screening	
	Community centers	↑ MN provision, ↑ health care utilization, ↑ knowledge about FP, ↑/NC use of FP	↑ MN provision, ↑ health care utilization, ↑ knowledge about FP, ↑/NC use of FP	↑ knowledge about nutritional needs, ↑ MN provision, ↓/NC maternal mortality, ↓ parasitemia, ↑ health care utilization, ↑ hospital deliveries, ↑ knowledge about FP, ↑/NC use of FP, ↑ STI testing	
Water, sanitation, and hygiene	Clinic-based			↓ maternal mortality, ↑ knowledge about hygiene, ↑ hand-washing, ↑ water quality	
	Home visits	↑/NC knowledge about hygiene and sanitation, ↑ hand-washing, ↑ water quality, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence	↑/NC knowledge about hygiene and sanitation, ↑ hand-washing, ↑ water quality, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence	↓ maternal mortality, ↑/NC knowledge about hygiene and sanitation, ↑/NC hand-washing, ↑ water quality, NC waste disposal, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence	↑/NC knowledge about hygiene and sanitation, ↑ hand-washing, ↑ water quality, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence
	Community centers	↑/NC knowledge about hygiene and sanitation, ↑ water quality, ↓ diarrheal morbidity	↑/NC knowledge about hygiene and sanitation, ↑ water quality, ↓ diarrheal morbidity	↑/NC knowledge about hygiene and sanitation, ↑/NC hand-washing, ↑ water quality, NC waste disposal, ↓ diarrheal morbidity	↑/NC knowledge about hygiene and sanitation, ↑ water quality, ↓ diarrheal morbidity

(*Continued*)

TABLE 1 (*Continued*)

Interventions	Delivery platforms	Outcomes			
		Adolescent girls	Women of reproductive age (nonpregnant, nonlactating)	Pregnant and lactating women; women with young children <5 y	Older women
	Schools	↑ knowledge about hygiene, ↓ diarrhea, ↑ school attendance (when school facilities)			
	Community mobilization (e.g., radio)	↑ knowledge about hygiene, ↑/NC hand-washing, ↓ diarrheal morbidity	↑ knowledge about hygiene, ↑ hand-washing, ↓ diarrheal morbidity	↑ knowledge about hygiene, ↑ hand-washing, NC waste disposal, ↓ diarrheal morbidity	↑ knowledge about hygiene, ↑ hand-washing, ↓ diarrheal morbidity
	Infrastructure	↓ water point distance, ↑ time savings, ↑/NC women's hygiene, ↑/NC water quality, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence, ↑ school attendance, NC wage employment	↓ water point distance, ↑ time savings, ↑/NC women's hygiene, ↑/NC water quality, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence, NC wage employment, ↑ participation in income-generating activities	↓ maternal mortality, ↓ water point distance, ↑ time savings, ↑/NC women's hygiene, ↑/NC water quality, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence, NC wage employment, ↑ participation in income-generating activities	↓ water point distance, ↑ time savings, ↑/NC women's hygiene, ↑/NC water quality, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence, NC wage employment, ↑ participation in income-generating activities
Family planning and birth spacing	Clinic-based	↑/NC knowledge about FP, ↑/NC use of FP		↓/NC anemia, NC serum ferritin, ↓/NC maternal depletion, NC MN deficiency (zinc, magnesium, copper, ferritin, folate), ↓ maternal mortality, NC BMI, ↑/NC weight gain, ↑/NC postpartum weight gain, ↑ use of FP, ↑ interbirth spacing	
	Home visits	↑ use of FP	↑ use of FP	NC maternal depletion, NC MN deficiency (zinc, magnesium, copper, ferritin, folate), ↑/NC use of FP	
	Community centers	↑ use of FP	↑ use of FP	↓ maternal mortality, ↑ use of FP, ↑ interbirth spacing	
	Community mobilization	↑ knowledge about FP	↑ knowledge about FP	↑ use of FP, ↑ knowledge about FP	
	Schools	↑ use of FP, ↑ knowledge about STIs, ↑ STI Tx, ↓ STI incidence			
Women's empowerment	Home visits		↑ food expenditures, ↑ intake of vegetables	↑ nutrition knowledge, ↑ food expenditures, ↑/NC dietary diversity, ↑ intake of vitamin A–rich foods, ↑ fruit intake, ↑/NC vegetable and ASF intake, ↓/NC night blindness, NC BMI, ↓ underweight	
	Community centers (e.g., women's groups, community kitchens)		↓ anemia, ↑ nutrition knowledge, ↑ HH food security, ↑ HH food consumption, ↑ dietary diversity, ↑ intake of Fe-rich foods, ↑ intake of ASF, ↑ income, ↑ control over resources, ↑ decision-making	↑ nutrition knowledge, ↓/NC anemia, ↑ food expenditures, ↑ HH food security, ↑ HH food consumption, ↑/NC dietary diversity, ↑ intake of vitamin A–rich foods, ↑/NC intake of vegetables and meat, ↑ intake of fruits and ASF, NC BMI, ↓ underweight, ↑ income, ↑ control over resources, ↑ decision-making	↑ HH food security, ↑ dietary diversity

(*Continued*)

TABLE 1 (*Continued*)

Interventions	Delivery platforms	Outcomes			
		Adolescent girls	Women of reproductive age (nonpregnant, nonlactating)	Pregnant and lactating women; women with young children <5 y	Older women
	Mass media		↑ nutrition knowledge	↑ nutrition knowledge, ↑ intake of ASF	
Income-generation activities	Home visits		↑ health knowledge, ↑ health care utilization, ↓ poverty	↑ nutrition and knowledge, ↓ anemia, ↓/NC night blindness, ↑ intake of vitamin A–rich foods, ↑/NC intake of vegetables, ↑ intake of ASF, ↓ underweight, ↑ health care utilization, ↓ poverty	↑ health knowledge, ↑ health care utilization, ↓ poverty
	Community centers	NC HH or individual food security, NC food expenditures, NC food consumption, ↑ social status, ↑ self-confidence	↑ health and knowledge, ↓ anemia, ↑/NC HH food security, NC individual food security, NC food expenditures, ↑/NC food consumption, ↑/NC dietary diversity, ↑ MN-rich foods (Fe, vitamin A, vitamin C, calcium), ↑/NC intake of protein, ↑ ASF intake, ↑/NC BMI, ↑ weight gain, ↑ social status, ↑ self-confidence, ↑/NC decision-making	↑ health and nutrition knowledge, ↓/NC anemia, ↑/NC HH food security, ↑/NC food expenditures, ↑/NC HH food consumption, ↑/NC dietary diversity, ↑ nutrient-rich foods (Fe, vitamin A), NC intake of protein, ↑/NC intake of vegetables and ASF, ↑/NC BMI, ↓ underweight, ↑ weight gain, NC diarrheal morbidity, ↑ self-confidence, ↑/NC decision-making, ↑ control HH resources	↑ health knowledge, ↑/NC HH food security, ↑/NC HH food consumption, ↑ dietary diversity, ↑ self-confidence, ↑/NC decision-making
	Community mobilization		↑ nutrition knowledge	↑ nutrition knowledge, ↑ intake of vitamin A–rich foods, ↑ intake of ASF	
	Microcredit institution	NC HH food security, NC individual food security, NC food expenditures, NC food consumption, ↑ social status, ↑ self-confidence	↑ health knowledge, NC health status, NC HH food security, NC individual food security, ↑/NC food expenditures, NC food consumption, NC school enrollment, ↑/NC empowerment, ↑ self-confidence, ↑/NC decision-making, ↑ social status, ↑/NC health care utilization	↑ health knowledge, NC health status, ↑/NC food expenditures, NC school enrollment, ↑/NC empowerment, ↑/NC decision-making power, ↑ self-confidence, ↑/NC health care utilization	NC health status, ↑/NC food expenditures, ↑/NC empowerment, ↑/NC decision-making power, ↑ self-confidence, NC health care utilization
Education of girls and women	Schools	↓ mortality, ↑ literacy, NC empowerment, ↑ social status, ↑ leadership and self-advocacy, ↑ use of FP, ↓/NC early pregnancy, fertility, and early marriage	↓ mortality, ↑ literacy, NC empowerment, ↓ early pregnancy and fertility		
	Community centers	↑ literacy, ↑ leadership and self-advocacy	↑ literacy		

(*Continued*)

TABLE 1 (*Continued*)

Interventions	Delivery platforms	Outcomes			
		Adolescent girls	Women of reproductive age (nonpregnant, nonlactating)	Pregnant and lactating women; women with young children <5 y	Older women
Social protection	Health centers ("condition" and delivery platform)		↑ knowledge about health and nutrition, ↑ HH food consumption, ↑ food expenditures, ↑/NC food share, ↑ dietary diversity, ↑ HH intake of fruits, vegetables, and ASF, ↑/NC intake of fats and sweets, ↑ participation in social networks, ↑ self-confidence, ↑ control HH resources	↑ knowledge about health and nutrition, ↑ HH food security, ↑ food expenditures, ↑/NC food share, ↑ HH food consumption, ↑ dietary diversity, ↑ HH intake of fruits, vegetables, and ASF, ↑/NC intake of fats and sweets, ↑ self-confidence, ↑ participation in social networks, ↑ control HH resources, ↑ ANC coverage	
	Schools ("condition" and delivery platform)	↑ food expenditures, ↑/NC food share, ↑ HH food consumption, ↑ dietary diversity, ↑ HH intake of fruits, vegetables, and ASF, ↑/NC intake of fats and sweets	↑ knowledge about health and nutrition, ↑ food expenditures, ↑/NC food share, ↑ HH food consumption, ↑ dietary diversity, ↑ HH intake of fruits, vegetables, and ASF, ↑/NC intake of fats and sweets, ↑ participation in social networks, ↑ self-confidence, ↑ control HH resources	↑ knowledge about health and nutrition, ↑ HH food security, ↑ food expenditures, ↑/NC food share, ↑ HH food consumption, ↑ dietary diversity, ↑ HH intake of fruits, vegetables, and ASF, ↑/NC intake of fats and sweets, ↑ participation in social networks, ↑ self-confidence, ↑ control over resources	↑ knowledge about health, NC hypertension, ↓ missed meals, ↑ health care utilization
	Community centers (including banks, town halls, post offices)		↑ knowledge about health and nutrition, ↑ food expenditures, ↑/NC food share, ↑ HH food consumption, ↑ dietary diversity, ↑ intake of MN (except for heme-Fe), ↑ HH intake of fruits, vegetables, and ASF, ↑/NC intake of fats and sweets, ↑ weight gain (greater among high BMI), ↑ participation in social networks, ↑ self-confidence, ↑ control over resources	↑ knowledge about health and nutrition, ↑ HH food security, ↑ food expenditures, ↑/NC food share, ↑ HH food consumption, ↑ dietary diversity, ↑ HH intake of fruits, vegetables, and ASF, ↑/NC intake of fats and sweets, ↑ participation in social networks, ↑ self-confidence, ↑ control over resources, ↑ ANC coverage	↑ knowledge about health, NC hypertension, ↓/NC missed meals, NC food sufficiency, ↑ health care utilization

[1] 25(OH)D, 25-hydroxyvitamin D; ANC, antenatal care; ASF, animal-sourced foods; Fe, iron; FP, family planning; Hgb, hemoglobin; HH, household; MN, micronutrient; MUAC, midupper arm circumference; NC, no change, or reported null findings; PTH, parathyroid hormone; STI, sexually transmitted infection; Tx, treatment.
[2] It is hard to disentangle the direct impact on nutritional status of nutrition-sensitive interventions, and they often report on pathways that theoretically influence nutrition outcomes.

(16, 22, 25, 30). Many of the nutrition education interventions were clinic-based (17–20, 23, 24). However, nutrition education was also delivered through community-based programs, including home visits (16, 21), community centers (15, 16, 20, 21), worksites (25), and schools (25, 27, 30, 34).

Of the few studies evaluating nutrition education interventions for women and adolescent girls who were overweight and obese, many were "facility-based" and involved delivery platforms such as health clinics (13, 22), worksites (30), and schools (26, 27, 29). Delivery platforms targeting women and adolescents who were undernourished similarly involved facility-based settings (13), but also included community outreach (16, 28), home visits, community kitchens (15, 28), and text messaging platforms (32). Such community-based platforms could provide additional opportunities for the delivery of nutrition education interventions addressing overweight, obesity, and associated noncommunicable disease in the future.

Micronutrient supplementation. Micronutrient supplementation programs for vitamin A, iron and folic acid, calcium, zinc, and multiple micronutrients effectively impacted the micronutrient status of pregnant and lactating women, as well as women of reproductive age and adolescent girls (13, 14, 33, 35–48). Interventions making use of multiple micronutrients were more effective at changing plasma micronutrient concentrations than interventions focused solely on 1 nutrient alone (38, 42). In countries with comprehensive programs for iron supplementation during pregnancy, anemia prevalence dropped (1, 49). Positive health impacts of supplementation were most notable among pregnant women who were deficient and at risk of low intake (43, 50). However, there were some studies that showed inconsistent or limited evidence for the effectiveness of supplementation on other maternal health outcomes (31, 51–58).

A number of implementation challenges exist for micronutrient supplementation. Access to care is often associated with socioeconomic status and may influence women's access to and use of supplementation programs. For instance, in one study, the highest wealth quintile of pregnant women had the highest use of iron and folic acid supplementation during antenatal care (33). However, even for women who have access to micronutrient supplements, the coverage and quality of micronutrient supplementation programs were limited (39). Incorrect doses, inadequate supplies, and incomplete adherence were major limitations (33), and poorly performing programs had limited impact on nutrition outcomes (59). Integration of supplementation programs with behavior change interventions improved knowledge, adherence, and coverage of supplementation interventions (32, 33, 60). The use of local micronutrient-rich foods can also help overcome limitations associated with supplement provision. In Nepal, improvements in the dark adaptation of night-blind pregnant women did not differ significantly between food and synthetic sources of vitamin A (61). When available, consumption of micronutrient-rich foods can be as effective as micronutrient supplements.

Women often received micronutrient supplements during antenatal and postnatal care (13, 35–42, 51, 60), and, as such, supplementation was often targeted to pregnant and lactating women. The delivery of micronutrient supplementation commonly occurred in health care settings for at-home consumption. Community-based antenatal care that involved home visits by community health workers was also a common delivery platform for supplementation delivery. There were some studies that reported micronutrient supplementation to adolescents, women of reproductive age, pregnant women, and women with young children outside of the antenatal care setting. These included primary health care clinics, home visits, community centers, pharmacies, and workplaces (32, 38–43, 45, 52, 53). Adolescent girls were also reached by community- and school-based programs (26, 41, 46). School-based programs were more efficacious in reducing rates of anemia among adolescent girls, compared with the community-based interventions (26, 46). However, many of the reported studies to date involved small samples of adolescents in controlled settings, and additional research is needed on the effectiveness of these programs (59, 62).

Food fortification. Food fortification is one of the most cost-effective strategies to improve micronutrient status through a variety of food vehicles, including staples, condiments, and processed foods (63, 64). Common fortifiable micronutrients include iron, folic acid, vitamin A, vitamin D, vitamin E, and iodine, although B vitamins and vitamin C are also used as fortificants (33, 64). Food fortification reduced anemia and iron deficiency anemia, and improved vitamin A, folate, niacin, thiamin, vitamin B-6, vitamin B-12, zinc, and iodine status of women of reproductive age and adolescents (13, 46, 61, 63–74). Vitamin D and calcium fortification were found to reduce the risk of osteoporosis among older women, especially for those exposed to inadequate sunlight (63, 64). Biofortification efforts, including those that involved breeding or genetic modification of plants to improve micronutrient content, have also shown improvements in the vitamin A and iron status of women (64, 75). Similar to micronutrient supplementation, women and girls with low micronutrient status were most likely to benefit.

However, many fortification programs in low- and middle-income countries are regional or voluntary and, thus, might have a limited nutritional impact at the national level (76). Although many efficacy trials show benefits of fortification interventions, scaling up fortification is limited by inadequate coverage and resources (13, 77, 78). Evidence for impact is also affected by suboptimal programming, low-bioavailability fortificants (e.g., reduced iron powder), poor consumption rates, weak enforcement mechanisms, and inadequate monitoring (76, 79, 80). More research is needed to evaluate the long-term impact of fortification and biofortification programs (75). In addition, there is also growing concern about fortifying and promoting food vehicles that have adverse health consequences when consumed in excess, such as salt and sugar, given the rising prevalence of overweight, obesity, and noncommunicable disease (81–83).

In our review, we found that fortification interventions that provided fortified foods reached women of all life stages through home visits, community distribution centers, local markets, and retail stores. Delivery of fortified foods in school-based programs, at work, and in maternal–child health centers were also used to target school-age children, women of reproductive age, and pregnant and lactating women that were engaged with those facilities (37, 72–74, 84). There was mixed evidence that consumption of fortified foods reached all socioeconomic groups. Some studies showed differences in consumption between nonpoor and extremely poor, and between urban and rural stakeholders (33, 64, 85). Women who have restricted access to markets, depend largely on locally grown foods, are in areas

with underdeveloped distribution channels, or have limited purchasing power, might have limited access to fortified foods (64). Additional research is needed to address implementation gaps and to determine the best platforms for reaching high-risk populations.

Energy and protein supplementation. Energy and protein supplementation was most often associated with weight gain of women, and often targeted pregnant women with suboptimal weight. For pregnant women, energy and protein supplementation modestly increased maternal weight (86–90). Other maternal outcomes were not frequently reported, and were often secondary objectives of protein-energy supplementation interventions (33, 88). Many studies reported on infant health outcomes, including reductions in low birth weight and preterm births (19, 89–91). Adequate energy and protein intake was also relevant for interventions targeting the prevention of excessive gestational weight gain of overweight and obese pregnant women. These interventions restricted dietary energy intake of overweight women during pregnancy and resulted in reduced excess weight gain during pregnancy but had no impact on pregnancy-related hypertension and pre-eclampsia (19, 88).

There were also supplementation programs that targeted nonpregnant women. National supplementation programs that provided food baskets to low-income families increased maternal BMI and improved household food insecurity (92, 93). However, there were some unintended consequences. In Mexico, food transfer programs disproportionately increased weight gain in overweight women compared with underweight women (93), and 1 study in Bangladesh found that food transfers had larger impacts on men's intake than women's intake, except with less preferred foods (94). Adolescents who received protein-energy supplementation at school showed an increase in weight gain during supplementation, as well as improvements in school attendance and mathematics scores (46, 95). However, the impact of supplementation on micronutrient deficiencies and, specifically, hemoglobin concentration, was limited (46).

Evaluations of protein-energy supplementation were limited to specific situations and contexts, and few studies evaluated national-scale programs (14, 33). National-level protein-energy supplementation programs for women and adolescent girls are expensive and challenging to implement compared with other efficacious interventions (33). Procuring, preparing, and distributing food and appropriately targeting women most in need (e.g., women below the poverty line, women who have or are at high risk of malnutrition, etc.) present challenges to protein-energy supplementation interventions (33).

Our review found that protein-energy supplementation was largely targeted to pregnant and lactating women (19, 86–88, 90, 91); however, there were some studies that evaluated the delivery of protein-energy supplementation to households (92, 93) and adolescents (46). The only studies we found that evaluated the impact of protein-energy supplementation in older, healthy women were hospital-based studies in high-income countries (96). Delivery platforms varied depending on the target audience. The majority of studies targeted pregnant women through antenatal care or through antenatal care–associated community-based programs. National programs targeting low-income families had broader reach, although they targeted households and not women specifically (92). Additional research is needed for how women might best be reached (94). For programs that provided provisions for women to take home, there was also limited information about how much was shared with other members of the household. School-based programs targeting adolescents could be an important venue to target interventions to adolescents in the future. However, children and adolescents not in school would be missed. Despite limited evidence of impacts of energy and protein supplementation on the health of women, supplementation might be an important complement to other interventions (e.g., nutrition education and counseling) to ensure that women have the resources needed to implement other interventions successfully. Indeed, many large-scale programs for protein-energy supplementation are often complemented with nutrition education and counseling (33).

Lipid-based nutrient supplements. Lipid-based nutrient supplement (LNS) programs are intended to enrich diets with micronutrients and essential fatty acids (97), and are often used in emergency settings to meet nutritional needs of pregnant and lactating women (98). Of the studies that report on women's health outcomes, LNSs provided to pregnant and lactating women increased body weight and midupper arm circumference, particularly of multiparous women and women >25 y of age (99). They were associated with increased plasma α-linoleic acid, although not plasma lipids and other fatty acids (100). LNSs did not affect women's immune responses, particularly pregnant women's anti-malarial antibody responses (101). There was limited evidence connecting LNS supplementation to unhealthy weight gain and retention, and this is being explored in ongoing studies in Ghana (97).

All of the identified studies focused on LNSs for pregnant and lactating women through antenatal care–based and –affiliated delivery platforms (97–101). These studies relied on antenatal care to recruit mothers but delivered the intervention through home visits. There was no evidence evaluating use of LNSs for women who were not pregnant or lactating. The majority of studies evaluating LNS interventions involved children with severe or moderate acute malnutrition. Although LNS supplementation could be an intervention to provide essential nutrients to women and girls, it is expensive. Filling energy gaps using local foods or other commodities can often be done at a lower cost (97). LNS supplementation should be limited to contexts in which cheaper, more sustainable solutions are not available.

Nutrition-sensitive approaches

Nutrition-sensitive approaches are difficult to link to women's nutritional status (5, 102). This is due to limited measurement of benefits to program beneficiaries, families, households, and communities, limited timeframes to evaluate long-term impact, logistical and political realities that make implementation difficult, and different priorities of different stakeholders in multisectoral programs (102). Many nutrition-sensitive approaches, as will be described, thus focus on more distal measures of impact (e.g., coverage, knowledge) and not more proximal measures of women's nutritional status (e.g., BMI, anemia status, etc.).

Integrated health care. Integrated health care, which integrates curative and preventive interventions, can improve nutrition outcomes for women across the life course through improved access to counseling, vaccinations, and screening and treatment of illnesses (103–107). Access to primary health care positively contributed to the prevention,

diagnosis, and management of both communicable and noncommunicable disease (108). Distribution of insecticide-treated bed nets, condoms, screening and testing for disease, and delivery of medical treatments were often associated with integrated health initiatives and improved health and nutrition outcomes (13, 109). Access to health care was associated with the delivery of nutrition-specific interventions to manage pregnancy-induced hypertension, diabetes, pre-eclampsia, and hemorrhage (106, 107, 110). However, some studies showed that integrated services increased knowledge, but did not result in changes in health or nutrition outcomes (103). In addition, in many settings, quality of care was inadequate (107) and incorrect diagnoses and treatments were common (111).

In low- and middle-income countries, health care services often respond to acute health needs and many focus on maternal–child health (105, 106, 110, 112). The use of preventative care is limited, and there are concerns about the capacity of health systems to address noncommunicable diseases, such as diabetes, in low- and middle-income settings (108, 112). This has implications for the reach of integrated health care interventions across the life course. Maternal and reproductive health care is often sought by women when they are pregnant and in the early years of their children's lives (3, 113). Even so, many women visit health facilities late in their pregnancy or not at all (114–116). For adolescents and adult women, care is often not sought until they are sick (3, 117, 118). This is problematic for older women, in particular, as screening and treatment for age-related health issues, such as diabetes, cancer, and hypertension, require access to preventative health care services (3).

Not surprisingly, many integrated health services were delivered in health clinics and facilities. Many women faced barriers to health facility–based care for nutrition, such as distance, time, quality of care, stocking of supplies, and the capacity and nutrition knowledge of healthcare professionals (105, 119). These barriers need to be taken into consideration to enhance the coverage of integrated health care services. Universal health care mitigated cost barriers to seeking health care, but did not address all of the barriers noted here (105, 109, 114, 120–123).

Community health posts and home visits provided a platform to make health care services more accessible (109, 110, 124). Community-based platforms for the delivery of health services included community center and home visits from community health workers, mobile clinics, community support groups, mobile phones, and mass media campaigns (105, 110). Community-based services were effective in reducing maternal mortality and managing HIV (106). However, 1 review found that community-based interventions were only effective in reducing maternal morbidity and not mortality (107, 110). In high-income settings, community-based services were associated with hypertension and diabetes management, and cervical and breast cancer screening (106). We found no references for the use of community-based integrated care to address women's nutrition in low- and middle-income settings. It could be an effective way to reach older women and women of reproductive age who do not regularly engage with health centers. For children, community-based services were effective in improving health outcomes, particularly among the poorest wealth quintiles (13, 110). More research is needed on the potential of community-based services to reduce inequities in delivery of care to women in different settings and across different socioeconomic statuses.

WASH. WASH interventions, such as toilet facilities, access to improved and safe water supply, and hand washing are associated with improved nutrition and health of entire communities (13, 14, 125–128). For women and adolescent girls, WASH interventions were associated with improved menstrual hygiene (126), reduced diarrhea and intestinal worm infections (128–131), and reduced maternal mortality (132). Women and young girls are also more affected by the physical and time burdens of collecting water (126), and harassment and violence associated with inadequate and unsafe toilet facilities (133, 134). Closer water points and sanitation facilities eased these gendered burdens (126, 135). WASH interventions and perceived water availability were associated with less time spent on water-related chores, and improved school attendance, women's empowerment, and self-esteem (126, 135, 136).

Interventions resulting in public infrastructure changes were found to be less effective than household-based interventions; however, both are important aspects of improved health outcomes for women (128, 130). Public water infrastructure requires regular maintenance and periodic replacement and water from these sources is often contaminated (130). However, even public water points that provide good-quality water have had minimal impacts on health outcomes (136). One review estimated that water-source interventions were associated with a 27% reduction in diarrhea risk at all ages, whereas household-based interventions were associated with a 43% reduction (128). This could be associated with bias and confounding, as measuring WASH outcomes is not a blinded process (128). The differential impact could also be related to practice. As compared with public water sources, home water connections were associated with greater odds of handwashing and fecal waste disposal (136). As a significant portion of diarrheal disease is a result of person-to-person transmission and poor hygiene, interventions that improve domestic hygiene behaviors can have a significant impact (136). Behavior change communication and resource provision, e.g., soap and point-of-use water treatment resources, were also important and sustainable aspects of WASH interventions (131, 137).

Many WASH interventions targeted mothers and their caregiving behaviors for children. However, these interventions were applied to entire households and not individual household members. Larger community-based hygiene and sanitation initiatives broadly reached more people in the community (131). However, certain populations such as the elderly and young children might have limited access to public infrastructure, such as public latrines, particularly if there are physical and economic barriers to accessing them (136).

WASH interventions were typically community-based. WASH interventions were delivered to households and communities through community mobilization, mass media, home visits, and infrastructural development (126, 130, 136–138). There were some examples of facility-based delivery of WASH interventions, such as in health clinics and schools (139, 140); however, this was not representative of the majority of delivery platform coverage. Health clinic delivery platforms had limited reach, often targeting pregnant women and women with young children. In an evaluation of WASH interventions delivered in India (141), more demanding behavioral practices, such as handwashing and consistent use of latrines, required more intense contact (e.g., multiple home visits) than less intense interventions, such as sweeping of courtyards, that could be effectively delivered in small group meetings

such as those in health clinics and community centers. More research is needed to evaluate the benefits and barriers of different delivery platforms for women across the life course.

Family planning and birth spacing. Family planning and birth spacing can influence the nutrition of adolescent girls, women of reproductive age, and women with young children by reducing the number of adverse outcomes associated with pregnancy and abortion. For adolescent girls, in particular, pregnancy is associated with increased risk of birth complications, anemia, hindered linear growth, and loss of educational attainment (8, 107). Delaying early child marriages and providing access to family planning, particularly for young wives, allow girls to achieve their maximum growth potential (8, 142). However, for women with young children, there was scarce evidence from observational studies to suggest that greater birth spacing had any impact on anthropometric status (BMI, weight), micronutrient status (anemia, as well as serum zinc, copper, magnesium, and folate), and maternal mortality outcomes (13, 107, 143–147). Findings were mixed, which was attributed to sample size and other confounding factors such as maternal age, breastfeeding status, and supplementation status (146, 147). The strongest evidence of the impact of birth spacing on women's nutrition was related to increased risk of preterm delivery and maternal anemia in interpregnancy intervals <6 mo (14, 146, 147) and increased risk of pre-eclampsia in intervals >5 y (107).

The delivery platforms of birth spacing and family planning interventions were often associated with health clinics and community health posts (148–150). Many interventions targeted lactating women during the follow-up with their young children (148, 151–153). Home visits by community health workers and service provision at community health posts and mobile clinics were also used to target women and adolescents who were married, and were found to be effective at increasing use of contraception (150, 154). School-based programs were also effective at reaching adolescent girls and increased their knowledge about contraceptives and sexually transmitted infections, use of contraception, and treatment of sexually transmitted infections (155). In high-income settings, school-based interventions were most effective at reducing pregnancies and repeated pregnancies among adolescents when contraception was also available on-site (107). This might have implications for their effectiveness in low- and middle-income countries, as well. In addition, formative work of 2 ongoing studies suggested that mass media, mobile devices, texting, and community mobilization could also be used as platforms to reach adolescent girls and women of reproductive age (156, 157). Community-based programs that target men, families, and communities, beyond those that reach married and postpartum women alone, have potential to change cultural norms and enhance women's health outcomes; however, these are not well captured in the literature.

Women's empowerment. Women's empowerment relates to women's ability to make life choices (158). Higher levels of empowerment were associated with increased income, household decision-making, control over resources, and utilization of health resources (5, 158–160). For nutrition outcomes, empowerment was associated with increased income allocated to food expenditures and improved household food security (160, 161). It was also associated with increased dietary diversity, but had no impact on women's BMI (5, 161, 162). For example, mothers' participation in empowerment activities through Helen Keller International's Enhanced Homestead Food Production (EHFP) program in Burkina Faso was associated with increased fruit intake (difference-in-differences = 15.8 percentage points, $P = 0.02$) and nearly statistically significant increases in meat intake and dietary diversity (163). Participation was also associated with decreased prevalence of underweight (difference-in-differences = −8.7 percentage points, $P < 0.01$) but not overall mean BMI (163). In addition, the EHFP program in Bangladesh and Nepal was associated with decreasing trends in maternal anemia (anemia prevalence decreased by a magnitude of 12%, $P = 0.075$ in Bangladesh, and 26%, $P = 0.009$ in Nepal) (160). However, this was not consistent with findings from Cambodia (160).

There are many well-documented challenges in disentangling empowerment interventions from other interventions with which they are delivered. Empowerment interventions are often integrated into income-generating activities and agricultural extension, and many empowerment approaches are retroactively classified as "nutrition-sensitive" despite a lack of nutrition components in the original intervention designs (5). In addition, many studies are limited in scope and their evaluation of nutrition outcomes (159), and it is difficult to evaluate which dimensions of women's empowerment matter most for nutrition (162). Notably, indicators to quantify women's empowerment are also not used consistently and vary widely between individual studies (158).

Adult women, and particularly women with children, were the primary targets for empowerment interventions. Empowerment interventions were predominantly delivered through community-based programs, including home visits, community groups, and community centers (5, 161, 163). There was some evidence that empowerment interventions that included delivery platforms such as radio and television, as a complement to the community- and home-based delivery platforms (5), could have some impact on reaching a wider audience. Adolescent girls were largely not the target of empowerment interventions, except for those relating to reproductive health (158), and could potentially benefit from them.

Income-generation interventions. The impact of income-generation interventions on women's nutrition has not been sufficiently evaluated. Income-generating interventions were associated with increases in women's income, empowerment, and household decision-making (161, 164–166). However, these gains were often at the expense of more work for women (5). Income-generation interventions have been associated with increased food-related expenditures, improved household food security, and greater household dietary diversity (160, 161, 165–168). Income-generating interventions targeting adolescents improved their social status; however, these showed no impact on their access to food, nor on individual and household food security (169). There was also limited evidence of impacts of income-generating interventions on women's anthropometric and biochemical nutrition outcomes (5, 169, 170). Increased income was associated with reductions in maternal underweight and anemia, but the reductions were modest (171). Studies suggested that the limited impact was related to continued poor access to health services (167), poor measurement, and the need for longer evaluation periods (164, 165, 167, 169).

Complementing income-generating interventions with interventions that more directly target women's nutrition has potential to have greater impacts on women's nutritional status (171). Integrated interventions were associated with improvements in health knowledge and behaviors, as well as increased intake of nutrient-rich foods (5, 164, 169, 170, 172). In Bangladesh and Cambodia, the aforementioned EHFP program was associated with increased income, decision-making power in the household, food expenditure (including on oils, salts, spices, fish, rice, and meat), and consumption of fruits and vegetables from home gardens (160, 173). There was also limited, but mixed, evidence of income-generating interventions and behavior change communication causing improvements in maternal anemia and BMI (164, 168, 170).

Income-generation interventions largely target adult women (women of reproductive age, women with young children, and older women). Many microfinance and loan programs are targeted to women because of their likelihood to pay back the loans, although women with lower education levels and smaller businesses do not benefit to the same degree as women who are educated or who have bigger businesses (165). There was limited evidence of such interventions targeting adolescent girls (169). In order to understand the potential impact of income-generating activities on adolescents, more information is needed about the pathways by which adolescents contribute to their own food security, the degree to which they rely on their caregivers to meet their nutritional needs, and how those dynamics change with the age of adolescents (169). Training, workshops, and extension activities were often delivered through community centers, community groups, and financial institutions (165). Other affiliated interventions, such as agricultural extension and nutrition education, were provided at the community level and at home visits (160, 173). These delivery platforms were effective at reaching women, including low-income women, particularly when they engaged with existing community groups (e.g., self-help, farmers', and women's groups) (160, 161, 167, 169, 172, 173).

Education of girls and women. For girls and adult women, educational interventions are considered a powerful means of improving their health and nutritional status throughout their lives. Education level is often associated with maternal caregiving practices and the nutritional outcomes of their children (174, 175). Few studies, however, evaluated the impact of education as an intervention on women's nutrition outcomes. Instead, many studies used survey data and reported on associations between education and nutrition. For instance, in low- and middle-income countries, higher levels of education were associated with lower prevalence of underweight and higher prevalence of overweight among women (176, 177). However, this depended on the type of employment in which women participated (178, 179). In addition, in many high-income settings, the converse was true (177). Level of literacy was also associated with improved anthropometric measures. In southern Ethiopia, literate mothers were 25% less likely to be undernourished than were illiterate women (180). One econometric analysis suggested that doubling primary school attendance in settings with low school attendance was associated with a 20–25% decrease in food insecurity (181). Overall, though, these associations were limited in their ability to draw conclusions about causality and the effect of education interventions on nutrition outcomes.

The effect of education programs on nutrition outcomes is difficult to assess because programs often have poor baseline data or nutrition outcomes are not evaluated (174, 182). Studies that used longitudinal analyses and "natural" experiments (e.g., before and after a national education policy) found that education was associated with reduced fertility (183, 184), and delayed early marriages and pregnancies (184–187). The impact was more significant for higher levels of education (185). However, 1 study in Malawi identified negative associations between education and timing of first birth, although these findings were largely not statistically significant (188). Secondary education for adolescents and women of reproductive age also showed no impact on women's empowerment (184), although it did show an impact on improved literacy and leadership (174). Educational interventions that provided conditional cash transfers (CCTs) and school feeding, as well as other forms of social protection to families of enrolled girls, were associated with greater school enrollment and attendance (189–191), improved test scores (189, 190), reduced gender gaps (192), and reduced hunger (190, 191).

Educational interventions most often targeted school-age children and adolescent girls, and there were few examples of programs targeting women of reproductive age (174). The majority of education interventions were delivered in formal school-based settings (174). However, this is a "selective" delivery platform given that not all adolescents attend schools (193). School fees and distance to school are major barriers to school enrollment (174, 194). Educational interventions need to be sensitive to the reasons why girls are not in school, e.g., work, and to the hours and locations that might make education interventions more accessible (193). Nonformal education, alternative education, mobile schools, and literacy programs can target women and girls not in school, although these approaches were less common and not as well evaluated (174). Interventions that target girls who are no longer in school provide valuable examples about how such interventions could be delivered to hard-to-reach groups (182).

Social protection. Social protection interventions are intended to support vulnerable households by providing them with in-kind (e.g., food) or cash transfers. The impact of social protection on women's nutrition was nuanced, as such interventions were associated with protecting against adverse nutrition outcomes, but were also associated with excess weight gain in some settings. In-kind transfers, including food baskets, fortified foods, and school lunches, improved women's and adolescent girls' energy and micronutrient intakes, as described in the preceding sections. Both CCTs and unconditional cash transfers were common around the world and were associated with improvements in health care utilization and increased food expenditures (5, 14, 195, 196). CCTs were dependent on "conditions" such as school attendance and health care utilization. For children in Burkina Faso, CCTs were associated with greater numbers of preventative health visits compared with unconditional cash transfers (197), and this could be relevant to adult women's health care utilization as well. Unconditional cash transfers, such as old-age pensions, were also common, including in low- and middle-income countries (5, 198). Older women who received pensions had fewer missed meals (199), although evidence was mixed (200). In South Africa, granddaughters who cohabitated with women who received pensions had improved anthropometric measures and fewer missed meals, indicating spillover effects of pension transfers (199, 201).

CCTs have been more thoroughly evaluated for nutrition outcomes, particularly in Latin American countries. They were associated with improvements in women's knowledge of health and nutrition, as well as their self-esteem, participation in social networks, control over resources, and decision-making power (5, 202). Although intrahousehold allocation for women is not clear, CCTs increased household food expenditure and were associated with improved household dietary diversity, including increased household consumption of animal protein, fruits, and vegetables, and reduced consumption of staples and grains (14, 192, 202). There was also some evidence that household expenditure on fats and sweets also increased significantly (202). However, these findings were not consistent and some evaluations showed no significant increase (14, 202, 203). Despite this, in Mexico, there was evidence that in-kind and cash transfer programs resulted in excess weight gain in women who were not underweight (5, 93). This warrants future research given the burden of overweight and obesity among women.

Social protection programs typically target the most marginalized members of communities and typically families with children (5, 196). Cash transfers are often targeted to women in these households because they more often invest the transfers in household and food expenditures than men do (192, 202, 204, 205). Cash transfer programs were also targeted to older adults through government-coordinated programs (196, 198, 206). The delivery of transfers involved community centers (town halls, post offices) and banks, as well as locations associated with other services, e.g., schools or health centers (192, 206, 207). These latter platforms were relevant not only for the distribution of social protection programs (i.e., the receipt of transfers), but also for enrollment in and "conditions" of those programs. Conditional transfers required that recipients had access to certain delivery platforms (e.g., schools and health centers) in order to meet the "conditions" of their transfer, and this was a limitation in very rural areas. Although social protection programs are intended for the most vulnerable populations, their delivery platforms can serve as barriers to individuals' receipt of services, particularly if they require engagement with health care, school, or work-related systems.

Gaps in Progress and Ways Forward

Our findings identified gaps and limitations in the evaluation, scope, targeting, and delivery platforms of nutrition interventions in low- and middle-income countries. First, the monitoring and evaluation of nutrition programs that reported on women's nutrition outcomes was generally inadequate. Many of the studies we identified included small-scale efficacy trials. Although there were many large-scale programs that targeted women and adolescent girls with nutrition-specific and nutrition-sensitive approaches, they lacked rigorous evaluation. Whether the evidence about women's outcomes was limited because they are not systematically measured or because they are not well reported is not clear. Negative results are often not published, and many evaluations of nutrition interventions that are conducted by the same groups responsible for implementing them are typically presented positively. This may have also skewed our findings. More intentional research-quality program evaluation, including of large-scale programs, would provide a stronger evidence base. Of the studies identified in this review, many reported on short-term findings such as changes in knowledge, dietary behaviors, and program coverage. They were limited in their ability to report clinical and anthropometric outcomes for women, the duration of those outcomes, and the feasibility of scaling up programs. There is also a need for systematic, long-term evaluations of interventions whose effects on nutrition outcomes are more distal (e.g., nutrition education compared with micronutrient supplementation). The effects of multisectoral interventions are even more complex to measure. However, frameworks exist to evaluate complex interventions (102) and could be utilized to evaluate the impact of interventions across the life course.

Second, the scope of nutrition-specific and nutrition-sensitive approaches was largely focused on undernutrition. There were major research and programming gaps in studies targeting overweight, obesity, and noncommunicable disease. In our review, the interventions addressing overweight, obesity, and noncommunicable disease were limited to nutrition education and integrated healthcare. However, overweight and obesity were identified as potential concerns for interventions targeting undernutrition, including food supplementation, and in-kind and cash transfers. This might be a result of the types of interventions that were evaluated, but also speaks to the need to broaden the scope of nutrition interventions that are commonly assessed (5, 13, 14) to explicitly address overweight, obesity, and noncommunicable disease as nutrition outcomes, and not just as unintended consequences. Globally, there is limited evidence of large-scale interventions that effectively prevent, treat, or correctly classify adiposity-related noncommunicable diseases, and this is a growing area of concern around the world (208). Future evaluations of nutrition interventions might also include interventions that influence women's time and physical environment, and that encourage physical activity or change in access to and affordability of certain foods, as these might also influence overweight, obesity, and noncommunicable disease outcomes for women.

Third, of the interventions that were evaluated, many interventions targeted women who were pregnant, lactating, or with young children <5 y of age. We do not refute the important focus on mothers and their children as a group deserving of special attention, given women's increased nutrient needs during pregnancy and lactation and the intergenerational consequences during this period. However, even the interventions that focused on maternal nutrition often only reported on birth and nutrition outcomes of the child, and not those of the mother. In addition, although there were interventions that targeted adolescent girls and women of reproductive age, they were fewer and less well evaluated than interventions that targeted women as mothers. This aligns with findings from other research which illustrated a higher proportion of programs targeting pregnant and lactating women and women with young children (209). We also found major gaps in the targeting of interventions for older women. With growing rates of overweight, obesity, and noncommunicable diseases, in addition to undernutrition and micronutrient deficiencies, it is essential to think outside of the maternal-focused paradigm to reach women at all life stages.

In addition, more research is needed to evaluate the impact of targeting women alone compared with targeting women alongside other members of their families and communities (e.g., with groups of other women, men, husbands, children, parents, in-laws, other

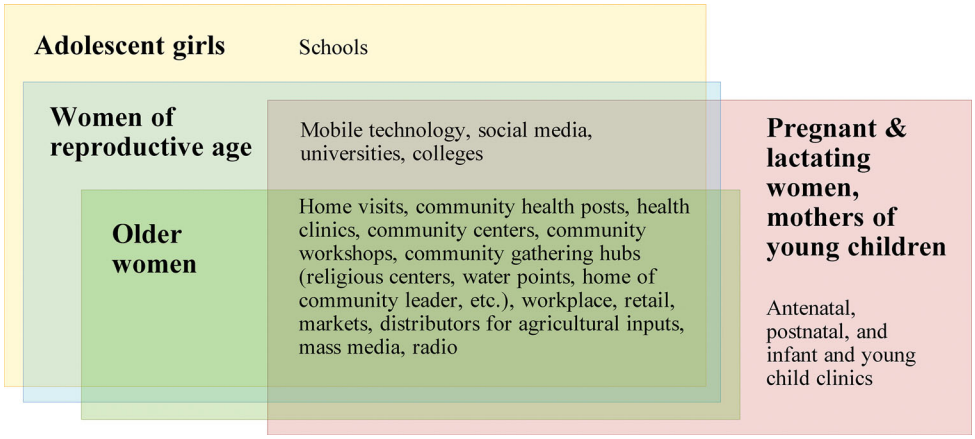

FIGURE 1 Delivery platforms for women across the life course. This Venn diagram represents the delivery platforms for different interventions by target population. The overlapping regions indicate delivery platforms that are shared by the target groups: adolescent girls, women of reproductive age, pregnant and lactating women, mothers of young children, and older women.

family members, other community members, etc.). Interventions that targeted women with their children during child health visits or alongside other members of their communities through community mobilization and mass media campaigns showed improvements in knowledge and some health and nutrition behaviors of women. The inclusion of boys and men, for instance, as well as the inclusion of other family and community members, could enhance the impact and delivery of nutrition interventions for women through support of certain practices, reminders, time-savings, and normalization of nutrition behaviors. However, more research is needed to identify effective targeting mechanisms (i.e., alone or alongside other members of households and communities) and we expect that these will likely need to be context- and content-specific.

Fourth and finally, there was a general lack of focus on the relevant delivery platforms for nutrition interventions. Many studies were not explicit about how and where interventions were delivered, and we had to cross-reference multiple sources to identify the delivery platform for many interventions. Delivery platforms are important and relevant information in terms of replicability, but also for identifying who is effectively reached and missed. Information about delivery platforms is also instrumental in understanding gaps in implementation. A greater emphasis on delivery platforms could enhance the reach of nutrition interventions and could also strengthen the capacity to mobilize resources more effectively. For instance, organizing and grouping interventions by delivery platform (e.g., antenatal care, community centers, schools, clinics) or by the relevant stakeholders required for delivery (e.g., ministries, health care providers, teachers, administrators, transporters, etc.) could have the potential to more efficiently deliver nutrition interventions.

Our review highlighted how a focus on delivery platforms could indicate who is missed by different nutrition interventions, by evaluating where there is overlap or divergence in where interventions are delivered (as represented in the Venn diagram in **Figure 1**). Our findings showed that a large proportion of nutrition-specific interventions were delivered at clinic-based settings or community-based health posts. Health centers are important delivery platforms, particularly for pregnant and lactating women (113, 210). However, only half of women worldwide even attend the appropriate number of antenatal care visits (with nearly 86% of women attending 1 visit) and only 59% receive appropriate postnatal care (211). Other delivery platforms, such as schools and universities, were more effective at reaching some adolescents and women of reproductive age. However, interventions delivered at "facilities" (schools, health clinics, health posts) require participation with those facilities, and participation is often limited because of time, costs, distance, and other responsibilities, including work and childcare (116). Facilities-based care is also more likely to miss certain groups, including older women.

Many nutrition-sensitive approaches were delivered in broader community-based settings and more equitably reached women across the life course. Non-facilities-based settings more equitably delivered nutrition interventions to women who were not pregnant or lactating, and who were less engaged with health clinics and schools. For instance, food fortification, which was often delivered through markets, home visits, and community centers, seemed to be more effective at reaching women of reproductive age than health center–based delivery platforms. Community-level interventions are often reported as more equitable than platforms that require access to "fixed and well-equipped health facilities" (212). This aligns with our findings, where we found that community-based platforms such as home visits, community centers, homes of community leaders, work, mass media, mobile phones, and commercial settings were effective at reaching women across the life course (Table 1). Other delivery platforms such as marketplaces, water points, tailoring shops, and agricultural points for seeds or inputs were also effective. These locations need to be context-specific in order to capture where women spend their time. For instance, in countries where many adolescent girls do not attend school, school-based delivery platforms might be less effective. Delivery platforms also need to be sensitive to the sociodemographic differences that influence where women spend their time, such as differences for women in rural and urban areas, and of different socioeconomic statuses. Additional research needs to identify and report where women and adolescent girls are, and how best to reach them.

In order to reshape policies and programs to more appropriately serve all women, at all life stages, we propose the following policy, program, and research priorities:

- Reframe the need to support women's nutrition not only because women are or might become mothers, but also because they are individuals who are deserving of optimal health and nutrition.
- Develop intentional research-quality program evaluation, including of large-scale programs, to provide a stronger evidence base for the impacts of nutrition interventions on women's nutrition outcomes across the life course.
- Systematically report and evaluate women's nutrition outcomes in research and program evaluation documents in low- and middle-income countries, including outcomes for adolescents, older women, and mothers (as opposed to reporting on women's nutrition as child nutrition outcomes alone). When possible, report and evaluate differences by setting (e.g., rural compared with urban) and socioeconomic status.
- Systematically report and evaluate delivery platforms to illuminate opportunities and gaps in the delivery and coordination of nutrition interventions.
- Build on calls from the WHO and other international agencies to fill the gaps in the literature about interventions that affect overweight, obesity, and noncommunicable diseases, and report them as relevant and explicit nutrition outcomes in practice and research in low- and middle-income countries.
- Identify effective ways to engage women across the life course, determine the most appropriate places to reach them, and explore how interventions might need to adapt to account for differences in life stages.

Conclusions

Although there is evidence that interventions can address widespread malnutrition among women, there is a lack of operational research and programs to tackle the issue. There is an imperative for the nutrition community to look beyond maternal nutrition and to address women's nutrition across their lives (3). How we reach women matters, and different delivery platforms are more appropriate for some women than others. Delivery platforms for reaching young mothers are different from those for adolescents and postmenopausal women. There is a need to intentionally consider strategies that appropriately target and deliver interventions to all women. This means that nutrition researchers and practitioners need to further adapt existing strategies and modes of delivery to adequately engage women who might not be in clinic settings (78). This also requires that researchers and practitioners explore *how* to deliver nutrition interventions to women and at different stages of life in order to reduce inequities in the delivery of nutrition services and to reach women missed by programs focusing on maternal nutrition alone.

Acknowledgments

The authors' contributions were as follows—ELF and CD: were involved in the acquisition of the data; ELF, CD, SMD, and JF: were responsible for the interpretation of the data; ELF: wrote the paper and had primary responsibility for the content; CD, SMD, WS, and JF: were involved in providing detailed comments and revising the manuscript for important intellectual content; and all authors: were involved in the conception of this review and read and approved the final manuscript.

References

1. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013;382(9890):427–51.
2. UN Department of Economic and Social Affairs Population Division. World Fertility Report 2015 (ST/ESA/SER.A/415). New York: United Nations; 2017.
3. Langer A, Meleis A, Knaul FM, Atun R, Aran M, Arreola-Ornelas H, Bhutta ZA, Binagwaho A, Bonita R, Caglia JM, et al. Women and health: the key for sustainable development. Lancet 2015;386(9999):1165–210.
4. Knaul FM, Langer A, Atun R, Rodin D, Frenk J, Bonita R. Rethinking maternal health. Lancet Glob Health 2016;4(4):e227–8.
5. Ruel MT, Alderman H. Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? Lancet 2013;382(9891):536–51.
6. Fanzo J, Cordes KY, Fox EL, Bulman A. Tying the knot: an interdisciplinary approach to understanding the human right to adequate nutrition. Colum J Transnatl Law 2018;57(1):62–114.
7. Powers M, Faden RR. Social Justice: The Moral Foundations of Public Health and Health Policy. New York: Oxford University Press; 2006.
8. Christian P, Smith ER. Adolescent undernutrition: global burden, physiology, and nutritional risks. Ann Nutr Metab 2018;72(4):316–28.
9. Das JK, Salam RA, Thornburg KL, Prentice AM, Campisi S, Lassi ZS, Koletzko B, Bhutta ZA. Nutrition in adolescents: physiology, metabolism, and nutritional needs. Ann N Y Acad Sci 2017;1393(1):21–33.
10. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, Mullany EC, Biryukov S, Abbafati C, Abera SF, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014;384(9945):766–81.
11. Grant MJ, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. Health Info Libr J 2009;26(2):91–108.
12. Shekar M, Ruel-Bergeron J, Herforth A. A. Introduction. Improving Nutrition Through Multisectoral Approaches. Washington (DC): International Bank for Reconstruction and Development, International Development Association of the World Bank; 2013.
13. Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, Webb P, Lartey A, Black RE; Lancet Nutrition Interventions Review Group, the Maternal and Child Nutrition Study Group. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? Lancet 2013;382(9890):452–77.
14. Bhutta ZA, Ahmed T, Black RE, Cousens S, Dewey K, Giugliani E, Haider BA, Kirkwood B, Morris SS, Sachdev HP, et al. What works? Interventions for maternal and child undernutrition and survival. Lancet 2008;371(9610):417–40.
15. Creed-Kanashiro HM, Uribe TG, Bartolini RM, Fukumoto MN, Lopez TT, Zavaleta NM, Bentley ME. Improving dietary intake to prevent anemia in adolescent girls through community kitchens in a periurban population of Lima, Peru. J Nutr 2000;130(2S Suppl):459S–61S.
16. Hien VT, Khan NC, Mai LB, Lam NT, Phuong TM, Nhung BT, Nhien NV, Nakamori M, Yamamoto S. Effect of community-based nutrition education intervention on calcium intake and bone mass in postmenopausal Vietnamese women. Public Health Nutr 2009;12(5):674–9.
17. Liu N, Mao L, Sun X, Liu L, Yao P, Chen B. The effect of health and nutrition education intervention on women's postpartum beliefs and practices: a randomized controlled trial. BMC Public Health 2009;9:45.

18. Moore JB, Pawloski L, Rodriguez C, Lumbi L, Ailinger R. The effect of a nutrition education program on the nutritional knowledge, hemoglobin levels, and nutritional status of Nicaraguan adolescent girls. Public Health Nurs 2009;26(2):144–52.
19. Ota E, Hori H, Mori R, Tobe-Gai R, Farrar D. Antenatal dietary education and supplementation to increase energy and protein intake. Cochrane Database Syst Rev 2015;(6):CD000032.
20. Wijaya-Erhardt M, Muslimatu S, Erhardt JG. Effect of an educational intervention related to health and nutrition on pregnant women in the villages of Central Java Province, Indonesia. Health Educ J 2014;73(4):370–81.
21. Nair N, Tripathy P, Sachdev HS, Pradhan H, Bhattacharyya S, Gope R, Gagrai S, Rath S, Rath S, Sinha R, et al. Effect of participatory women's groups and counselling through home visits on children's linear growth in rural eastern India (CARING trial): a cluster-randomised controlled trial. Lancet Glob Health 2017;5(10):e1004–e16.
22. Rodriguez-Ramirez S, Gonzalez de Cosio T, Mendez MA, Tucker KL, Mendez-Ramirez I, Hernandez-Cordero S, Popkin BM. A water and education provision intervention modifies the diet in overweight Mexican women in a randomized controlled trial. J Nutr 2015;145(8):1892–9.
23. Amiri P, Hamzavi Zarghani N, Nazeri P, Ghofranipour F, Karimi M, Amouzegar A, Mirmiran P, Azizi F. Can an educational intervention improve iodine nutrition status in pregnant women? A randomized controlled trial. Thyroid 2017;27(3):418–25.
24. Jahan K, Roy SK, Mihrshahi S, Sultana N, Khatoon S, Roy H, Datta LR, Roy A, Jahan S, Khatun W, et al. Short-term nutrition education reduces low birthweight and improves pregnancy outcomes among urban poor women in Bangladesh. Food Nutr Bull 2014;35(4):414–21.
25. Katz DL, O'Connell M, Yeh MC, Nawaz H, Njike V, Anderson LM, Cory S, Dietz W; Task Force on Community Preventive Services. Public health strategies for preventing and controlling overweight and obesity in school and worksite settings: a report on recommendations of the Task Force on Community Preventive Services. MMWR Recomm Rep 2005;54(RR-10):1–12.
26. Salam RA, Hooda M, Das JK, Arshad A, Lassi ZS, Middleton P, Bhutta ZA. Interventions to improve adolescent nutrition: a systematic review and meta-analysis. J Adolesc Health 2016;59(4S):S29–39.
27. Kropski JA, Keckley PH, Jensen GL. School-based obesity prevention programs: an evidence-based review. Obesity (Silver Spring) 2008;16(5):1009–18.
28. Osei A, Pandey P, Nielsen J, Pries A, Spiro D, Davis D, Quinn V, Haselow N. Combining home garden, poultry, and nutrition education program targeted to families with young children improved anemia among children and anemia and underweight among nonpregnant women in Nepal. Food Nutr Bull 2017;38(1):49–64.
29. Sbruzzi G, Eibel B, Barbiero SM, Petkowicz RO, Ribeiro RA, Cesa CC, Martins CC, Marobin R, Schaan CW, Souza WB, et al. Educational interventions in childhood obesity: a systematic review with meta-analysis of randomized clinical trials. Prev Med 2013;56(5):254–64.
30. Selvam S, Murugesan N, Snehalatha C, Nanditha A, Raghavan A, Simon M, Susairaj P, Ramachandran A. Health education on diabetes and other non-communicable diseases imparted to teachers shows a cascading effect. A study from southern India. Diabetes Res Clin Pract 2017;125:20–8.
31. Haider BA, Bhutta ZA. Multiple-micronutrient supplementation for women during pregnancy. Cochrane Database Syst Rev 2017;4:CD004905.
32. Lin Q, Yang L, Li F, Qin H, Li M, Chen J, Deng J, Hu X. A village-based intervention: promoting folic acid use among rural Chinese women. Nutrients 2017;9(2):174.
33. Victora CG, Barros FC, Assuncao MC, Restrepo-Mendez MC, Matijasevich A, Martorell R. Scaling up maternal nutrition programs to improve birth outcomes: a review of implementation issues. Food Nutr Bull 2012;33(2 Suppl):S6–26.
34. Perez-Rodrigo C, Aranceta J. School-based nutrition education: lessons learned and new perspectives. Public Health Nutr 2001;4(1A):131–9.
35. Hofmeyr GJ, Lawrie TA, Atallah AN, Duley L, Torloni MR. Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems. Cochrane Database Syst Rev 2014;(6):CD001059.
36. Darling AM, Mugusi FM, Etheredge AJ, Gunaratna NS, Abioye AI, Aboud S, Duggan C, Mongi R, Spiegelman D, Roberts D, et al. Vitamin A and zinc supplementation among pregnant women to prevent placental malaria: a randomized, double-blind, placebo-controlled trial in Tanzania. Am J Trop Med Hyg 2017;96(4):826–34.
37. Hoa PT, Khan NC, van Beusekom C, Gross R, Conde WL, Khoi HD. Milk fortified with iron or iron supplementation to improve nutritional status of pregnant women: an intervention trial from rural Vietnam. Food Nutr Bull 2005;26(1):32–8.
38. Ziaei S, Rahman A, Raqib R, Lonnerdal B, Ekstrom EC. A prenatal multiple micronutrient supplement produces higher maternal vitamin B-12 concentrations and similar folate, ferritin, and zinc concentrations as the standard 60-mg iron plus 400-μg folic acid supplement in rural Bangladeshi women. J Nutr 2016;146(12):2520–9.
39. Sanghvi TG, Harvey PW, Wainwright E. Maternal iron-folic acid supplementation programs: evidence of impact and implementation. Food Nutr Bull 2010;31(2 Suppl):S100–7.
40. Stoltzfus RJ, Hakimi M, Miller KW, Rasmussen KM, Dawiesah S, Habicht JP, Dibley MJ. High dose vitamin A supplementation of breast-feeding Indonesian mothers: effects on the vitamin A status of mother and infant. J Nutr 1993;123(4):666–75.
41. Gunaratna NS, Masanja H, Mrema S, Levira F, Spiegelman D, Hertzmark E, Saronga N, Irema K, Shuma M, Elisaria E, et al. Multivitamin and iron supplementation to prevent periconceptional anemia in rural Tanzanian women: a randomized, controlled trial. PLoS One 2015;10(4):e0121552.
42. Salam RA, Das JK, Bhutta ZA. Multiple micronutrient supplementation during pregnancy and lactation in low-to-middle-income developing country settings: impact on pregnancy outcomes. Ann Nutr Metab 2014;65(1):4–12.
43. Graham JM, Haskell MJ, Pandey P, Shrestha RK, Brown KH, Allen LH. Supplementation with iron and riboflavin enhances dark adaptation response to vitamin A-fortified rice in iron-deficient, pregnant, nightblind Nepali women. Am J Clin Nutr 2007;85(5):1375–84.
44. Cavalli-Sforza T, Berger J, Smitasiri S, Viteri F. Weekly iron-folic acid supplementation of women of reproductive age: impact overview, lessons learned, expansion plans, and contributions toward achievement of the millennium development goals. Nutr Rev 2005;63(12 Pt 2):S152–8.
45. Rice AL, Stoltzfus RJ, de Francisco A, Chakraborty J, Kjolhede CL, Wahed MA. Maternal vitamin A or β-carotene supplementation in lactating Bangladeshi women benefits mothers and infants but does not prevent subclinical deficiency. J Nutr 1999;129(2):356–65.
46. Lassi ZS, Moin A, Das JK, Salam RA, Bhutta ZA. Systematic review on evidence-based adolescent nutrition interventions. Ann N Y Acad Sci 2017;1393(1):34–50.
47. Fernandez-Gaxiola AC, De-Regil LM. Intermittent iron supplementation for reducing anaemia and its associated impairments in menstruating women. Cochrane Database Syst Rev 2011;(12):CD009218.
48. Pena-Rosas JP, De-Regil LM, Garcia-Casal MN, Dowswell T. Daily oral iron supplementation during pregnancy. Cochrane Database Syst Rev 2015;(7):CD004736.
49. Casey GJ, Montresor A, Cavalli-Sforza LT, Thu H, Phu LB, Tinh TT, Tien NT, Phuc TQ, Biggs BA. Elimination of iron deficiency anemia and soil transmitted helminth infection: evidence from a fifty-four month iron-folic acid and de-worming program. PLoS Negl Trop Dis 2013;7(4):e2146.
50. Imdad A, Bhutta ZA. Effects of calcium supplementation during pregnancy on maternal, fetal and birth outcomes. Paediatr Perinat Epidemiol 2012;26(Suppl 1):138–52.
51. Ramakrishnan U, Neufeld LM, Gonzalez-Cossio T, Villalpando S, Garcia-Guerra A, Rivera J, Martorell R. Multiple micronutrient supplements during pregnancy do not reduce anemia or improve iron status compared to iron-only supplements in semirural Mexico. J Nutr 2004;134(4):898–903.
52. West KP Jr, Christian P, Labrique AB, Rashid M, Shamim AA, Klemm RD, Massie AB, Mehra S, Schulze KJ, Ali H, et al. Effects of vitamin A or beta carotene supplementation on pregnancy-related mortality and infant mortality in rural Bangladesh: a cluster randomized trial. JAMA 2011;305(19):1986–95.

53. Kirkwood BR, Hurt L, Amenga-Etego S, Tawiah C, Zandoh C, Danso S, Hurt C, Edmond K, Hill Z, Ten Asbroek G, et al. Effect of vitamin A supplementation in women of reproductive age on maternal survival in Ghana (ObaapaVitA): a cluster-randomised, placebo-controlled trial. Lancet 2010;375(9726):1640–9.
54. Donangelo CM, King JC. Maternal zinc intakes and homeostatic adjustments during pregnancy and lactation. Nutrients 2012;4(7):782–98.
55. Horton S, Begin F, Greig A, Lakshman A. Best practice paper: micronutrient supplements for child survival (vitamin A and zinc). Copenhagen Consensus 2008. Copenhagen: Copenhagen Consensus Center; 2008.
56. Hess SY, King JC. Effects of maternal zinc supplementation on pregnancy and lactation outcomes. Food Nutr Bull 2009;30(1 Suppl):S60–78.
57. Palacios C, De-Regil LM, Lombardo LK, Pena-Rosas JP. Vitamin D supplementation during pregnancy: updated meta-analysis on maternal outcomes. J Steroid Biochem Mol Biol 2016;164:148–55.
58. Harding KB, Pena-Rosas JP, Webster AC, Yap CM, Payne BA, Ota E, De-Regil LM. Iodine supplementation for women during the preconception, pregnancy and postpartum period. Cochrane Database Syst Rev 2017;3:CD011761.
59. Deshmukh PR, Garg BS, Bharambe MS. Effectiveness of weekly supplementation of iron to control anaemia among adolescent girls of Nashik, Maharashtra, India. J Health Popul Nutr 2008;26(1):74–8.
60. Martin SL, Omotayo MO, Pelto GH, Chapleau GM, Stoltzfus RJ, Dickin KL. Adherence-specific social support enhances adherence to calcium supplementation regimens among pregnant women. J Nutr 2017;147(4):688–96.
61. Haskell MJ, Pandey P, Graham JM, Peerson JM, Shrestha RK, Brown KH. Recovery from impaired dark adaptation in nightblind pregnant Nepali women who receive small daily doses of vitamin A as amaranth leaves, carrots, goat liver, vitamin A-fortified rice, or retinyl palmitate. Am J Clin Nutr 2005;81(2):461–71.
62. Kotecha PV, Nirupam S, Karkar PD. Adolescent girls' Anaemia Control Programme, Gujarat, India. Indian J Med Res 2009;130(5):584–9.
63. Das JK, Salam RA, Kumar R, Bhutta ZA. Micronutrient fortification of food and its impact on woman and child health: a systematic review. Syst Rev 2013;2:67.
64. Allen LH, de Benoist B, Dary O, Hurrell R. Guidelines on food fortification with micronutrients. Geneva: WHO and FAO; 2006.
65. Gera T, Sachdev HS, Boy E. Effect of iron-fortified foods on hematologic and biological outcomes: systematic review of randomized controlled trials. Am J Clin Nutr 2012;96(2):309–24.
66. Crider KS, Bailey LB, Berry RJ. Folic acid food fortification—its history, effect, concerns, and future directions. Nutrients 2011;3(3):370–84.
67. Steyn NP, Wolmarans P, Nel JH, Bourne LT. National fortification of staple foods can make a significant contribution to micronutrient intake of South African adults. Public Health Nutr 2008;11(3):307–13.
68. Rohner F, Raso G, Ake-Tano SO, Tschannen AB, Mascie-Taylor CG, Northrop-Clewes CA. The effects of an oil and wheat flour fortification program on pre-school children and women of reproductive age living in Cote d'Ivoire, a malaria-endemic area. Nutrients 2016;8(3):148.
69. Shah D, Sachdev HS, Gera T, De-Regil LM, Pena-Rosas JP. Fortification of staple foods with zinc for improving zinc status and other health outcomes in the general population. Cochrane Database Syst Rev 2016;(6):CD010697.
70. Whitfield KC, Karakochuk CD, Kroeun H, Hampel D, Sokhoing L, Chan BB, Borath M, Sophonneary P, McLean J, Talukder A, et al. Perinatal consumption of thiamine-fortified fish sauce in rural Cambodia: a randomized clinical trial. JAMA Pediatrics 2016;170(10):e162065.
71. Huo J, Sun J, Huang J, Li W, Wang L, Selenje L, Gleason GR, Yu X. Effectiveness of fortified flour for enhancement of vitamin and mineral intakes and nutrition status in northwest Chinese villages. Food Nutr Bull 2012;33(2):161–8.
72. Hotz C, Porcayo M, Onofre G, Garcia-Guerra A, Elliott T, Jankowski S, Greiner T. Efficacy of iron-fortified Ultra Rice in improving the iron status of women in Mexico. Food Nutr Bull 2008;29(2): 140–9.
73. Abdollahi Z, Elmadfa I, Djazayery A, Golalipour MJ, Sadighi J, Salehi F, Sadeghian Sharif S. Efficacy of flour fortification with folic acid in women of childbearing age in Iran. Ann Nutr Metab 2011;58(3):188–96.
74. Aaron GJ, Dror DK, Yang Z. Multiple-micronutrient fortified non-dairy beverage interventions reduce the risk of anemia and iron deficiency in school-aged children in low-middle income countries: a systematic review and meta-analysis. Nutrients 2015;7(5):3847–68.
75. De Moura FF, Palmer AC, Finkelstein JL, Haas JD, Murray-Kolb LE, Wenger MJ, Birol E, Boy E, Peña-Rosas JP. Are biofortified staple food crops improving vitamin A and iron status in women and children? New evidence from efficacy trials. Adv Nutr 2014;5(5):568–70.
76. Hurrell R, Ranum P, de Pee S, Biebinger R, Hulthen L, Johnson Q, Lynch S. Revised recommendations for iron fortification of wheat flour and an evaluation of the expected impact of current national wheat flour fortification programs. Food Nutr Bull 2010;31(1 Suppl):S7–21.
77. Mason JB, Saldanha LS, Ramakrishnan U, Lowe A, Noznesky EA, Girard AW, McFarland DA, Martorell R. Opportunities for improving maternal nutrition and birth outcomes: synthesis of country experiences. Food Nutr Bull 2012;33(2 Suppl):S104–37.
78. Mason JB, Shrimpton R, Saldanha LS, Ramakrishnan U, Victora CG, Girard AW, McFarland DA, Martorell R. The first 500 days of life: policies to support maternal nutrition. Glob Health Action 2014;7:23623.
79. Neufeld LM, Baker S, Garrett GS, Haddad L. Coverage and utilization in food fortification programs: critical and neglected areas of evaluation. J Nutr 2017;147(5):1015S–19S.
80. Assuncao MC, Santos IS, Barros AJ, Gigante DP, Victora CG. Flour fortification with iron has no impact on anaemia in urban Brazilian children. Public Health Nutr 2012;15(10):1796–801.
81. Garcia-Casal MN, Pena-Rosas JP, McLean M, De-Regil LM, Zamora G. Fortification of condiments with micronutrients in public health: from proof of concept to scaling up. Ann N Y Acad Sci 2016;1379(1):38–47.
82. Wojcicki JM, Heyman MB. Malnutrition and the role of the soft drink industry in improving child health in sub-Saharan Africa. Pediatrics 2010;126(6):e1617–21.
83. World Health Organization. Salt reduction and iodine fortification strategies in public health: report of a joint technical meeting convened by the World Health Organization and The George Institute for Global Health in collaboration with the International Council for the Control of Iodine Deficiency Disorders Global Network, Sydney, Australia, March 2013. Geneva: World Health Organization; 2014.
84. van Stuijvenberg ME. Using the school feeding system as a vehicle for micronutrient fortification: experience from South Africa. Food Nutr Bull 2005;26(2 Suppl 2):S213–19.
85. Imhoff-Kunsch B, Flores R, Dary O, Martorell R. Wheat flour fortification is unlikely to benefit the neediest in Guatemala. J Nutr 2007;137(4):1017–22.
86. Khan MM, Ahmed S, Protik AE, Dhar BC, Roy SK. Effects of a food supplementation program on the nutritional status of pregnant women in Bangladesh. Food Nutr Bull 2005;26(4):330–7.
87. Kardjati S, Kusin JA, Schofield WM, de With C. Energy supplementation in the last trimester of pregnancy in East Java, Indonesia: effect on maternal anthropometry. Am J Clin Nutr 1990;52(6):987–94.
88. Kramer MS, Kakuma R. Energy and protein intake in pregnancy. Cochrane Database Syst Rev 2003;(4):CD000032.
89. Yang Z, Huffman SL. Review of fortified food and beverage products for pregnant and lactating women and their impact on nutritional status. Matern Child Nutr 2011;7(Suppl 3):19–43.
90. Imdad A, Bhutta ZA. Maternal nutrition and birth outcomes: effect of balanced protein-energy supplementation. Paediatr Perinat Epidemiol 2012;26(Suppl 1):178–90.
91. Potdar RD, Sahariah SA, Gandhi M, Kehoe SH, Brown N, Sane H, Dayama M, Jha S, Lawande A, Coakley PJ, et al. Improving women's diet quality preconceptionally and during gestation: effects on birth weight and prevalence of low birth weight—a randomized controlled efficacy trial in India (Mumbai Maternal Nutrition Project). Am J Clin Nutr 2014;100(5):1257–68.

92. Ghodsi D, Omidvar N, Eini-Zinab H, Rashidian A, Raghfar H. Impact of the National Food Supplementary Program for Children on household food security and maternal weight status in Iran. Int J Prev Med 2016;7:108.
93. Leroy JL, Gadsden P, Gonzalez de Cossio T, Gertler P. Cash and in-kind transfers lead to excess weight gain in a population of women with a high prevalence of overweight in rural Mexico. J Nutr 2013;143(3):378–83.
94. Ahmed AU, Quisumbing AR, Nasreen M, Hoddinott JF, Bryan E. Comparing food and cash transfers to the ultra poor in Bangladesh. Washington (DC): International Food Policy Research Institute; 2009.
95. Kristjansson EA, Robinson V, Petticrew M, MacDonald B, Krasevec J, Janzen L, Greenhalgh T, Wells G, MacGowan J, Farmer A, et al. School feeding for improving the physical and psychosocial health of disadvantaged elementary school children. Cochrane Database Syst Rev 2007;(1):CD004676.
96. Potter J, Langhorne P, Roberts M. Routine protein energy supplementation in adults: systematic review. BMJ 1998;317(7157):495–501.
97. Arimond M, Zeilani M, Jungjohann S, Brown KH, Ashorn P, Allen LH, Dewey KG. Considerations in developing lipid-based nutrient supplements for prevention of undernutrition: experience from the International Lipid-Based Nutrient Supplements (iLiNS) Project. Matern Child Nutr 2015;11(Suppl 4):31–61.
98. Chaparro CM, Dewey KG. Use of lipid-based nutrient supplements (LNS) to improve the nutrient adequacy of general food distribution rations for vulnerable sub-groups in emergency settings. Matern Child Nutr 2010;6(Suppl 1):1–69.
99. Matias SL, Mridha MK, Paul RR, Hussain S, Vosti SA, Arnold CD, Dewey KG. Prenatal lipid-based nutrient supplements affect maternal anthropometric indicators only in certain subgroups of rural Bangladeshi women. J Nutr 2016;146(9):1775–82.
100. Oaks BM, Young RR, Adu-Afarwuah S, Ashorn U, Jackson KH, Lartey A, Maleta K, Okronipa H, Sadalaki J, Baldiviez LM, et al. Effects of a lipid-based nutrient supplement during pregnancy and lactation on maternal plasma fatty acid status and lipid profile: results of two randomized controlled trials. Prostaglandins Leukot Essent Fatty Acids 2017;117:28–35.
101. Chandrasiri UP, Fowkes FJ, Richards JS, Langer C, Fan YM, Taylor SM, Beeson JG, Dewey KG, Maleta K, Ashorn P, et al. The impact of lipid-based nutrient supplementation on anti-malarial antibodies in pregnant women in a randomized controlled trial. Malar J 2015;14: 193.
102. Olney DK, Leroy JL, Ruel MT. Evaluation of nutrition-sensitive programs. In: de Pee S, Taren D Bloem MW, editors. Nutrition and health in a developing world. New York: Humana Press; 2017:603–24.
103. Dudley L, Garner P. Strategies for integrating primary health services in low- and middle-income countries at the point of delivery. Cochrane Database Syst Rev 2011;(7):CD003318.
104. Walley J, Lawn JE, Tinker A, de Francisco A, Chopra M, Rudan I, Bhutta ZA, Black RE; Lancet Alma-Ata Working Group. Primary health care: making Alma-Ata a reality. Lancet 2008;372(9642):1001–7.
105. Kruk ME, Kujawski S, Moyer CA, Adanu RM, Afsana K, Cohen J, Glassman A, Labrique A, Reddy KS, Yamey G. Next generation maternal health: external shocks and health-system innovations. Lancet 2016;388(10057):2296–306.
106. Perry HB, Zulliger R, Rogers MM. Community health workers in low-, middle-, and high-income countries: an overview of their history, recent evolution, and current effectiveness. Annu Rev Public Health 2014;35:399–421.
107. Bhutta ZA, Das JK, Bahl R, Lawn JE, Salam RA, Paul VK, Sankar MJ, Blencowe H, Rizvi A, Chou VB, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? Lancet 2014;384(9940):347–70.
108. Beaglehole R, Epping-Jordan J, Patel V, Chopra M, Ebrahim S, Kidd M, Haines A. Improving the prevention and management of chronic disease in low-income and middle-income countries: a priority for primary health care. Lancet 2008;372(9642):940–9.
109. Lewin S, Lavis JN, Oxman AD, Bastias G, Chopra M, Ciapponi A, Flottorp S, Martí SG, Pantoja T, Rada G, et al. Supporting the delivery of cost-effective interventions in primary health-care systems in low-income and middle-income countries: an overview of systematic reviews. Lancet 2008;372(9642):928–39.
110. Bhutta ZA, Ali S, Cousens S, Ali TM, Haider BA, Rizvi A, Okong P, Bhutta SZ, Black RE. Alma-Ata: Rebirth and Revision 6 Interventions to address maternal, newborn, and child survival: what difference can integrated primary health care strategies make? Lancet 2008;372(9642):972–89.
111. Bitton A, Ratcliffe HL, Veillard JH, Kress DH, Barkley S, Kimball M, Secci F, Wong E, Basu L, Taylor C, et al. Primary health care as a foundation for strengthening health systems in low- and middle-income countries. J Gen Intern Med 2017;32(5):566–71.
112. Beran D. The impact of health systems on diabetes care in low and lower middle income countries. Curr Diab Rep 2015;15(4):20.
113. Myer L, Harrison A. Why do women seek antenatal care late? Perspectives from rural South Africa. J Midwifery Womens Health 2003;48(4):268–72.
114. Mills A. Health care systems in low- and middle-income countries. N Engl J Med 2014;370(6):552–7.
115. Downe S, Finlayson K, Walsh D, Lavender T. 'Weighing up and balancing out': a meta-synthesis of barriers to antenatal care for marginalised women in high-income countries. BJOG 2009;116(4):518–29.
116. Finlayson K, Downe S. Why do women not use antenatal services in low- and middle-income countries? A meta-synthesis of qualitative studies. PLoS Med 2013;10(1):e1001373.
117. Poels M, Koster MP, Boeije HR, Franx A, van Stel HF. Why do women not use preconception care? A systematic review on barriers and facilitators. Obstet Gynecol Surv 2016;71(10):603–12.
118. Azenha GS, Parsons-Perez C, Goltz S, Bhadelia A, Durstine A, Knaul F, Torode J, Starrs A, McGuire H, Drake JK, et al. Recommendations towards an integrated, life-course approach to women's health in the post-2015 agenda. Bull World Health Organ 2013;91(9):704–6.
119. Leonard KL. Active patients in rural African health care: implications for research and policy. Health Policy Plan 2014;29(1):85–95.
120. Kruk ME, Mbaruku G, McCord CW, Moran M, Rockers PC, Galea S. Bypassing primary care facilities for childbirth: a population-based study in rural Tanzania. Health Policy Plan 2009;24(4):279–88.
121. Simkhada B, Teijlingen ER, Porter M, Simkhada P. Factors affecting the utilization of antenatal care in developing countries: systematic review of the literature. J Adv Nurs 2008;61(3):244–60.
122. Dzakpasu S, Powell-Jackson T, Campbell OM. Impact of user fees on maternal health service utilization and related health outcomes: a systematic review. Health Policy Plan 2014;29(2):137–50.
123. McKinnon B, Harper S, Kaufman JS, Bergevin Y. Removing user fees for facility-based delivery services: a difference-in-differences evaluation from ten sub-Saharan African countries. Health Policy Plan 2015;30(4):432–41.
124. Kerber KJ, de Graft-Johnson JE, Bhutta ZA, Okong P, Starrs A, Lawn JE. Continuum of care for maternal, newborn, and child health: from slogan to service delivery. Lancet 2007;370(9595):1358–69.
125. Rah JH, Cronin AA, Badgaiyan B, Aguayo VM, Coates S, Ahmed S. Household sanitation and personal hygiene practices are associated with child stunting in rural India: a cross-sectional analysis of surveys. BMJ Open 2015;5(2):e005180.
126. Campbell OM, Benova L, Gon G, Afsana K, Cumming O. Getting the basic rights – the role of water, sanitation and hygiene in maternal and reproductive health: a conceptual framework. Trop Med Int Health 2015;20(3):252–67.
127. Fuller JA, Eisenberg JN. Herd protection from drinking water, sanitation, and hygiene interventions. Am J Trop Med Hyg 2016;95(5):1201–10.
128. Cairncross S, Hunt C, Boisson S, Bostoen K, Curtis V, Fung IC, Schmidt WP. Water, sanitation and hygiene for the prevention of diarrhoea. Int J Epidemiol 2010;39(Suppl 1):i193–205.
129. Wolf J, Pruss-Ustun A, Cumming O, Bartram J, Bonjour S, Cairncross S, Clasen T, Colford JM Jr, Curtis V, De France J, et al. Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression. Trop Med Int Health 2014;19(8):928–42.

130. Bartram J, Cairncross S. Hygiene, sanitation, and water: forgotten foundations of health. PLoS Med 2010;7(11):e1000367.
131. Fewtrell L, Kaufmann RB, Kay D, Enanoria W, Haller L, Colford JM Jr. Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. Lancet Infect Dis 2005;5(1):42–52.
132. Benova L, Cumming O, Campbell OM. Systematic review and meta-analysis: association between water and sanitation environment and maternal mortality. Trop Med Int Health 2014;19(4):368–87.
133. Phillips-Howard PA, Caruso B, Torondel B, Zulaika G, Sahin M, Sommer M. Menstrual hygiene management among adolescent schoolgirls in low- and middle-income countries: research priorities. Global Health Action 2016;9(1):33032.
134. Sebastian A, Hoffmann V, Adelman S. Menstrual management in low-income countries: needs and trends. Waterlines 2013;32(2):135–53.
135. Koolwal G, van de Walle D. Access to water, women's work, and child outcomes. Econ Dev Cult Change 2013;61(2):369–405.
136. Cairncross S, Valdmanis V. Water supply, sanitation, and hygiene promotion. In: Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M, Evans DB, Jha P, Mills A Musgrove P, editors. Disease Control Priorities in Developing Countries. 2nd ed. Washington (DC): The World Bank; 2006:771–92.
137. Dangour AD, Watson L, Cumming O, Boisson S, Che Y, Velleman Y, Cavill S, Allen E, Uauy R. Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children. Cochrane Database Syst Rev 2013;(8):CD009382.
138. Christensen G, Dentz HN, Pickering AJ, Bourdier T, Arnold BF, Colford JM Jr, Null C. Pilot cluster randomized controlled trials to evaluate adoption of water, sanitation, and hygiene interventions and their combination in rural western Kenya. Am J Trop Med Hyg 2015;92(2):437–47.
139. Morgan C, Bowling M, Bartram J, Lyn Kayser G. Water, sanitation, and hygiene in schools: status and implications of low coverage in Ethiopia, Kenya, Mozambique, Rwanda, Uganda, and Zambia. Int J Hyg Environ Health 2017;220(6):950–9.
140. Parker AA, Stephenson R, Riley PL, Ombeki S, Komolleh C, Sibley L, Quick R. Sustained high levels of stored drinking water treatment and retention of hand-washing knowledge in rural Kenyan households following a clinic-based intervention. Epidemiol Infect 2006;134(5):1029–36.
141. Cairncross S, Shordt K. It does last! Some findings from a multi-country study of hygiene sustainability. Waterlines 2004;22(3):4–7.
142. Alkema L, Kantorova V, Menozzi C, Biddlecom A. National, regional, and global rates and trends in contraceptive prevalence and unmet need for family planning between 1990 and 2015: a systematic and comprehensive analysis. Lancet 2013;381(9878):1642–52.
143. Ahmed S, Li Q, Liu L, Tsui AO. Maternal deaths averted by contraceptive use: an analysis of 172 countries. Lancet 2012;380(9837):111–25.
144. Winkvist A, Rasmussen KM, Habicht JP. A new definition of maternal depletion syndrome. Am J Public Health 1992;82(5):691–4.
145. Yeakey MP, Muntifering CJ, Ramachandran DV, Myint Y, Creanga AA, Tsui AO. How contraceptive use affects birth intervals: results of a literature review. Stud Fam Plann 2009;40(3):205–14.
146. Conde-Agudelo A, Rosas-Bermudez A, Castano F, Norton MH. Effects of birth spacing on maternal, perinatal, infant, and child health: a systematic review of causal mechanisms. Stud Fam Plann 2012;43(2):93–114.
147. Dewey KG, Cohen RJ. Does birth spacing affect maternal or child nutritional status? A systematic literature review. Matern Child Nutr 2007;3(3):151–73.
148. Gilmore K, Gebreyesus TA. What will it take to eliminate preventable maternal deaths? Lancet 2012;380(9837):87–8.
149. Black RE, Levin C, Walker N, Chou D, Liu L, Temmerman M. Reproductive, maternal, newborn, and child health: key messages from Disease Control Priorities 3rd Edition. Lancet 2016;388(10061): 2811–24.
150. Wallace A, Ryman T, Mihigo R, Ndoutabe M, Tounkara B, Grant G, Anya B, Kiawi EC, Kone S, Tesfaye H, et al. Strengthening evidence-based planning of integrated health service delivery through local measures of health intervention delivery times. J Infect Dis 2012;205(Suppl 1): S40–8.
151. Rajan S, Speizer IS, Calhoun LM, Nanda P. Counseling during maternal and infant health visits and postpartum contraceptive use in Uttar Pradesh, India. Int Perspect Sex Reprod Health 2016;42(4):167–78.
152. Jalang'o R, Thuita F, Barasa SO, Njoroge P. Determinants of contraceptive use among postpartum women in a county hospital in rural Kenya. BMC Public Health 2017;17(1):604.
153. Cooper CM, Ogutu A, Matiri E, Tappis H, Mackenzie D, Pfitzer A, Galloway R. Maximizing opportunities: family planning and maternal, infant, and young child nutrition integration in Bondo sub-county, Kenya. Matern Child Health J 2017;21(10):1880–9.
154. Douthwaite M, Ward P. Increasing contraceptive use in rural Pakistan: an evaluation of the Lady Health Worker Programme. Health Policy Plan 2005;20(2):117–23.
155. Oringanje C, Meremikwu MM, Eko H, Esu E, Meremikwu A, Ehiri JE. Interventions for preventing unintended pregnancies among adolescents. Cochrane Database Syst Rev 2016;2:CD005215.
156. Gonsalves L, L'Engle KL, Tamrat T, Plourde KF, Mangone ER, Agarwal S, Say L, Hindin MJ. Adolescent/Youth Reproductive Mobile Access and Delivery Initiative for Love and Life Outcomes (ARMADILLO) Study: formative protocol for mHealth platform development and piloting. Reprod Health 2015;12:67.
157. Buttolph J, Inwani I, Agot K, Cleland CM, Cherutich P, Kiarie JN, Osoti A, Celum CL, Baeten JM, Nduati R, et al. Gender-specific combination HIV prevention for youth in high-burden settings: the MP3 youth observational pilot study protocol. JMIR Res Protoc 2017;6(3):e22.
158. Pratley P. Associations between quantitative measures of women's empowerment and access to care and health status for mothers and their children: a systematic review of evidence from the developing world. Soc Sci Med 2016;169:119–31.
159. Herforth A, Ballard TJ. Nutrition indicators in agriculture projects: current measurement, priorities, and gaps. Glob Food Sec 2016;10(Supplement C):1–10.
160. Talukder A, Haselow NJ, Osei AK, Villate E, Reario D, Kroeun H, SokHoing L, Uddin A, Dhunge S, Quinn V. Homestead food production model contributes to improved household food security and nutrition status of young children and women in poor populations. Field Actions Science Reports 2010;(Special Issue 1):1–9.
161. Weinhardt LS, Galvao LW, Yan AF, Stevens P, Mwenyekonde TN, Ngui E, Emer L, Grande KM, Mkandawire-Valhmu L, Watkins SC. Mixed-method quasi-experimental study of outcomes of a large-scale multilevel economic and food security intervention on HIV vulnerability in rural Malawi. AIDS Behav 2017;21(3):712–23.
162. Malapit HJL, Quisumbing AR. What dimensions of women's empowerment in agriculture matter for nutrition in Ghana? Food Policy 2015;52(Supplement C):54–63.
163. Olney DK, Bliznashka L, Pedehombga A, Dillon A, Ruel MT, Heckert J. A 2-year integrated agriculture and nutrition program targeted to mothers of young children in Burkina Faso reduces underweight among mothers and increases their empowerment: a cluster-randomized controlled trial. J Nutr 2016;146(5):1109–17.
164. Lorenzetti LMJ, Leatherman S, Flax VL. Evaluating the effect of integrated microfinance and health interventions: an updated review of the evidence. Health Policy Plan 2017;32(5):732–56.
165. Bauchet J, Marshall C, Starita L, Thomas J, Yalouris A. Latest findings from randomized evaluations of microfinance. Washington (DC): Consultative Group to Assist the Poor and World Bank; 2011.
166. Supporting Transformation by Reducing Insecurity and Vulnerability with Economic Strengthening (STRIVE) Program. The impact of savings groups on children's wellbeing: a review of the literature. Washington (DC): USAID; 2015.
167. Vir SC. Improving women's nutrition imperative for rapid reduction of childhood stunting in South Asia: coupling of nutrition specific interventions with nutrition sensitive measures essential. Matern Child Nutr 2016;12(Suppl 1):72–90.

168. Karlan D, Savonitto B, Thuysbaert B, Udry C. Impact of savings groups on the lives of the poor. Proc Natl Acad Sci U S A 2017;114(12):3079–84.
169. Gash M. Learning brief: understanding the impact of savings groups. Arlington: SEEP Network; 2017.
170. Girard AW, Self JL, McAuliffe C, Olude O. The effects of household food production strategies on the health and nutrition outcomes of women and young children: a systematic review. Paediatr Perinat Epidemiol 2012;26(Suppl 1):205–22.
171. Alderman H, Linnemayr S. Anemia in low-income countries is unlikely to be addressed by economic development without additional programs. Food Nutr Bull 2009;30(3):265–9.
172. Berti PR, Krasevec J, FitzGerald S. A review of the effectiveness of agriculture interventions in improving nutrition outcomes. Public Health Nutr 2004;7(5):599–609.
173. Bushamuka VN, de Pee S, Talukder A, Kiess L, Panagides D, Taher A, Bloem M. Impact of a homestead gardening program on household food security and empowerment of women in Bangladesh. Food Nutr Bull 2005;26(1):17–25.
174. Lloyd C. The Power of Educating Adolescent Girls: A Girls Count Report on Adolescent Girls. New York: The Population Council; 2009.
175. Taukobong HF, Kincaid MM, Levy JK, Bloom SS, Platt JL, Henry SK, Darmstadt GL. Does addressing gender inequalities and empowering women and girls improve health and development programme outcomes? Health Policy Plan 2016;31(10):1492–514.
176. Bukania ZN, Mwangi M, Karanja RM, Mutisya R, Kombe Y, Kaduka LU, Johns T. Food insecurity and not dietary diversity is a predictor of nutrition status in children within semiarid agro-ecological zones in eastern Kenya. J Nutr Metab;2014:907153.
177. Cohen AK, Rai M, Rehkopf DH, Abrams B. Educational attainment and obesity: a systematic review. Obes Rev 2013;14(12):989–1005.
178. Aitsi-Selmi A, Chen R, Shipley MJ, Marmot MG. Education is associated with lower levels of abdominal obesity in women with a non-agricultural occupation: an interaction study using China's four provinces survey. BMC Public Health 2013;13:769.
179. Ali AT, Crowther NJ. Factors predisposing to obesity: a review of the literature. J Endocrinol Metab Diabetes S Afr 2009;14(2):81–4.
180. Regassa N, Stoecker BJ. Contextual risk factors for maternal malnutrition in a food-insecure zone in southern Ethiopia. J Biosoc Sci 2012;44(5):537–48.
181. De Muro P, Burchi F. Education for Rural People and Food Security: A Cross-Country Analysis. Rome: FAO; 2007.
182. Administrative Staff College of India (ASCI). Evaluation of SABLA Scheme: A Report Submitted to the Ministry of Women and Child Development, Government of India. Hyderabad: ASCI; 2013.
183. Viner RM, Hargreaves DS, Ward J, Bonell C, Mokdad AH, Patton G. The health benefits of secondary education in adolescents and young adults: an international analysis in 186 low-, middle- and high-income countries from 1990 to 2013. SSM Popul Health 2017;3(Supplement C):162–71.
184. Grepin KA, Bharadwaj P. Maternal education and child mortality in Zimbabwe. J Health Econ 2015;44:97–117.
185. Bongaarts J, Mensch BS, Blanc AK. Trends in the age at reproductive transitions in the developing world: the role of education. Popul Stud (Camb) 2017;71(2):139–54.
186. Gebel M, Heyne S. Delayed transitions in times of increasing uncertainty: school-to-work transition and the delay of first marriage in Jordan. Res Soc Stratif Mobil 2016;46(Part A):61–72.
187. Psaki S. Addressing child marriage and adolescent pregnancy as barriers to gender parity and equality in education. PROSPECTS 2016;46(1):109–29.
188. Grant MJ. The demographic promise of expanded female education: trends in the age at first birth in Malawi. Popul Dev Rev 2015;41(3):409–38.
189. Simeon DT. School feeding in Jamaica: a review of its evaluation. Am J Clin Nutr 1998;67(4):790S–4S.
190. Greenhalgh T, Kristjansson E, Robinson V. Realist review to understand the efficacy of school feeding programmes. BMJ 2007;335(7625):858–61.
191. Alderman H. School feeding programs and development: are we framing the question correctly? World Bank Research Observer 2012;27(2):204–21.
192. Fiszbein A, Schady N, Ferreira FHG, Grosh M, Kelleher N, Olinto P, Skoufias E. Conditional Cash Transfers: Reducing Present and Future Poverty. Washington (DC): The World Bank; 2009.
193. Anthrologica, World Food Programme (WFP). Bridging The Gap: Engaging Adolescents for Nutrition, Health and Sustainable Development. Rome: World Food Programme; 2018.
194. Coady DP, Parker SW. Cost-effectiveness analysis of demand- and supply-side education interventions: the case of PROGRESA in Mexico. Rev Dev Econ 2004;8(3):440–51.
195. Davis B, Gaarder M, Handa S, Yablonski J. Evaluating the impact of cash transfer programmes in sub-Saharan Africa: an introduction to the special issue. J Dev Effect 2012;4(1):1–8.
196. Owusu-Addo E, Renzaho AM, Mahal AS, Smith BJ. The impact of cash transfers on social determinants of health and health inequalities in sub-Saharan Africa: a systematic review protocol. Syst Rev 2016;5(1):114.
197. Akresh R, de Walque D, Kazianga H. Alternative Cash Transfer Delivery Mechanisms: Impacts on Routine Preventative Health Clinic Visits in Burkina Faso. NBER Working Paper No. 17785. Cambridge, MA: National Bureau of Economic Research (NBER); 2012.
198. Filgueira F, Manzi P. Pension and Income Transfers for Old Age: Inter- and Intra-Generational Distribution in Comparative Perspective. Santiago: United Nations; 2017.
199. Case A, Menendez A. Does money empower the elderly? Evidence from the Agincourt demographic surveillance site, South Africa. Scand J Public Health Suppl 2007;69:157–64.
200. Mugomeri E, Chatanga P, Khetheng T, Dhemba J. Quality of life of the elderly receiving old age pension in Lesotho. J Aging Soc Policy 2017;29(4):371–93.
201. Duflo E. Grandmothers and granddaughters: old-age pensions and intrahousehold allocation in South Africa. World Bank Econ Rev 2003;17(1):1–25.
202. Leroy JL, Ruel M, Verhofstadt E. The impact of conditional cash transfer programmes on child nutrition: a review of evidence using a programme theory framework. J Dev Effect 2009;1(2):103–29.
203. Hoddinott J, Skoufias E, Washburn R. The Impact of PROGRESA on Consumption: A Final Report. Washington (DC): International Food Policy and Research Institute; 2000.
204. Thomas D. Intra-household resource allocation: an inferential approach. J Hum Resour 1990;25(4):635–64.
205. Hoddinott J, Haddad L. Does female income share influence household expenditures? Evidence from Côte d'Ivoire. Oxf Bull Econ Stat 1995;57(1):77–96.
206. Lloyd-Sherlock P, Agrawal S. Pensions and the health of older people in South Africa: is there an effect? J Dev Stud 2014;50(11):1570–86.
207. Medllín N, Sánchez Prada F. How does Más Familias en Acción work? Best Practices in the Implementation of Conditional Cash Transfer Programs in Latin America and the Caribbean. Technical Note No IDB-TN-884. Washington (DC): Inter-American Development Bank; 2015.
208. World Health Organization (WHO). WHO Independent High-Level Commission on NCDs. Geneva: WHO; 2018. Available from: http://www.who.int/ncds/governance/high-level-commission/en/.
209. Masters WA, Rosettie K, Kranz S, Pedersen SH, Webb P, Danaei G, Mozaffarian D; Global Nutrition and Policy Consortium. Priority interventions to improve maternal and child diets in sub-Saharan Africa and South Asia. Matern Child Nutr 2017;14(2):e12526.
210. Bhatia JC, Cleland J. Health-care seeking and expenditure by young Indian mothers in the public and private sectors. Health Policy Plan 2001;16(1):55–61.
211. UNICEF. Maternal Health. UNICEF Data: Monitoring the Situation of Children and Women [Internet]. New York: UNICEF; 2018 [cited 1 Jun, 2018]. Available from: https://data.unicef.org/topic/maternal-health/antenatal-care/#.
212. Countdown to 2030 Collaboration. Countdown to 2030: tracking progress towards universal coverage for reproductive, maternal, newborn, and child health. Lancet 2018;391(10129):1538–48.