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

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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.

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.
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

| Interventions         | Delivery platforms | Adolescent girls                                                                 | Women of reproductive age (nonpregnant, nonlactating) | Pregnant and lactating women; women with young children <5 y | Older women |
|-----------------------|--------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------------|-------------|
| Nutrition-specific interventions | 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 |            |
| Nutrition education   | Home visits        | ↑ knowledge, NC anemia, ↑ intake of Fe and ascorbic acid                           |                                                                                   | ↓ bone loss, ↑ intake dietary calcium                          |            |
|                        | Community centers  | ↑ knowledge, NC anemia, ↑ intake of Fe and ascorbic acid                           |                                                                                   | ↓ bone loss, ↑ intake dietary calcium                          |            |
|                        | Community outreach | ↑ knowledge                                                                         |                                                                                   | ↓ bone loss, ↑ intake dietary calcium                          |            |
| Worksites             | Schools            | ↑ knowledge, ↑/NC Hgb, ↓ intake of junk foods and sugar-sweetened beverages, ↓/NC BMI (↓ in Tx setting), NC weight loss, ↑ physical activity | ↑ 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, ↓ 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 anemia, ↑/NC MN status (Hgb, ferritin, folate, B-12, zinc, riboflavin), ↑/NC serum retinol, ↓/NC night blindness, ↑ weight gain, NC maternal mortality, NC depression |            |
|                       | Home visits        | ↓ anemia, ↑ Hgb, ↑ food consumption, ↑ weight gain (underweight adolescents), NC mortality, ↓ fatigue | ↓ anemia, ↑ serum folate, ↑ serum B-12, NC 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)
| Interventions | Delivery platforms | Adolescent girls | Women of reproductive age (nonpregnant, nonlactating) | Pregnant and lactating women; women with young children <5 y | Older women |
|---------------|-------------------|------------------|-----------------------------------------------------|------------------------------------------------------|------------|
| Pharmacies    |                   |                  | ↓ anemia, ↑/NC MN status [Hgb, retinol, 25(OH)D], ↑ MN status (ferritin, zinc, vitamin C, riboflavin), ↑/NC PTH, ↑ weight gain, ↑ cognitive function | ↓ anemia | ↓ anemia |
| Schools       |                   |                  | ↓ anemia, ↑ Hgb, ↓ vitamin A deficiency | ↓ anemia | ↓ anemia | 25(OH)D concentrations, ↓ PTH, ↓ bone loss, ↓ bone turnover |
| Workplace     |                   |                  | ↓ 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 | ↓ anemia, ↓ NC Hgb, ↑ serum ferritin, ↑/NC serum retinol, ↑/NC serum folate, ↑ serum ferritin, ↑ serum folate, ↑ serum zinc, ↑ NC serum retinol | 25(OH)D concentrations, ↓ PTH, ↓ bone loss, ↓ bone turnover |
| Health clinics|                   |                  | ↓ NC anemia, ↑ NC Hgb, ↑ serum ferritin, ↑ NC serum retinol, ↓ vitamin A deficiency | ↓ NC anemia and Fe-deficiency anemia, ↑ NC Hgb, ↑ NC serum retinol, ↑ erythrocyte thiamine diphosphate concentrations, ↓ night blindness, ↑/NC weight gain | ↓ NC anemia, ↑ NC Hgb, ↑ serum ferritin, ↑ NC serum retinol, ↑ serum ferritin, ↑ serum folate, ↑ serum zinc, ↑ NC serum retinol | ↓ anemia, ↑ NC Hgb, ↓ serum ferritin, NC serum retinol, ↑ serum calcium, ↑ 25(OH)D concentrations, ↓ PTH, ↓ bone turnover |
| Home visits   |                   |                  | ↑ NC anemia, ↑ Hgb, ↑ serum retinol, ↑ urinary iodine, ↓ vitamin A deficiency | ↑ NC anemia and Fe-deficiency anemia, ↑ NC Hgb, ↑ NC serum retinol, ↑ erythrocyte thiamine diphosphate concentrations | NC anemia, ↑ NC Hgb, ↑ MN status (folate, zinc, retinol, iodine), NC weight gain/BMI | NC anemia, ↑ MN status (folate, zinc, retinol, iodine), NC weight gain/BMI |
| Community centers |       |                  | ↑ NC anemia, ↑ Hgb, ↑ serum retinol, ↑ urinary iodine, ↓ vitamin A deficiency | ↑ NC anemia and Fe-deficiency anemia, ↑ NC Hgb, ↑ NC serum retinol, ↑ erythrocyte thiamine diphosphate concentrations | ↑ 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 diarrhea 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          | 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, 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 | NC pre-eclampsia, NC BMI, ↑/NC gestational weight gain, ↓ weight gain in overweight women, ↑ ANC coverage | NC BMI, ↑/NC gestational weight gain, ↑ food consumption, ↑ intake of protein and fat nutrition knowledge and practices, ↑/NC BMI, ↑/NC gestational weight gain, ↑ ANC coverage | ↑/NC food consumption | |
| Energy and protein supplementation        | Health clinics              | ↓/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) | |
| Home visits                                |                             |                                                                                  | |
| 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) | |
| Schools                                    | ↑ BMI, ↑ weight, ↑ MUAC, ↑ body fat, ↑ work capacity, ↑ 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)
| Interventions                  | Delivery platforms | Adolescent girls | Women of reproductive age (nonpregnant, nonlactating) | Pregnant and lactating women; women with young children <5 y | Older women |
|-------------------------------|-------------------|------------------|-------------------------------------------------------|-------------------------------------------------------------|-------------|
| Home visits                   |                   |                  |                                                       |                                                             |             |
| Nutrition-sensitive interventions
  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 |
| Home visits                   | ↑ MN provision, ↑ knowledge about FP, NC use of FP | ↑ MN provision, ↑ knowledge about FP, NC use of FP |
| Community centers             | ↑ MN provision, ↑ knowledge about FP, ↑/NC use of FP | ↑ MN provision, ↑ knowledge about FP, ↑/NC use of FP |
| Water, sanitation, and hygiene|                   |                  |                                                       |                                                             |             |
| Clinic-based                  |                   |                  |                                                       |                                                             |             |
| 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 |
| Community centers             | ↑/NC knowledge about hygiene and sanitation, ↑ water quality, ↓ diarrheal morbidity | ↑/NC knowledge about hygiene and sanitation, ↑ water quality, ↓ diarrheal morbidity |

Outcomes

- ↑ 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
- ↓/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
| Interventions                      | Delivery platforms | Adolescents            | Women of reproductive age (nonpregnant, nonlactating) | Pregnant and lactating women; women with young children <5 y | Older women                                      |
|-----------------------------------|--------------------|------------------------|------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------|
| Schools                           |                     | ↑ knowledge about hygiene, ↑ hand-washing, ↓ diarrhea, ↑ school attendance (when school facilities) | ↑ knowledge about hygiene, ↑ hand-washing, ↓ diarrhea morbidity | ↑ knowledge about hygiene, ↑ hand-washing, ↓ diarrhea morbidity, ↓ NC waste disposal, ↓ NC hand-washing | ↑ knowledge about hygiene, ↑ hand-washing, ↓ diarrhea morbidity, ↓ NC waste disposal, ↓ NC hand-washing |
| Community mobilization (e.g., radio) Infrastructure |                     | ↑ knowledge about hygiene, ↑/NC hand-washing, ↓ diarrhea morbidity | ↓ water point distance, ↑ time savings, ↑/NC women's hygiene, ↑/NC water quality, ↓/NC diarrheal morbidity, ↓ intestinal parasite prevalence, NC wage employment | ↑ knowledge about hygiene, ↑ hand-washing, ↓ diarrhea morbidity, ↓ NC waste disposal, ↓ NC hand-washing, ↓ 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 | ↑ knowledge about hygiene, ↑ hand-washing, ↓ diarrhea morbidity, ↓ NC waste disposal, ↓ NC hand-washing, ↓ 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 |
| Family planning and birth spacing | Clinic-based        | ↑/NC knowledge about FP, ↑/NC use of FP | ↑/NC knowledge about 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 | ↓ 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 | 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 | ↓ maternal mortality, ↑ use of FP, ↑ interbirth spacing |
| Community mobilization Schools    |                     | ↑ knowledge about FP    | ↑ knowledge about FP | ↑ use of FP, ↑ knowledge about FP | ↑ use of FP, ↑ knowledge about FP |
| 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 | ↑ nutrition knowledge, ↓/NC anemia, ↑ food expenditures, ↑ 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, ↑ 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 |
| 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, ↑ 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 | ↑ nutrition knowledge, ↓/NC anemia, ↑ food expenditures, ↑ HH food security, ↑ HH food consumption, ↑ 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 | ↑ nutrition knowledge, ↓/NC anemia, ↑ food expenditures, ↑ HH food security, ↑ HH food consumption, ↑ 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 |

(Continued)
| Interventions            | Delivery platforms | Adolescent girls (nonpregnant, nonlactating) | Women of reproductive age (nonpregnant, nonlactating) | Outcomes                                  | Pregnant and lactating women; women with young children <5 y | Older women                                                                 |
|--------------------------|--------------------|-----------------------------------------------|-------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------|
| Income-generating activities | Mass media Home visits | ↑ nutrition knowledge ↑ health knowledge, ↑ health care utilization, ↓ poverty | ↓ nutrition knowledge, ↓ intake of ASF ↑ nutrition knowledge, ↓ anemia, ↓ NC night blindness, ↑ intake of vitamin A-rich foods, ↑ NC intake of vegetables, ↑ intake of ASF, ↓ overweight, ↑ health care utilization, ↓ poverty | ↑ 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, ↓ overweight, ↑ weight gain, NC diarrheal morbidity, ↑ self-confidence, ↑ NC decision-making, ↑ control HH resources | ↑ 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 | ↑ nutrition knowledge, ↑ intake of vitamin A-rich foods, ↑ intake of ASF ↑ nutrition knowledge, NC health status, ↑ NC HH food security, ↑ NC individual food security, ↑ NC food expenditures, ↑ NC BMI, ↑ weight gain, ↑ social status, ↑ NC decision-making | ↑ nutrition knowledge, ↑ intake of vitamin A-rich foods, ↑ intake of ASF ↑ nutrition knowledge, NC health status, ↑ NC food expenditures, ↑ NC school enrollment, ↑ NC empowerment, ↑ NC decision-making power, ↑ self-confidence, ↑ NC health care utilization | ↑ health knowledge, ↑ NC HH food security, ↑ NC food consumption, ↑ dietary diversity, ↑ self-confidence, ↑ NC decision-making |
| Community mobilization  | Microcredit institution | NC HH food security, NC individual food security, NC food expenditures, NC food consumption, ↑ social status, ↑ self-confidence | ↑ nutrition knowledge | ↑ nutrition knowledge, NC health status, NC HH food security, NC individual food security, ↑ NC food expenditures, NC school enrollment, ↑ NC empowerment, ↑ self-confidence, ↑ NC decision-making, ↑ social status, ↑ NC health care utilization | NC health status, ↑ NC food expenditures, ↑ NC empowerment, ↑ NC decision-making power, ↑ self-confidence, ↑ NC health care utilization | NC health status, ↑ 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 | | | | |
| Interventions           | Delivery platforms                        | 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 | ↑ 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 | ↑ 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 |
| 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, ↑ self-confidence, ↑ participation in social networks, ↑ 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 | ↑ 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 |

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.
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 non-pregnant 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 noncommu-
nicable 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, I
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 im-
proved 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 in-
terventions 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
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) 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 how interventions might need to adapt to account for differences in 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.

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