Maternal Undernutrition before and during Pregnancy and Offspring Health and Development

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Key Messages

- Maternal undernutrition remains a critical public health problem with large regional and within-country disparities in the burden of underweight, anemia, and micronutrient deficiencies across the globe.
- Maternal preconception nutrition may influence birth outcomes and merits further research and program focus.
- Several evidence-based strategies exist to improve maternal nutrition during pregnancy; however, there remain key gaps in program implementation and equity.

Keywords

Maternal undernutrition · Micronutrients · Child growth and development

Abstract

Maternal undernutrition remains a critical public health problem. There are large regional and within-country disparities in the burden of underweight, anemia, and micronutrient deficiencies across the globe. Driving these disparities are complex and multifactorial causes, including access to health services, water and sanitation, women's status, and food insecurity as well as the underlying social, economic, and political

context. Women's health, nutrition, and wellbeing across the continuum of preconception to pregnancy are critical for ensuring positive pregnancy and long-term outcomes for both the mother and child. In this review, we summarize the evidence base for nutrition interventions before and during pregnancy that will help guide programs targeted towards women's nutrition. Growing evidence from preconception nutrition trials demonstrates an impact on offspring size at birth. Preconception anemia and low preconception weight are associated with an increased risk of low birth weight and small for gestational age births. During pregnancy, several evidence-based strategies exist, including balanced-energy protein supplements, multiple micronutrient supplements, and small-quantity lipid nutrient supplements for improving birth outcomes. There, however, remain several important priority areas and research gaps for improving women's nutrition before and during pregnancy. Further progress is needed to prioritize preconception nutrition and access to health and family planning resources. Additional research is required to understand the long-term effects of preconception and pregnancy interventions particularly on offspring development. Furthermore, while there is a strong evidence base for maternal nutrition interventions, the next frontier requires a greater focus on implementation science and equity to decrease global maternal undernutrition disparities.

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Introduction

Maternal undernutrition remains a critical public health problem across the globe. While there is growing recognition of the importance of maternal nutrition for child health and development, women's nutrition has historically not received the political or program prioritization required to make meaningful progress. In this review, we summarize the current global status of women's nutrition, provide an overview of the driving causes and consequences of maternal undernutrition, and summarize the evidence base for nutrition interventions before and during pregnancy that will help guide programs targeted towards women's nutrition.

Global Status of Maternal Undernutrition

Globally, 9.7% of women are underweight and 14.9% are obese [1]. While the obesity epidemic is growing, the persistence of underweight in some countries in South Asia and central and east Africa remains unacceptably high. There are large regional and within-country disparities in the burden of underweight, with the highest burden among the *poorest*

women in the poor countries [2]. This is concerning given that both over- and undernutrition are associated with poor birth outcomes [3]. Maternal overweight and obesity are associated with increased maternal morbidity, preterm birth (PTB), and infant mortality [3]. Maternal underweight is likewise associated with offspring growth and development, including increased risk for PTB, low birth weight (LBW), under-five mortality, and poor mental and physical development [3]. Another major public health problem that affects women of reproductive age disproportionately is anemia, which has been associated with an increased risk of poor birth outcomes (LBW, PTB, small for gestational age, stillbirth, and perinatal and neonatal mortality) and adverse maternal outcomes (maternal mortality, postpartum hemorrhage, preeclampsia, and blood transfusion) [4]. Globally, 29% of nonpregnant women and 38% of pregnant women are anemic [5]. Similar to underweight, there are large disparities in the global burden of anemia, particularly across South Asia and Central and West Africa (Fig. 1). The etiology of anemia is diverse and context specific, but a high burden of anemia may be an indicator of an even greater burden of micronutrient deficiencies among women. It is estimated that approximately 50% of anemia among nonpregnant and pregnant women is amenable to

Fig. 1. Global prevalence of anemia in pregnant women. Reproduced from World Bank [92].

iron supplementation; however, at the national and sub-national level, the role of iron deficiency in anemia has been shown to be extremely variable from <1 to 75% [6] and may be influenced by many conditions, including malaria, infection, hemoglobinopathies, or other micronutrient deficiencies (folate, vitamins B₁₂ and B₆, riboflavin, vitamins A and C). The World Health Organization (WHO) estimates that over two billion people are at risk for micronutrient deficiencies [7]. Micronutrient deficiencies of public health concern include iron, vitamin A, iodine, zinc, folate, and B vitamins. Figure 2 illustrates the current regional estimates of micronutrient deficiencies and anemia among women of reproductive age across the globe [8].

Conceptual Framework

The conceptual framework shown in Figure 3 provides an overview of the underlying complex and multifactorial causes and consequences of maternal undernutrition. This conceptual framework has been adapted based on the current understanding of the causes of child malnutrition [9–14]. Distal causes of malnutrition include social, economic, and political context and lack of capital (financial, human, physical, social, and natural). These factors may affect maternal and child health either directly or indirectly, through more proximal factors, including access to health services, water and sanitation, women's status, and food insecurity. Poor water and sanitation increase the risk for infectious diseases, malnutrition, and mortality and may disproportionately affect women [15–18]. Women's status, including reduced access to education, ear-

ly age at marriage, limited maternal empowerment, and gender inequality, remain critical barriers across the globe. In addition, 9.3% of the population are affected by severe food insecurity, with a slightly higher prevalence among women. Food insecurity is a key driver of poor nutrition across the globe and can be influenced by food affordability, availability, and distribution of food among household members [19]. Collectively, these factors influence the conditions (inadequate dietary intake, care for women, and disease) before pregnancy and during pregnancy. Diet quality remains a major concern globally [20], and women are particularly vulnerable. The vicious cycle of inadequate dietary intake and disease is well known. Poor nutrition lowers immunity and increases susceptibility to disease; disease in turn perpetuates poor nutrition by decreasing appetite, inhibiting nutrient absorption and increasing risk for micronutrient deficiencies and undernutrition.

Care for women includes women having adequate access to food and health care to prevent illness, availability of fertility regulation and birth spacing options, sufficient time for rest, and protection from abuse [11, 21]. Women who marry early are more likely to have children at a young age, when they are still growing and developing themselves. Adolescent pregnancy can adversely affect both maternal health and nutrition and increase the risk for poor birth outcomes [22]. In some contexts, women may have limited decision-making authority on the number of children or when they have them [23]. Early age at pregnancy and short interpregnancy intervals (<6 months) have been associated with increased risks for adverse pregnancy outcomes (PTB, LBW, stillbirth, and early neonatal death), highlighting the importance of women's

Fig. 2. Regional estimates of micronutrient deficiencies and anemia among women of reproductive age. Reproduced from Bourassa et al. [8], 2019. Data calculated from 52 national and regional surveys, published between 2013 and July 2017 using the World Health Organization VMNIS database. Missing bars means no data were found for that micronutrient in the specific region. LMIC, low- and middle-income countries; IDA, iron deficiency anemia. Black circles are not representative (<3 countries).

Fig. 3. Conceptual framework of the causes and consequences of maternal undernutrition. The conceptual framework provides an overview of the underlying complex and multifactorial causes and consequences of maternal undernutrition. This conceptual framework has been adapted based on the current understanding of the causes of child malnutrition [9–14].

health and nutritional status prior to conception [24–26]. Women who experience interpersonal violence may also be at increased risk of poor pregnancy outcomes [27]. The importance of a woman's nutrition before pregnancy, especially during adolescence and preconception, on infant and maternal outcomes is gaining recognition [28–31]; and this connection is both through the direct effect on outcomes as well as indirectly through influencing a woman's nutritional status during pregnancy.

Maternal short stature is a risk factor for caesarean delivery and complications at childbirth [32]. A woman's height is a product of her poor nutritional status as a child and is an important predictor of her own child's health as well. For example, in India, maternal height has been associated with child mortality, growth failure, and anemia [33]. Likewise, other measures of maternal nutritional status, such as her body mass index (BMI) or weight gain during pregnancy, are associated with adverse birth outcomes, such as LBW, PTB, and intrauterine growth restriction [30, 34–36]. As described in further depth below, maternal anemia and micronutrient status are likewise powerful determinants of pregnancy outcomes

and child health and nutrition [37]. Collectively, women's health, nutrition, and wellbeing across the continuum of pre-conception through pregnancy are critical for ensuring positive pregnancy and long-term outcomes for both the mother and child.

Importance of Maternal Nutritional Status before and during Pregnancy

The nutritional and health status of women as they enter pregnancy may play a key role in placental function and subsequent growth and development of the fetus [38, 39]. The placenta regulates nutrient availability for fetal growth and ultimately influences the long-term health of the newborn. Periconceptional nutrition may also influence offspring health and cognitive outcomes by affecting the growth and development of the brain, liver, and pancreas during the first few weeks of pregnancy [29]. Animal studies have shown that fetal growth and development are sensitive to maternal nutrition during implantation [38, 40]. Dietary restriction studies in

Table 1. Preconception nutrition interventions and impact on maternal and child health outcomes

Setting	Design	Impact	First author [ref.], year
Mumbai, India	RCT of micronutrient- and energy-dense snack before and/or during pregnancy	Women with a BMI >21.5 kg/m ² , who took the snack for at least 90 days prior to conception, gave birth to heavier babies (~113 g) when compared to those who received the intervention only during pregnancy	Potdar [49], 2014
Vietnam	RCT of preconception weekly supplements containing multiple micronutrients, iron-folate, or folic acid (PRECONCEPT; NCT 1665378)	No differences in birth outcomes in the intent-to-treat analysis; however, birthweight was ~60 g higher for offspring born to women who received the weekly MM supplement for at least 6 months compared to the other 2 groups	Ramakrishnan [50], 2016
India, Pakistan, Guatemala, and the Democratic Republic of Congo	Multisite RCT of lipid-based micronutrient supplement (WOMENS First trial)	Significant increases in mean birth length of offspring born to women who received lipid-based micronutrient supplements daily for at least 3 months before conception through pregnancy when compared to those born to women who received only routine prenatal care	Hambidge [51, 52], 2014, 2019

normal and overweight sheep have demonstrated the programming effects of periconceptional nutrition on fetal adipose tissue development and regulation of IGF1R signaling pathway postnatally [41, 42]. Findings from the Dutch Famine Study have also documented alterations in epigenetic signatures among offspring born to women exposed to acute malnutrition during the periconceptional period [43]. Micronutrients, including iron, zinc, folic acid (FA), and other vitamins, contribute to genome-wide alterations and/or epigenetic modifications during the crucial period of organogenesis [29]. These changes influence subsequent outcomes, such as body composition and cognitive function [44, 45].

Evidence, primarily from observational studies, shows that fetal growth during the first trimester is especially sensitive to preconceptional nutrition [38]. A systematic review by Young et al. [4] has shown that preconception anemia was associated with an increased risk of LBW and small for gestational age (SGA) births, while anemia in the first trimester of pregnancy was associated with LBW, PTB, and neonatal mortality. Studies have also demonstrated the role of maternal preconception nutrition on child linear growth from conception through the child's second birthday (the "first 1,000 days") [46, 47]. Women with a preconception weight less than 43 kg or a gestational weight gain less than 8 kg were around 3 times more likely to give birth to a SGA or LBW infant. Furthermore, women with preconception height less than 150 cm or a weight less than 43 kg were at nearly twice the increased risk of having a stunted child at age 2 years. The ev-

idence based on intervention studies that have been conducted before and during pregnancy is summarized in the following sections.

Maternal Nutrition Interventions and Birth Outcomes

In a systematic review that evaluated the role of nutrition interventions or exposures that were measured before 12 weeks' gestation but did not continue through pregnancy, Ramakrishnan et al. [30] found that most studies were observational and focused primarily on perinatal outcomes, including birth defects, pregnancy loss, or stillbirths. The quality of the evidence was also low to very low, with the exception of intervention trials that demonstrated the benefits of providing periconceptional FA to reduce the risk of birth defects, especially neural tube defects [48]. More recently, a few randomized controlled trials (RCTs) have evaluated the benefits of preconception nutrition interventions on maternal and child health outcomes as summarized in Table 1 [49–51]. In a trial conducted in Mumbai, India, low-income urban women were recruited prior to conception and randomized to receive a micronutrient and energy-dense snack before and/or during pregnancy [49]. This study found that among women with a BMI >21.5 kg/m², those who took the snack for at least 90 days prior to conception gave birth to heavier babies (~113 g) when compared to those who received the intervention only during

pregnancy; effects on offspring growth and development have not been reported. Ramakrishnan et al. [50] evaluated the benefits of providing preconceptional weekly supplements containing multiple micronutrients (MMs), iron-folate (IFA), or FA in a large RCT (PRECONCEPT) that was conducted in rural Vietnam. All women who conceived received daily prenatal IFA supplements. Although there were no differences in birth outcomes in the intent-to-treat analysis, birth-weight was ~60 g higher for offspring born to women who received the weekly MM supplement for at least 6 months compared to the other 2 groups [50]. Finally, findings from the WOMENS First trial, a large multisite RCT conducted in India, Pakistan, Guatemala, and the Democratic Republic of Congo, showed significant increases in mean birth length of offspring born to women who received lipid-based micronutrient supplements daily for at least 3 months preconception through pregnancy when compared to those born to women who received only routine prenatal care [52].

In contrast to the dearth of evidence for preconception interventions, considerable evidence has accumulated over the past few decades on the benefits of improving maternal nutrition during pregnancy. Several evidence-based interventions for improving maternal and child nutrition across the lifecycle have been reviewed, including a range of approaches from population-level fortification, nutrition education, and targeted supplementation for vulnerable populations [53]. Although prenatal IFA supplementation has been standard of care for over 50 years, recent evidence has demonstrated a promising impact of prenatal balanced energy protein supplements, MM supplements, and small-quantity lipid nutrient supplements for improving birth outcomes. Balanced protein and energy supplements reduced the risk of stillbirth by 40% and of SGA by 21%, and mean birth weight was increased by 41 g [54]. Several recent reviews of prenatal MM supplements have demonstrated clear benefits for cost-effectively improving birth outcomes; thus, leading to calls for revised WHO guidelines to support widescale adoption and replacement over traditional IFA supplementation programs [8, 55–60]. MM supplementation in pregnancy reduced the risk of LBW by 12–14%, PTB by 8–4%, and being born SGA by 8–3%, depending on the analytic approach used in a Cochrane Review meta-analysis versus an individual participant data meta-analysis [8, 55, 56]. Although some concerns about a potential increase in the risk of neonatal mortality associated with MM supplementation have been raised in the past, updated analyses indicate no adverse risk. Results from the Smith et al. [56] seminal paper on modifiers of the effect of prenatal MMs (Fig. 4) demonstrated improved survival of female offspring and increased benefits of micronutrient supplementation among infants born to undernourished or anemic mothers.

Another promising intervention are small-quantity lipid-based nutrient supplements that have shown improved birth weight (53.3 g) and birth length (0.24 cm) compared to IFA supplements [61].

Maternal Nutrition and Offspring Growth and Body Composition

To our knowledge, very few studies have examined the role of preconception micronutrient status on later offspring growth and body composition, including fat mass (FM), lean body mass, bone mineral content (BMC), and bone mineral density. The PRECONCEPT trial showed differences in offspring linear growth during the first 2 years of life. At age 2 years, children in the IFA group had significantly higher length-for-age z scores (LAZ; 0.14; 95% CI: 0.03, 0.26), reduced risk of being stunted (0.87; 95% CI: 0.76, 0.99), and smaller decline in LAZ from birth (0.10; 95% CI: 0.04, 0.15) than the children in the FA group. Similar trends were found for the children in the MM group compared with the FA group for LAZ (0.10; 95% CI: 0.02, 0.22) and the risk of being stunted (0.88; 95% CI: 0.77, 1.01) [62]. Although data on the effect of preconception nutrition on body composition are lacking, there is some evidence suggesting that micronutrient intakes during pregnancy may affect later offspring body size and composition as described below.

Micronutrient intakes during pregnancy may affect later offspring body size and composition

Several studies have evaluated the effects of prenatal nutrition on offspring growth during early childhood and beyond. Most notably, follow-up studies of the food-based supplementation trials that were conducted in the 1970s to 1980s have shown improved child growth and attained adult height among the offspring, but many of these interventions were not restricted to the prenatal period [63]. Devakumar et al. [64] (2016) conducted a systematic review of studies that included follow-up data from 6 RCTs and found no differences in weight-for-age z score (0.02; 95% CI: –0.03 to 0.07), height-for-age z score (0.01; 95% CI: –0.04 to 0.06), or head circumference (0.11 cm; 95% CI: –0.03 to 0.26) among offspring born to women who received antenatal MM supplements compared to routine IFA. Some of the limitations of these studies, however, are the variation in the age at follow-up and loss to follow-up.

Fig. 4. Modifiers of the effects of prenatal MM supplementation on birth outcomes. Reproduced from Smith et al. [56], 2017.

In Nepal, antenatal supplementation with FA, iron, and zinc resulted in lower offspring adiposity as assessed by skinfold thicknesses at age 6–8 years [65]. Maternal multivitamin use was also associated with a slower rate of FM accretion during infancy compared to offspring of control women (non-users) in the United States [66]. Regarding bone density, increased maternal intake of calcium-rich foods and higher folate status during mid-pregnancy were associated with greater offspring BMC and bone mineral density at age 6 years in India [67]. Findings from a Dutch cohort study (median age, 6 years) showed that vitamin B₁₂ status during the first trimester was associated with greater offspring BMC, adjusted for total bone area [68]. Overall, there is a lack of consistent and robust data on the influence of maternal micronutrient intake, either before or during pregnancy, on offspring body composition. Additionally, the effects of precon-

ceptional micronutrient intakes may only emerge during the pre-pubertal years of 9–14 years when rapid adipose tissue deposition occurs [69]. Potential mechanisms include epigenetic modifications that may occur early in pregnancy and influence offspring body composition in late childhood. For example, hypermethylation of the umbilical retinoic acid X-receptor, a key regulator of adipocyte proliferation, has been associated with increased offspring FM at 9 years of age [70].

Maternal Nutrition before and during Pregnancy Is Important for Brain Development and Cognitive Functioning

Brain development begins shortly after conception [71, 72]. Most of the structural features of the brain appear during the embryonic period (about the first 8 weeks after fertilization); these structures then continue to grow and develop throughout pregnancy [71, 72]. Iron, in particular, plays an important role in early fetal brain development [73], and other micronutrients, such as vitamin B₆, B₁₂, FA, and zinc, are influential [74]. FA, vitamin B₁₂, and zinc participate in brain DNA and RNA synthesis, which begins early in gestation [75]. Vitamin B₁₂ has also been shown to affect myelination, which begins during gestation and may affect cognitive functioning [76, 77]. As women may not realize they are pregnant during the first 1–2 months, optimal nutrition prior to pregnancy is critical.

A systematic review by Larson and Yousafzai [78] that included 10 prenatal trials that evaluated a variety of nutrition interventions (macro- and/or micronutrients) did not find a significant impact on young child mental development. Most of these studies were conducted in low- to middle-income

countries in Asia and Africa, but important limitations included sample size/power and sensitivity of tests to assess mental development in children under 2 years. Findings from the PRECONCEPT trial showed that children in the IFA group had improved motor development assessed by the Bayley Scales of Infant Development (BSID), especially fine motor development (IFA vs FA: 0.41; 95% CI: 0.05, 0.77), but there were no significant differences in Bayley mental or language scores [62]. Both early nutritional status and home learning environment were also associated with child development in this

sample [79]. Preliminary results from the most recent follow-up that was conducted when the offspring were aged 6–7 years show promising differences by treatment group. The Wechsler Intelligence Scale for Children IVth edition (WISC-IV®) was used to measure global intelligence, verbal comprehension, memory, and executive func-

tioning and compared to the FA group; offspring in the MM group had higher IQ scores as well as working memory and processing speed. These differences were also stronger among the subgroup of children born to women who received the preconception intervention for at least 6 months, and there is also evidence of effect modification by baseline socioeconomic status (SES), indicating that MM attenuated the effects of SES on perceptual reasoning and IQ [80]. Important strengths of this study include the low rates of attrition (<10%) and that the groups were balanced on several baseline characteristics including SES and maternal education.

Two large studies, from Nepal and Indonesia, have also documented the impact of maternal micronutrient supplementation on cognitive functioning in school-age children [81, 82]. In Nepal, working memory, inhibitory control, and fine motor functioning at age 7–9 years were positively associated with prenatal IFA supplementation [81]. In Indonesia, MM supplementation that began early in pregnancy had long-term benefits for cognitive development at age 9–12 years compared to IFA, including positive associations with procedural memory and general intellectual ability (for children of anemic mothers) [82]. This study also noted the importance of measuring socio-environmental determinants, such as home environment and maternal depression, which were strongly associated with school-age cognitive, motor, and socio-emotional scores. However, concerns about the limited findings and null results from follow-up studies in other settings like China and Tanzania have been raised, and further

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Table 2. Program priority areas and research gaps for improving women's nutrition before and during pregnancy

Key priority areas for research and programs
<ul style="list-style-type: none">• Program prioritization is needed to improve access and counseling on family planning (delayed age at first pregnancy, inter-pregnancy interval) and preconception care• Additional research is required to understand the long-term effects of periconceptional nutritional supplementation on later cognitive outcomes, including aspects of intellectual functioning, executive function, and academic achievement• Greater research and program focus on implementation science is required to develop effective strategies to scale up evidence-based maternal nutrition interventions• Political and program support is needed for the promotion and scale up of multiple micronutrient supplement programs among women• Research on long-term impact of multiple micronutrient supplementation during pregnancy• Strong formative research is needed to contextualize and develop multiple micronutrient supplementation programs to help overcome prior barriers with iron and folic acid programs• An enhanced program focus on equity is required to ensure programs are reaching vulnerable and marginalized communities in order to decrease global maternal undernutrition disparities

research is needed to better understand the long-term health effects on maternal and child health [60, 83].

Finally, long-term studies from Guatemala have demonstrated the benefits of nutritional supplementation during the first 1,000 days of life on cognitive outcomes in later childhood and adolescence, effects which were considerably larger than those seen in early childhood [84–88]. At ages 3–7 years, there was only a small effect (<0.2 standard deviation) of the Atole-Fresco differences compared to medium to large effects (0.6 standard deviation) during adolescence/young adulthood (11–26 years). Although the findings are mixed for the influence of prenatal docosahexaenoic acid (DHA) on cognitive outcomes, especially during the first 2 years of life [89], there is evidence of a small but significant effect of prenatal DHA on measures of attention in the offspring at age 5 years in Mexico, and higher global scores of intelligence among those from poorer home environments when compared to those in the placebo group [90]. Results from the MAL-ED longitudinal cohort corroborate the importance of a nurturing home environment, adequate micronutrient status, and maternal reasoning on child cognitive function at age 5 years [91]. These studies highlight the importance of assessing the impact of maternal nutrition interventions on cognitive outcomes in later childhood and adolescence.

Priority Areas and Research Gaps for Improving Women's Nutrition before and during Pregnancy

Despite recent progress and shifts in global agenda, women's nutrition has historically not received sufficient political or program prioritization. Furthermore, narrowing the focus of

women's nutrition to the pregnancy window may limit the effectiveness of interventions. This is particularly critical in settings of severe food insecurity with high rates of anemia, micronutrient deficiencies, and undernutrition and where women may not enter antenatal care until into the second or third trimester. Simply put, maternal nutrition interventions in these settings may be *too little, too late*. Table 2 outlines several program priorities areas and research gaps for improving women's nutrition. While efforts to improve timely and quality antenatal care that includes interventions that effectively address the nutrient gaps during pregnancy need strengthening, greater program prioritization is needed to reach women earlier to provide preconception care and family planning services. Programs focused on school-age or adolescent girls have also been identified as promising strategies for reaching women earlier. A notable gap in the field includes research examining the long-term effects of periconceptional nutritional supplementation on later cognitive outcomes, including aspects of intellectual functioning, executive function, and academic achievement. Examining these effects during early adolescence is particularly important as effects of early-life experiences may become more pronounced at later ages. Further, the role of improving maternal nutrition right before and during the periconceptional period, along with the home environment, on later cognitive outcomes can provide much needed information on the relative importance of early nutrition and socio-environmental factors on cognitive outcomes.

During pregnancy, we have several evidence-based maternal nutrition interventions. However, while it is clear we know *what to do*, challenges remain in knowing *how to do it at scale*? Research and program focus on implementation science is required to develop effective strategies to scale up

evidence-based maternal nutrition interventions. For example, providing MM supplements during pregnancy is a highly effective strategy for improving birth outcomes; however, there is limited national policy adoption and evidence of impact at scale. Further political and program advocacy is needed for the promotion and scale up of multiple micronutrient supplement programs among women. In addition, strong formative research is needed to contextualize and develop MM supplementation programs to help overcome prior barriers with IFA programs. Finally, an enhanced focus on equity is re-

quired to ensure programs are reaching vulnerable and marginalized communities in order to decrease global maternal undernutrition disparities.

Conflict of Interest Statement

The writing of this article was supported by Nestlé Nutrition Institute and the authors declare no other conflicts of interest.

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