

**Improving Nutrition and
Reproductive Health:
The Importance of
Micronutrient Nutrition**

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Executive Summary

The improved nutritional status of women, particularly during their childbearing years, is an important element of reproductive health. Efforts to improve women's nutrition and health include increasing food intake at all stages of the life cycle, eliminating micronutrient deficiencies, preventing and treating parasitic infections, reducing women's workload, and reducing unwanted fertility.

This paper outlines the critical role of maternal nutrition and, in particular, micronutrients to reproductive health. The micronutrient status of women in developing countries affects their health during pregnancy and lactation, the outcomes of their pregnancies, and the health of their infants. For women who are vitamin and nutrient deficient, improving micronutrient intake can be an important means of reducing maternal morbidity and mortality.

Micronutrient malnutrition is primarily the result of inadequate dietary intake. Dietary surveys in developing countries have consistently shown that multiple micronutrient deficiencies, rather than single deficiencies, are common, and that low dietary intakes and poor bioavailability of micronutrients account for the high prevalence of these multiple deficiencies. Recent evidence concerning increased micronutrient supplementation suggests the following findings:

- Enhancing vitamin A intake reduces maternal mortality.
- Increasing calcium and magnesium intake can reduce the risk of death from eclampsia.
- Ensuring adequate intake of iron, zinc, iodine, calcium, magnesium, and folic acid during pregnancy can improve pregnancy outcome.
- Increasing the intake of folic acid before pregnancy can reduce birth defects.
- Providing zinc, calcium, and magnesium supplements during pregnancy can improve birthweight and reduce prematurity, especially among high-risk women.
- Improving the maternal intake of many nutrients directly enhances the quality of breast milk.

In addition, micronutrients play an essential role in the function of the immune system, and deficiencies in them influence the rate, duration, and severity of infections. Infection rates during pregnancy or lactation, including reproductive tract infections, increase because of deficiencies in iron, vitamin A, and zinc. Also, low serum vitamin A levels in pregnant women have been associated with increased transmission of HIV to infants and with increased transition from HIV to AIDS and increased mortality from AIDS among infants.

The consequences of malnutrition affect the ability of women to sustain work and care for their families. Solutions to prevent or eliminate micronutrient malnutrition include nutrient supplementation of women of childbearing age before and after pregnancy through repeated reproductive cycles. Combined supplements are usually more effective in improving micronutrient status than single supplements, since women are usually deficient in more than one micronutrient. In addition, universal or targeted food fortification, which has proved cost-effective, can be an important strategy in preventing micronutrient malnutrition.

Improving Nutrition and Reproductive Health: The Importance of Micronutrient Nutrition

Background

Food and nutrition are essential for good health. However, chronic energy deficiency and stunting among women in developing countries are the results of malnutrition during fetal development, infancy, and childhood with low energy intakes continuing into adulthood. Recent evidence suggests that vitamin A deficiency in women may increase the risk of death. Anemia contributes to 20 percent of the maternal deaths in Africa and 23 percent in Asia and is associated with poor birth outcomes such as low birthweight and prematurity. Mild maternal zinc deficiency has been related to complications of labor and delivery, including placental abruption, prolonged labor, premature rupture of the membranes, and the need for assisted or operative delivery. Also, low calcium intakes have been associated with hypertensive disorders and preeclampsia.

An important element of reproductive health is improved nutritional status of women of childbearing years. This paper outlines the critical role of maternal nutrition and, in particular, micronutrients to reproductive health. Reproductive health refers to the period beginning at adolescence when a woman is potentially fertile and continues throughout pregnancy and lactation and between all subsequent pregnancies.

Micronutrients play an essential role in the function of the immune system, and deficiencies in them influence the rate of infections as well as their duration and severity. Adequate folate levels at conception, for instance, are associated with reduced neural tube defects. Multiple supplements are beneficial in preventing cleft palate and other birth defects. Micronutrient status in breastfeeding women affects the quality of their breast milk, which in turn affects their infants' growth and development. Efforts to improve women's nutrition and health include increasing food intake at all stages of the life cycle, eliminating micronutrient deficiencies, preventing and treating parasitic infections, reducing women's workload, and controlling fertility.

The Evidence: Intakes and Prevalence

Micronutrient malnutrition is primarily related to inadequate dietary intake. Dietary surveys in developing countries have consistently shown that multiple micronutrient deficiencies, rather than single deficiencies, are common, and that low dietary intake and poor bioavailability of micronutrients account for the high prevalence of these multiple deficiencies. Huffman et al. (1998) summarized evidence of poor micronutrient intake among women. In India, the results of several countrywide surveys found that pregnant and lactating women have low intakes of several nutrients, especially iron, vitamin A, riboflavin, and calcium (Banji and Lakshmi, 1998). The WHO (1996) reported dramatic prevalence figures for anemia in pregnant women ranging from 20 percent in Europe to 79 percent in South East Asia (see Table 1). In populations in which large amounts of iron come from vegetable sources, such as cereals and legumes, iron bioavailability is low because of inhibiting factors such as phytates and tannins (FAO/WHO, 1988). Absorption of iron from iron-containing foods eaten with high tannin foods may be as low as 1 or 2 percent.

The WHO summarized the prevalence of vitamin A deficiency by country in each WHO region (see Table 1). Among pregnant women, signs of vitamin A deficiency (night blindness) were reported, particularly among those living on the Indian subcontinent (Christian et al., 1998a; Rasmussen in WHO, 1998). Recent surveys in Egypt and Swaziland found vitamin A deficiency to be at least as widespread in women as in children (Moussa et al., 1997; Vilakati et al., 1997).

Table 1. Regional Prevalence of Iron and Vitamin A Deficiency

Region	Anemia (%)¹	Vitamin A (%)²
South East Asia	79	69
Eastern Mediterranean	61	22
Africa	44	49
Western Pacific	39	27
Americas	29	20
Europe	20	NA

¹Regional prevalence of anemia in pregnant women (hemoglobin < 11 g/dL) (WHO, 1996).

²Estimates of affected and at-risk populations from those countries in each region for which data were available. These data are for preschool children (WHO, 1995).

Although iron and vitamin A deficiencies are most common, deficiencies in other micronutrients have been reported. Approximately 100 million women of reproductive age suffer from iodine deficiency (Leslie, 1991). According to the WHO (1996), several national dietary surveys found that deficiencies in zinc and copper persist for most age groups in Africa, the Eastern Mediterranean, South East Asia, and the Western Pacific, which is supported by reported mean intakes of less than two-thirds of the recommended daily allowance in several countries (Gibson, 1994; Allen, 1993; Caulfield et al., 1998). Caulfield et al. (1998) estimated that 82 percent of pregnant women worldwide have inadequate intakes of zinc to meet the normative needs of pregnancy. Zinc deficiency was reported in 24 percent of postpartum women in a study in Indonesia (Wieringa et al., 1997) and 60 percent of pregnant women in Peru (Caulfield et al., 1997). Suboptimal vitamin B₆ status was observed in one-third of breastfeeding women, based on low breast milk concentrations (McCullough et al., 1990).

In India, B₁₂ deficiency is common because of the strict limitation of animal products. Low levels of B₁₂ in breast milk were reported in Kenya and low serum B₁₂ observed among pregnant and lactating women in Mexico (Allen, 1993). In addition, riboflavin deficiency was found to be endemic in The Gambia and common in other parts of Africa, China, Indonesia, the former Soviet Union (Powers et al., 1985), and India (Banji and Lakshmi, 1998). Folate deficiency persists in Burma, parts of India, West Africa (Sloan et al., 1992), and Kenya (Calloway, 1988), and is a frequent complication of protein-energy malnutrition in both west and southern Africa (Osifo et al., 1974; Margo et al., 1978; Nkrumah et al., 1988).

The Consequences: Safe Motherhood

Maternal Mortality

Recent Demographic and Health Survey (DHS) analyses have shown that 20 to 50 percent of maternal deaths occur during delivery. Between 12 and 40 percent of deaths occurred postpartum, with the remainder occurring during pregnancy before delivery (Stanton et al., 1997). The WHO estimated that about 80 percent of maternal deaths are due to direct causes, the most common of which are hemorrhage (25%), sepsis (15%), eclampsia (12%), and unsafe abortion (13%), generally due to hemorrhaging or infection. About 20 percent are due to indirect causes, including anemia, malaria, and heart disease (WHO, 1996). The micronutrient status of mothers can affect several of these causes of death, including hemorrhage, anemia, eclampsia, sepsis, and perhaps malaria. In addition, micronutrients can reduce morbidity caused by previous adverse conditions and other illnesses.

Vitamin A deficiency in women increases the risk of death. From a trial in Nepal, preliminary results based on more than 20,000 pregnancy outcomes indicated a 44-percent reduction in mortality related to pregnancy through 12 weeks postpartum in groups receiving a 7,000 RE weekly supplement of Vitamin A (either as β -carotene or retinyl palmitate) compared with women who received a placebo prior to conception, through pregnancy and lactation (West et al., 1999). Of those who died either from obstetric related causes or infection, 30 percent in the placebo group died because of infections.

Anemia is a major contributory cause of postpartum maternal mortality (Ross and Thomas, 1996). Viteri (1998) suggested that because many malnourished women in developing countries are unable to expand plasma volume sufficiently during pregnancy, the true deficit in hemoglobin mass is masked, and, therefore, even mild anemia is pathological. Ross and Thomas (1996) reviewed 21 studies and concluded that a reasonable estimate of the risk of maternal mortality attributable to anemia is 20 percent in Africa and 22.6 percent in Asia. These deaths could have been avoided if the mothers were not anemic. Deaths from severe anemia result from heart failure, shock, or infection due to lowered resistance to disease (Tinker and Koblinsky, 1993). These values are composites of direct anemia-related mortality—7.6 percent and 10.9 percent in Africa and Asia, respectively—in addition to indirect anemia-related mortality—25 percent of all hemorrhage deaths and 10 percent of other maternal deaths. It is not only severely anemic women who are at risk of dying during childbirth. The risk of maternal mortality has been seen to decrease as hemoglobin levels increase (Harrison, 1982).

Because iron-deficiency anemia increases the risk of mortality, efforts should be made to reduce the risk. Providing iron during pregnancy was found to reduce the prevalence of anemia (Sloan et al., 1992; Mohammed and Hytten, 1989). However, in areas where anemia rates are high, most studies found that even with daily supplements in randomized, controlled trials starting in the second trimester, significant levels of anemia persist. Part of the explanation is that anemia may be related to other micronutrient deficiencies such as folate and B₁₂, or that it is associated with parasitic infections; and unless treated, the iron status will not improve significantly. For example, in countries where riboflavin deficiency is common, improving riboflavin status will help reduce anemia (Powers, 1998). Where megaloblastic anemia is caused by lack of folic acid and B₁₂, improving the status for these nutrients will reduce anemia.

Provision of vitamin A may also have an impact on iron status. In a randomized, control trial in Indonesia, the provision of vitamin A supplements in addition to routine iron supplements for two months during pregnancy was most effective in reducing the prevalence of anemia compared with iron or vitamin A supplements only (Suharno et al., 1993). Routine vitamin A or β -carotene supplementation

was associated with reducing anemia in about 10 percent of women during pregnancy and postpartum, and with an increase (2 g/L) in infants' hemoglobin concentrations compared with the placebo group (Stoltzfus et al., 1997b).

Parasitic infections, including schistosomiasis, hookworm, and malaria, are other factors that may contribute to iron-deficiency anemia. Intestinal helminths affect more than one-quarter of the world's population. Gillespie and Johnson (1998, p. 11) provided regional estimates. Hookworms (*Necator americanus* and *Ancylostoma duodenale*), which affect approximately 20 percent of the world's population, have the most detrimental effect on iron status (Stephenson, 1987). Chronic fecal blood loss from hookworm is a significant contributor to anemia (particularly moderate and severe anemia) among certain populations (Roche and Layrisse, 1966; Srinivasan et al., 1987; Stoltzfus et al., 1997a). Among Nepalese pregnant women who received a β -carotene supplement or placebo, hookworm was strongly associated with iron-deficiency anemia, modifying the effect of vitamin A on iron status. In women without hookworm, prevalence of anemia was 50 percent lower in the vitamin A group than the control group. The impact of vitamin A on iron status in hookworm-infested women was small, apparently overcome by the effect of blood loss (Stoltzfus et al., 1997b).

Plasmodium falciparum malaria can cause anemia from red blood cell breakdown. In areas of high malaria incidence, Verhoeff et al. (1998) estimated that improving hemoglobin through the treatment of plasmodium falciparum malaria would provide an average increase of 1 g/dL to 3 g/dL in infants and pregnant women (especially women pregnant for the first time) (Bloland et al., 1993). Thus, in areas where malaria and iron deficiency coexist, malaria controls should be integrated in iron-deficiency control strategies.

Maternal Morbidity

Several micronutrients play essential roles in immune function, including vitamins A, thiamin, riboflavin, B₆, B₁₂, C, E, folic acid, and zinc and iron (Tang et al., 1996). Thus, deficiencies in these micronutrients are likely to influence the rate of infections or their duration and severity. The rates of infections during pregnancy or lactation, including reproductive tract infections, increase because of iron, vitamin A (Christian and West, 1998), and zinc deficiencies (Swanson and King, 1987; Caulfield, 1998). For example, preliminary findings from the Nepalese study indicated there may have been a 10- to 30-percent decrease in certain infections that lasted for more than seven days during pregnancy and lactation among women consuming either vitamin A or β -carotene (Dali et al., 1997). The importance of improving the level of iron during pregnancy is emphasized when considering that anemia predisposes premature labor, impaired resistance to infection, and poor tolerance to heavy blood loss and surgical interventions during delivery (Feightner, 1994).

Night blindness, which results from moderate to severe vitamin A deficiency, is seen in women and children whose vitamin intake is extremely low or whose vitamin requirements increase (during pregnancy, lactation, or infections such as measles). A case-control study (117 pairs) of night-blind Nepalese pregnant women found that night blindness generally occurs in the seventh month of pregnancy when the need for vitamin A increases because of its transfer to the fetus. More women were vitamin A deficient in the night-blind group (51.8%) compared with the control group (21%), and the mean hemoglobin level was lower in the first group (8.9 compared with 9.6 g/dL). Night-blind women were two to three times more likely to have urinary and reproductive tract infections, diarrhea and dysentery, nausea/vomiting/poor appetite, preeclampsia or eclampsia, or anemia. They were also more likely to have had infections and diarrhea earlier in pregnancy as well, suggesting that either their lower vitamin A levels prior to night blindness increased the risk of illness or that their illness increased their risk of becoming more vitamin A deficient. Since night-blind women also had lower intakes of foods containing

vitamin A, it is likely that their low vitamin A levels increased their risk of illness as has been observed among children. The Nepalese study found that routine maternal vitamin A supplementation reduced the incidence of night blindness during pregnancy by nearly 70 percent; β -carotene supplementation, on the other hand, was less effective (Christian et al, 1998a; 1998b).

Caulfield et al. (1998) reported the potential contribution of maternal zinc supplementation during pregnancy to maternal and child survival. Severe maternal zinc deficiency has been associated with spontaneous abortion and congenital malformations, whereas milder forms have been associated with low birthweight, intrauterine growth retardation, and preterm delivery. In addition, milder forms of zinc deficiency have been related to labor and delivery complications, including placental abruption (Kynast and Saling, 1986); prolonged or inefficient first-stage labor and protracted second-stage labor (with a four-fold increase of having labor last more than 20 hours) (Lazebnik et al., 1988; Dura-Trave et al., 1984); premature rupture of membranes (Sikorski et al., 1990; Scholl et al., 1993); and the need for assisted or operative delivery (Jameson, 1993). These complications impair maternal and perinatal health because they lead to an increased risk of maternal lacerations, high blood loss, maternal infections, fetal distress, stillbirth, neonatal asphyxia (low Apgar scores), respiratory distress, and neonatal sepsis (Jameson, 1993).

Calcium supplementation has shown an association with hypertension disorders as well as preeclampsia and eclampsia during pregnancy. Randomized, controlled trials examined the effect of daily doses of calcium consumed by pregnant women on preeclampsia (Bucher et al., 1996). Recent analyses of the Cochrane database of randomized, controlled trials of pregnant women consuming low baseline calcium intakes (less than 900 mg per day) found that the risk of high blood pressure was reduced by one-half, and that the risk of preeclampsia as well as preterm delivery among women with a high risk of hypertension was reduced greatly (Villar and Belizan, 1998). In India, where dietary intakes of calcium were only 350 mg per day, the incidence of gestational hypertension was 6 percent in women receiving 2 g of calcium per day from 20 weeks gestation compared with 17 percent in the placebo group; and the incidence of preeclampsia was 2 percent compared with 12 percent (Purwar et al., 1996). In the United States, a randomized trial of more than 4,500 nulliparous pregnant women found that calcium has no effect on hypertension disorders during pregnancy; however, baseline calcium intakes (about 1,100 mg per day) were higher than intakes found in most developing countries (Levine et al., 1997). Zinc deficiency has also been reported to be associated with the increased risk of pregnancy-induced hypertension (Hunt et al., 1984; Swanson and King, 1987).

Several studies examined the role of micronutrients and HIV, including effects on immune response, the rate of transition from HIV to AIDS, and maternal–infant transmission. Maternal deficiencies can also inhibit the infant’s immune system, making it more susceptible to infection. HIV-infected individuals often have low serum concentrations of vitamins A, B₆, B₁₂, C, E, folate, carotenoids, and selenium and magnesium (Friis, 1998). In developing countries where intakes are often inadequate, micronutrient status is even further compromised. Low serum, vitamin A levels in pregnant women have been associated with increased transmission of the HIV virus to the infant (Semba et al., 1994) and with increased transition from HIV to AIDS and increased mortality among infants.

Improving Pregnancy Outcomes

Ramakrishnan et al. (1999) suggested that there is strong evidence from randomized, controlled trials that zinc, calcium, and magnesium supplements during pregnancy improve birthweight and reduce prematurity, especially in high-risk groups. Based on the results of epidemiologic evidence, they suggest that deficiencies in several other nutrients, including vitamins A, B₆, B₁₂, D, folic acid, and iron and iodine, can lead to low birthweight and increased risk of preterm births, premature rupture of membranes,

and fetal death.

Only a few studies examined the relationship between mild iodine deficiency and child growth; however, the likely association of marginal deficiency with birthweight as suggested by Thilly et al. (1979) deserves further attention. Consequences of severe iodine deficiency, including mental retardation and stunted physical growth (cretinism and dwarfism), are better known (Hetzel, 1993). A Chinese study found that in areas with severe endemic iodine deficiency, iodine treatment before the end of the second trimester protects the fetal brain from the effects of iodine deficiency. Treatment of women later in pregnancy or of children after birth may partially improve brain growth and developmental achievement, but does not improve neurological status (DeLong et al., 1998).

A review of nutritional interventions in randomized, controlled trials, and their effect on preventing intrauterine growth retardation, was recently conducted by the WHO (de Onis et al., 1998). Of the 19 trials that the authors considered adequately designed to assess impacts, only six were conducted in developing countries, where initial micronutrient status is likely to be worse than in developed countries. The authors observed that folate supplementation appears to reduce the incidence of low birthweight and that zinc and magnesium supplementation may have beneficial effects and should be studied further.

Improving folate status before pregnancy reduces neural tube defects, such as spina bifida. It is estimated that more than 200,000 such defects worldwide could be prevented by improving folate levels prior to pregnancy (Molinari, 1993). Randomized, controlled trials in Australia, Canada, France, Hungary, Israel, Russia, and the United Kingdom reduced neural tube defects with a protective effect of 72 percent (MRC Vitamin Study Research Group, 1991; Czeizel and Dudás, 1992).

Other studies demonstrated the benefits of periconceptional multiple vitamin supplements in preventing cleft palate and other types of birth defects (Li et al., 1995; Shaw et al., 1995; Yang et al., 1997). When multiple vitamin supplements were provided to HIV-positive pregnant women in Tanzania in a randomized, controlled trial, the risk of low birthweight decreased by 44 percent, preterm births (less than 34 weeks of gestation) by 39 percent, and small size for gestational age by 43 percent (Fawzi et al., 1998).

Improving the Quality of Breast Milk and Infant Health

Micronutrient status in breastfeeding women affects the quality of breast milk. Allen (1994) suggested categorizing nutrients for lactating women based on the nutrients' relationship to breast-milk quality. Deficiencies of thiamin, riboflavin, vitamins A, B₆, B₁₂, and iodine and selenium in lactating women result in lower concentrations in breast milk, which in turn has negative effects on infants. Mothers are especially vulnerable to further depletion of these nutrients as well as folic acid, vitamin D, calcium, iron, copper, and zinc during lactation. In addition, postnatal supplementation is more likely to benefit the mother than her infant.

Improving a mother's lactating micronutrient status can improve her child's health in other ways. Improved vitamin B₆ and iron levels can increase mothers' attentiveness to child rearing, with possible benefits for children's health and development (McCullough et al., 1990). In Egypt, Kirksey et al. (1991) found that maternal dietary intake of zinc predicted most of the variance in the status of newborn and infant development at age six months. Other studies illustrated the importance of improved zinc status on enhancing child growth and reducing infections from diarrhea and pneumonia (Black, 1998). Improved iron and zinc status was found to be also closely associated with improvements in psychomotor or cognitive measures (Bentley et al., 1997).

Conclusion

As highlighted in this paper, the micronutrient status of women in developing countries affects their health during pregnancy and lactation, the outcomes of their pregnancies, and the health of their infants. For women who are vitamin and nutrient deficient, improving micronutrient intake, especially iron, vitamin A, zinc, calcium, magnesium, and iodine, can be an important means of reducing maternal morbidity and mortality. Improving the status of iron in anemic pregnant women can reduce the risk of mortality and morbidity from hemorrhage, sepsis, and prolonged labor. Recent evidence suggests that enhancing vitamin A intake reduces maternal mortality. Both increases in calcium and magnesium can reduce the risk of death from eclampsia. Ensuring adequate intake of iron, zinc, iodine, calcium, magnesium, and folic acid is especially important for improving pregnancy outcome, including reducing rates of prematurity and increasing birthweights. Increasing the intake of folic acid before pregnancy reduces birth defects, as does improved consumption of iodine. Nutrient intake is also especially important for lactating women because improving the maternal intake of many nutrients (thiamin, riboflavin, vitamin A, B₆, and B₁₂, iodine, and selenium) directly enhances the quality of breast milk. For other nutrients (iron, zinc, calcium, folic acid, vitamin D), the mother's own nutritional status can be compromised if intake is limited and stores are low.

Although this paper focuses on aspects of safe motherhood, the consequences of malnutrition in women go beyond those of having low birthweight babies. It also affects women's abilities to sustain work and care for their families. As stated by James (1998), "this is an area that we have not taken on board at all." The WHO/World Bank-supported analysis, "Global Burden of Disease," ranked iron-deficiency anemia as the third leading cause of loss of disability-adjusted life years (DALYs) for females ages 15–44 worldwide (Murray and Lopez, 1996).

Solutions proposed to prevent or eliminate micronutrient malnutrition include nutrient supplementation of women of childbearing age before and after pregnancy through repeated reproductive cycles. Because there is growing evidence that combined supplements are usually more effective in improving micronutrient status than a single supplement, and since women are usually deficient in more than one micronutrient, inclusion of other micronutrients such as vitamin A, zinc, and possibly vitamins B₁₂, B₆, and riboflavin should be considered in addition to iron and folate. Calcium has proved also important; however, because of the size of the capsule that would be required to provide sufficient calcium, it may not be feasible to include it in a multivitamin/mineral supplement. Universal or targeted food fortification, which has proved cost-effective, is also an important strategy in preventing micronutrient malnutrition.

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