

A life cycle micronutrient perspective for women's health¹⁻³

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ABSTRACT

Micronutrients not only benefit women's health during childbearing years and during pregnancy and lactation, but they also have substantial impact on women's health during adolescence and the aging years. Thus, for women, diet quality is important for health today and in the future. Realizing that there are many ways to improve the quality of a diet and to obtain adequate amounts of vitamins and minerals from foods, food-based approaches are still not attaining adequate intakes in most women, both in the United States and worldwide. Efforts are needed to improve diet quality, focusing on the diet as a whole, and not on single vitamins or minerals. However, consideration must be given to fortified foods and/or supplements to insure micronutrient adequacy. *Am J Clin Nutr* 2005;81(suppl):1188S-93S.

KEY WORDS Nutrition, micronutrients, women, life cycle, n-3 fatty acids, folic acid, obesity, pregnancy, iodine, iron, prevention, food-based approach, fortification

NUTRITION THROUGH THE LIFE CYCLE

Worldwide, micronutrient status of women is inadequate for several micronutrients. Women's micronutrient status affects not only their own health, but also those of the next generation, as depicted in **Figure 1** (1). Micronutrients benefit women's health during childbearing years, pregnancy and lactation, and they also have substantial impact on women's health during adolescence and the aging years. The rationale for micronutrient adequacy in the individual woman has been well defined for many micronutrients such as iron, calcium, iodine, folate, and vitamins A and D. The timing of when adequate intake is critical is often different for a particular micronutrient. Adequate folate status, for example, will reduce the risk of congenital defects only pre-conception, and this is also generally true for iron in reducing the level of pregnancy anemia. In contrast, correcting iodine inadequacy during pregnancy has a marked impact on preventing the devastating effects of subclinical iodine deficiency on infant and childhood cognitive development (2), whereas too little vitamin A during pregnancy can impair maternal immunological protection as well as impair development of the infant's immune system. During pregnancy and lactation, micronutrient adequacy for certain micronutrients such as iron can have substantial influence on pregnancy outcome, such as pregnancy mortality. Micronutrient adequacy will have impact on the ability of the mother to provide optimal feeding and lactation after delivery. An example of this includes prenatal n-3 fatty acid status, which affects the quality of human milk in terms of levels of these fatty

acids after delivery (3-5). These long-chain n-3 fatty acids influence pregnancy and infant outcomes in terms of potential for learning and resistance to infections.

For the infant itself, it is increasingly realized that micronutrient inadequacies can be one of the contributors to low birth weight (6, 7). Low birth weight in the infant is not only a major cause of stunting in childhood and adulthood, but will also lead to increased risks for adult chronic diseases (8). Some of these risks can either be enhanced or diminished in low birth weight infants depending on feeding patterns during the first year.

At the other end of the life cycle, relatively little is known about the nutritional requirements of older women, especially those living well beyond their 80's. Many of the normal processes of aging including acute and chronic illness, decline in organ function, and medications, all of which affect nutritional requirements. Multiple micronutrient deficiencies in elderly women are common (9-11). The limited information available on micronutrient requirements for elderly women is in large part due to the difficulty in conducting reliable and valid studies in this heterogeneous population that has various medication needs, different socioeconomic status, and different rates of aging and functional decline. Much benefit would be gained from additional research on the impact of better micronutrient status in young and middle age women on their health at older ages.

In macronutrient status, an increasing body of evidence indicates that maternal overweight and obesity before conception correlates to increasing risk of maternal complications during pregnancy such as gestational hypertension, gestational diabetes, need for delivery via Cesarean delivery, and need for hospitalization before delivery (**Figure 2**) (12). Very under-appreciated by many health professionals is the increasing body of evidence linking prepregnancy maternal overweight and obesity to increasing risk for birth defects. A number of publications now show close associations with maternal overweight with increasing risk of neural tube defects, as well as other neurological abnormalities, congenital heart disease, intestinal malformations, and multiple congenital anomalies (**Figure 3**) (13-16). Interestingly, for some of these defects, increased risk is already

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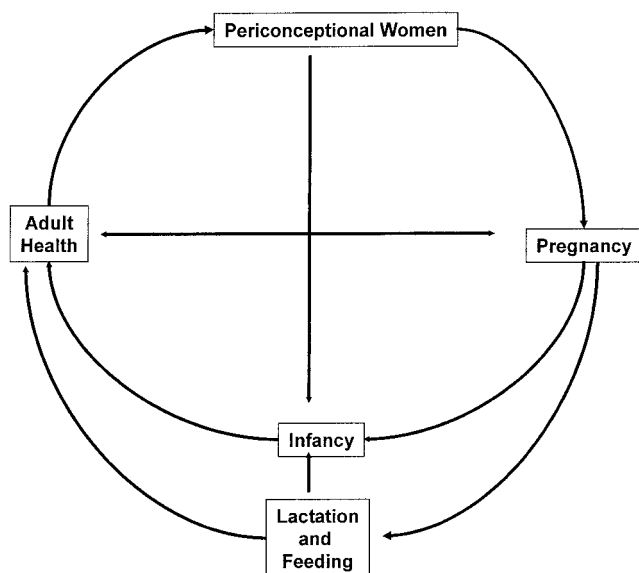


FIGURE 1. Schematic diagram of the life cycle showing relationships among the life stages. Source: *Nutrition Today Matters Tomorrow: A Report from the March of Dimes Task Force on Nutrition and Optimal Human Development*, 2002 (1).

maximal when the BMI is in the overweight range (25–25.9) with no further increase crossing over into the obesity range (BMI > 30) (16).

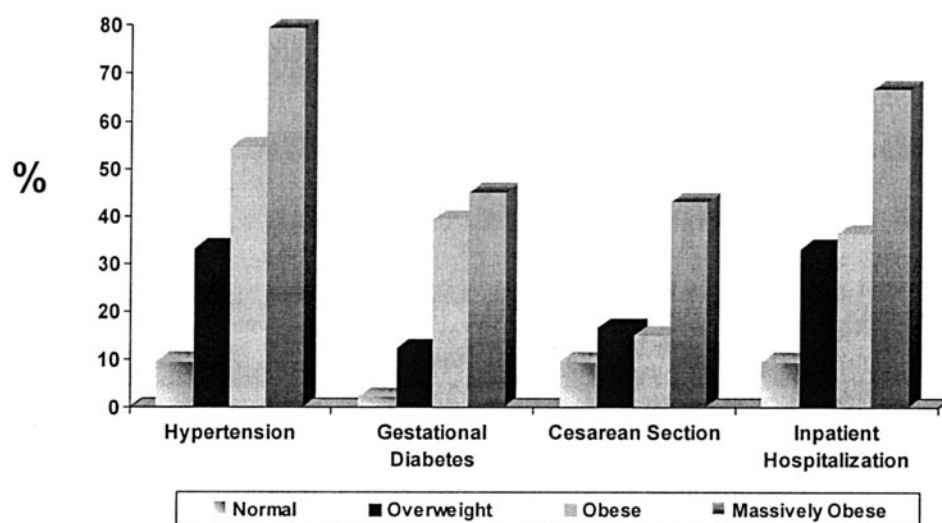
The importance of female nutrition precedes and extends beyond the reproductive years to optimize completion of adolescent growth and establish body nutrient reserves before pregnancy and to maintain adequate nutritional status, particularly skeletal health, through the postmenopausal years. Hence, the need for a constant, balanced, and adequate supply of all essential nutrients throughout a woman's lifetime to optimize both her and her offspring's health. This is best achieved safely through a

consistent balanced intake of nutrient-rich food, including fortified foods, and nutrient supplements when necessary, and regular exercise.

Effects of micronutrient deficiencies

Though prevalence rates of micronutrient inadequacy vary considerably between developing and industrialized nations, the problem of micronutrient deficiencies is highly prevalent worldwide. Low dietary intake is the primary cause of micronutrient deficiencies at a public health level, but genetic factors, nutrient interactions, poor absorption, drugs, and diseases such as diabetes and hypertension may contribute, especially at an individual level. Among women of childbearing age, inadequate intakes of calcium, iron, folate, zinc, and vitamins A and D remain too common (17, 18). Among these, iron, folate, vitamin D, and zinc are of greatest concern due to high losses and requirements; these can be linked to an inadequate consumption of fruits, vegetables, meat, and animal sources of food. Even in Europe as a whole, we can still find prevalences of iron deficiency anemia in almost 22% of children up to 4 y of age, and 24% prevalence of iron deficiency in pregnant women (19). Prenatal and early pregnancy supplementation is necessary to minimize the risk of adverse pregnancy outcomes because replenishment of stores is difficult to achieve during pregnancy. Thus, iron inadequacy is still a major contributor to suboptimal outcomes for women throughout the life cycle and particularly for children, in terms of cognitive development, worldwide.

B-vitamin deficiencies are also of concern in the United States and abroad. Recent years have drawn attention to deficient folate intakes because of the relation to neural tube and other birth defects that can occur early in pregnancy. Adverse risks can be controlled at intakes of 400 μg daily, achievable through food, natural and folic acid fortified, and/or supplements. Vitamin B-12 deficiency is a problem now documented in several countries, particularly among those who do not eat meat and other



Normal = 18-24.9 kg/m^2 ; Overweight = 25-29.9 kg/m^2 ; Obese = 30-34.9 kg/m^2 ; Massively Obese = >35 kg/m^2

FIGURE 2. Incidence of maternal complications during pregnancy by weight status before pregnancy. Adapted from reference 12.

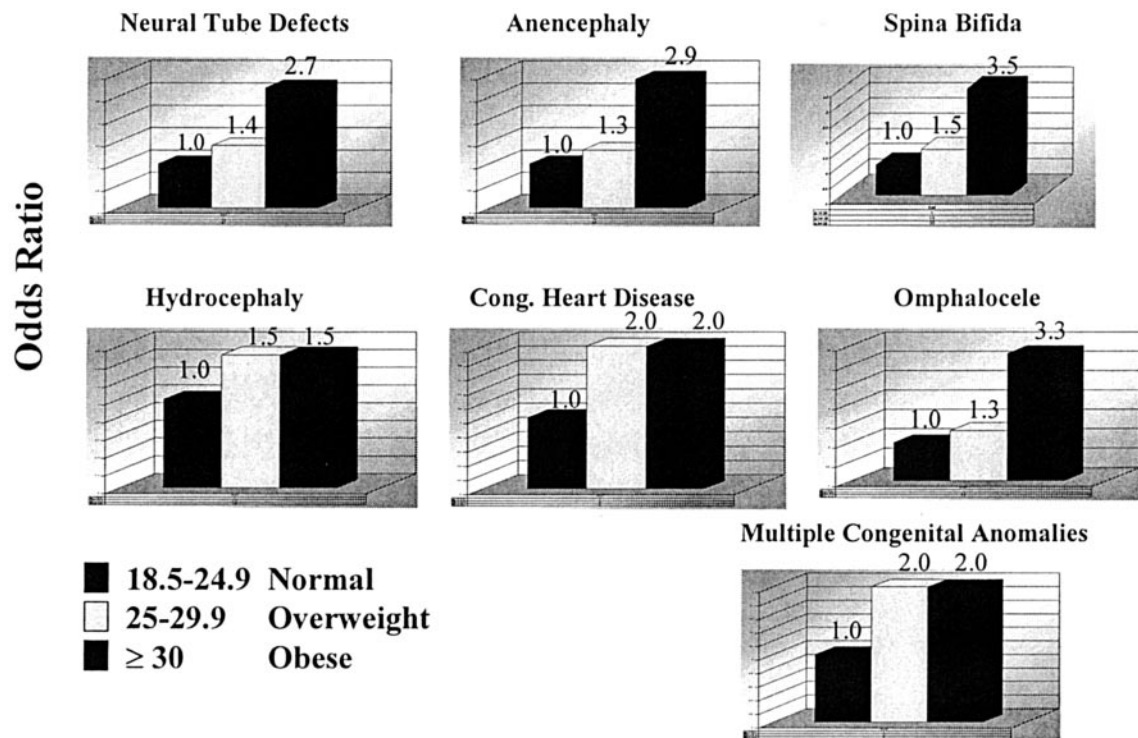


FIGURE 3. Prepregnancy maternal overweight/obesity and risk for birth defects. Data adapted from reference 16. RND: Recommended nutrient density

animal products, such as lacto-ovo vegetarians and those on restricted meat intakes for access, economic, and/or cultural reasons (20).

Goiter, hypothyroidism, and cretinism are well-recognized consequences of severe iodine inadequacy; however, less recognized is the effect of milder levels of iodine inadequacy on poor reproductive outcomes such as stillbirths and birth defects (21). Outside of the nutrition community, there is also an underappreciation of the effects of “subclinical iodine deficiency” and decreasing cognitive achievement in children who will develop into adults with lower levels of intelligence than if they had had adequate iodine supply in utero (22). Similarly, mild levels of vitamin A inadequacy, insufficient to lead to night blindness or complete blindness, result in higher susceptibility to morbidity and mortality from infectious diseases as well as to adverse reproductive outcomes (23). In addition, restored vitamin A status improved hemoglobin levels in deficient populations, including pregnant women.

Thus, there are overlapping reproductive and development consequences of micronutrient inadequacies, including impaired cognitive development in learning ability, impaired immunity, adverse reproductive outcomes and maternal health problems, and finally, among infants and children, an abnormal bone matrix and distorted skeletal formations.

Correction–prevention of micronutrient inadequacies

Optimally, adequate intake of micronutrients should be achieved by food-based approaches. If successfully implemented, food-based approaches offer the following advantages:

- Focus on food groups, not single nutrients
- Focus on amounts, knowledge, and behavior
- Focus goes beyond foods (eg, healthy weight)

- Varies portion size, not dose
 - Reduces risks of high dose or the adverse interactions among nutrients
 - Sustainability
- However, dependence on food alone can have the following disadvantages:
- Availability, access
 - Cost
 - Interference by sociocultural factors
 - Specific micronutrient adequacies may be difficult to achieve for certain nutrients (eg, iron, folate)
 - Decreased bioavailability with certain nutrients
 - Inadequate compliance to dietary recommendations

Examining the micronutrient quality of the major staples of diets in a number of regions such as rice, wheat, or maize/beans, it is clear that the major staples themselves are by and large poor sources of many important micronutrients (Figure 4A) (24). But, if successive other foods are added, which increases diversity of the diet, adequacy of most micronutrients can easily be achieved as demonstrated in (Figure 4B) (24) for rice. In this example, the addition of one serving of carrots a day will provide recommended levels of vitamin A, and vitamin C adequacy will be met by a serving of oranges. If sufficient diversity can be made available and affordable, adequacy of many micronutrients can be achieved through food. However, in most populations, this is not the usual pattern because of individual or family choices, or lack of accessibility. Therefore, fortification with micronutrients is emerging as a powerful tool in preventing or correcting inadequacies for a number of micronutrients. Classical examples include fortification of salt with iodine, milk with vitamins A and D, and especially for children, infant formula and cereals fortified with iron and/or other micronutrients. In the United States,

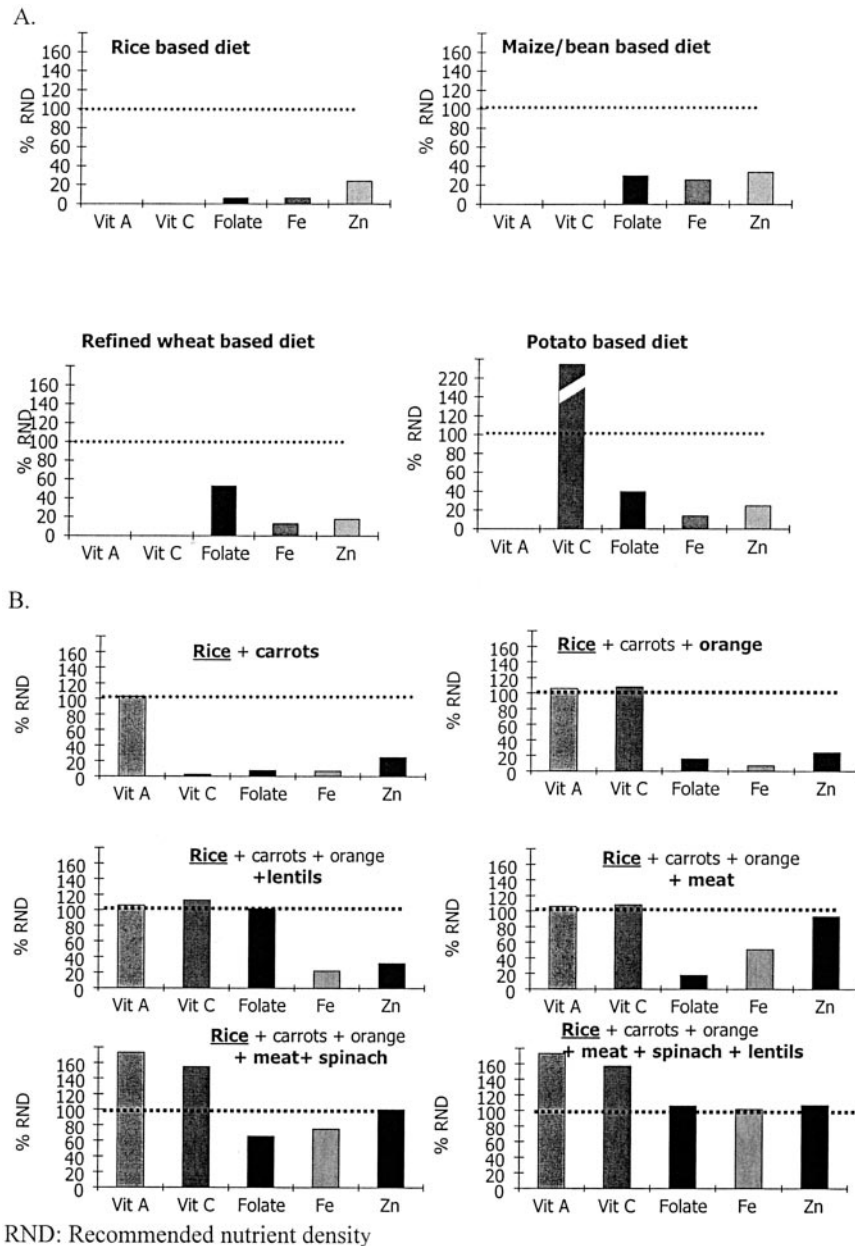


FIGURE 4. Nutrient density of common staple food (A): effects of sequentially adding small amounts (40-60g) of nutrient-dense foods to one example, rice (B). Data adapted from reference 24.

fortification of flour with folic acid is showing remarkable success in decreasing neural tube defects even though the level of fortification in the United States provides only about half of the recommended requirements for folic acid daily (25–27). In other countries such as Chile, fortification is at double the level of the United States and the results in terms of prevention of neural defects seem promising (28). The benefits of folic acid fortification/supplementation are not only applicable to women throughout the life cycle but also to all sectors of populations because of its ability to lower homocysteine levels and associated morbidity and mortality from cardiovascular disease (29, 30). High homocysteine levels are a risk factor not only for cardiovascular disease but are also related to adverse effects during pregnancy (31, 32), and perhaps even in neurological deterioration during aging (33). Folic acid is also emerging as important

in lowering the risk of certain types of cancers (34) and perhaps independently neuropsychiatric disorders (35).

Recommendations

Realizing that there are many ways to improve the quality of a diet and to obtain adequate amounts of vitamins and minerals from foods, food-based approaches are still not attaining adequate intakes in most women, both in the United States and worldwide. Efforts are needed to improve diet quality, focusing on the diet as a whole, and not on single vitamins or minerals. However, at the same time, consideration must be given to fortified foods and/or supplements to insure micronutrient adequacy. To achieve these goals, the following are summary recommendations for women throughout the life cycle:

1. Provide guidance for selecting, combining, preparing and serving micronutrient-rich foods to improve diet quality using available information.

2. Improve access to and use of foods that are rich in vitamins and minerals, using methods that are compatible with local dietary patterns and cultural values.

3. Where it is not possible to meet all needs through available food sources including fortified foods, insure the availability of appropriate vitamin and mineral supplements for women.

Overall, a life cycle and holistic perspective is essential in the design of effective intervention approaches to prevent micronutrient undernutrition in women and their children.


CONCLUSION

A decade ago, the World Bank summarized that vitamin/mineral deficiencies deprive one billion people worldwide of their "intellect, strength, and vitality." They estimated that for <0.3% of their GDP, micronutrient-deficient countries could rid themselves of this entirely preventable problem, which now is costing >5% of their GDP in lost lives, disability, and productivity (36). Thus, as we move into the 21st century, we can aim for new paradigms for micronutrient interventions, which would result in significant health improvement, better pregnancy and infant outcomes, and economic benefits worldwide. These paradigms include emphasizing:

Prevention more than cure

Promotion of healthy lifestyles

Insuring micronutrient adequacy to periconceptional women and infants within a life cycle mode

Because adequacy of micronutrient intakes is often not achieved through food-based approaches and because initiation of fortification programs often takes years of planning and integration between private and public sectors, supplementation is often necessary in vulnerable groups to achieve micronutrient adequacy. There are multiple reasons for assuring adequate micronutrient status pre-pregnancy and throughout lactation to achieve optimal infant and young child outcomes and maternal health. Multiple micronutrient containing supplements are widely available and after initial survey for adequacy, women should be encouraged to take supplements when their needs are not met by food-based or fortification approaches. 

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