Maternal Nutrition and Perinatal Outcomes

Mary K. Barger, CNM, MPH, PhD

Diet and patterns of eating during pregnancy can affect perinatal outcomes through direct physiologic effects or by stressing the fetus in ways that permanently affect phenotype. Supplements are not a magic nutritional remedy, and evidence of profound benefit for most supplements remains inconclusive. However, research supports calcium supplements to decrease preeclampsia. Following a low glycemic, Mediterranean-type diet appears to improve ovulatory infertility, decrease preterm birth, and decrease the risk of gestational diabetes. Although women in the United States have adequate levels of most nutrients, subpopulations are low in vitamin D, folate, and iodine. Vitamin D has increasingly been shown to be important not only for bone health, but also for glucose regulation, immune function, and good uterine contractility in labor. To ensure adequate vitamin and micronutrient intake, especially of folate before conception, all reproductive age women should take a multivitamin daily. In pregnancy, health care providers need to assess women’s diets, give them weight gain recommendations based on their body mass index measurement, and advise them to eat a Mediterranean diet rich in omega-3 fatty acids (ingested as low–mercury risk fatty fish or supplements), ingest adequate calcium, and achieve adequate vitamin D levels through sun exposure or supplements. Health care providers should continue to spend time on nutrition assessment and counseling. J Midwifery Womens Health 2010;55:502–511 © 2010 by the American College of Nurse-Midwives.

**keywords:** Barker hypothesis, glycemic index, nutrition, pregnancy, pregnancy outcome

## INTRODUCTION

Nutritional status during pregnancy affects outcomes for both mother and infant, yet the evidence that a particular supplement, or combination of them, is a magic nutritional remedy for women during their reproductive years is at best inconclusive. The latest research reaffirms that health care providers should continue to counsel women about nutrition during pregnancy. However, skepticism about claims that dispensing a pill can take the place of real nutrition counseling is valid. Finding some time to focus on patterns of eating—what is eaten, how much, and even how often one eats—remains an important part of adequate nutrition assessment and counseling in pregnancy. This article focuses on the “why” of nutrition counseling. The research and theory that explores how common foods may affect outcomes for both mother and infant—possibly even into adulthood among populations that have access to food—are reviewed and summarized. Readers are encouraged to read other related articles in this issue on the topics of gestational weight gain and effective assessment techniques, the perinatal effects of vitamin D and omega-3 fatty acids (omega-3s), and the newest information on healthy eating.

Scientific study of the effects of diet on pregnancy outcomes has proven difficult, and study results on the whole have not shown a large effect on outcomes, at least in reasonably well-nourished populations. Because it is much easier to conduct randomized trials using a supplement of a micronutrient or fat, most of the evidence relating nutrition to perinatal outcomes has not examined the diet as a whole. Normal pregnancy is not an inherently fragile event, and obsessing over nutrition is generally unnecessary. Nonetheless, there are important exceptions that show that nutrition counseling remains a significant component of good care.

## MECHANISM OF EFFECT

The proportion and type of macronutrients (protein, carbohydrates, or fat) may have effects not only on systemic hormones produced by the gastrointestinal system, liver, and pancreas, but also on eicosanoids which are produced by every cell in the body. Eicosanoids are a group of powerful, locally generated, and locally acting hormones that have both intercellular and intracellular effects. The most well known eicosanoid family is the prostaglandins, which includes prostacyclin, thromboxane A2, prostaglandin E1 (PGE1), and PGE2. Eicosanoids exert a strong effect on the production of cyclic adenosine monophosphate (cAMP). Certain soluble hormones can only exert their effect within a cell if cAMP is present. One of the most important nutritional processes, mobilization of glucose from glucagon in the liver or muscle, requires cAMP. Eicosanoids that promote production of cAMP, such as prostacyclin and PGE1, act to inhibit platelet aggregation, promote vasodilation, are antiinflammatory, and inhibit cellular proliferation. Those that inhibit cAMP (thromboxane A2, PGE2, PGF2α, and leukotrienes) stimulate opposite actions (e.g., vasoconstriction, inflammation, and immune system dysfunction). A balance of eicosanoids is needed for healthy bodily functioning. Recent research has focused on hormones that promote and inhibit production of cAMP, because many chronic diseases may be caused by inflammation, vascular narrowing, and immune dysfunction.
Eicosanoids are produced by individual cells from essential fatty acids, which must be supplied by the diet. The conversion of essential fatty acids from the diet to eicosanoids requires several enzymes. Factors that influence what type of eicosanoid is produced by cells include the ratio of omega-6 to omega-3 fatty acids ingested (see the article by Jordan et al. for a fuller discussion), the presence of trans fats, factors such as viruses and stress, including oxidative stress (e.g., from smoking), and the amount of insulin and glucagon stimulated by a meal. These play a role in determining the amount of arachidonic acid made, which influences the balance of eicosanoids. A high glycemic meal—one with easily digested carbohydrates like juices, white bread, and rice—stimulates more insulin production, and therefore, increases eicosanoid production of thromboxane A2, PGE2, PGF2α, and leukotrienes. When these eicosanoids are consistently overproduced, they have deleterious long-term effects that can result in chronic diseases, such as diabetes, cancer, and heart disease. This is the basis for the theory that the glycemic load of a meal can have health effects.

THE ROLE OF MICRONUTRIENTS AND VITAMINS

The role of micronutrients in health is more familiar to health care providers. Iron is essential for the oxygen-carrying capacity of hemoglobin and zinc for the proper function of enzymes that affect cell growth, healing, and reproduction. Iodine is vital to thyroid hormone regulation. Iodine deficiency in pregnancy can result in congenital hypothyroidism, causing stunted growth and mental retardation in newborns.

Vitamin A is needed for immune function and for reproductive and fetal health. However, it is well known that vitamin A synthetic analogues, such as isotretinoin (Accutane), are significant human teratogens. There is also evidence that large ingestion of preformed vitamin A, retinol (10,000 IU or more), can result in cranial-neural-crest fetal anomalies. It is recommended that pregnant women ingest vitamin A as β-carotene and limit the ingestion of retinol during pregnancy. Retinol is found in sources such as chicken or beef liver and cod liver oil.

Vitamins E and C are well-known antioxidants. Although vitamin D is known primarily for its role in calcium and phosphorus regulation, vitamin D receptors are present throughout the body. Recent research shows vitamin D has a role in immune function, glucose metabolism, pancreatic function, and other processes, causing some to now label it a hormone. The article in this issue on the role of vitamin D in the perinatal period discusses this more fully. Table 1 documents that vitamin D deficiency is probably quite prevalent among all ethnic groups of women of childbearing age in the United States. The B vitamins, especially folate and B12, are important in pregnancy because of their role in DNA synthesis which is essential during rapid cell proliferation. Adequate folate levels at the time of pregnancy have been shown to decrease the incidence of neural tube defects by 50% to 70%. Women with low folate or B12 levels are at risk for developing macrocytic anemia.

DEVELOPMENTAL ORIGINS OF HEALTH AND DISEASE

Although normal pregnancy remains a robust event, some research and theory now suggests that what mothers eat may affect their children’s health as adults. In 1986, Barker and Osmond proposed that the cardiovascular disease they observed in a mature population from England and Wales was at least partly related to undernutrition in utero. Since then, a plethora of studies have found an association between poor fetal growth and small size at birth possibly caused by maternal undernutrition, and increased risk of obesity, coronary heart disease, stroke, hypertension, type 2 diabetes, and osteoporosis.

Barker hypothesized that nourishment in utero can stress the fetus in ways that permanently affected development, creating a “reprogramming” of the fetus’s developing phenotype—for example, by creating a different insulin response to the nourishment available in utero, which expressed itself in later life as chronic disease. The “Barker hypothesis” (Box 1) has become widely accepted and grown into the field of developmental origins of health and disease, which seeks to delineate the mechanisms by which unbalanced nutrition in utero and during infancy can permanently affect health. It proposes, for example, that both fetal undernutrition (sometimes manifested as low birth weight) and overnutrition (seen as a large for gestational age infant or a high ponderal index) increase the risk of future diabetes. In addition, there is evidence that the fetal effects of exposures to specific substances, such as environmental contaminants, drugs, or infections, may be mediated by maternal diet. Ideally, infants should be born at term, not growth restricted, but without high ponderal indexes.

In sum, maternal nutrition can affect both mother and infant. Nutrition can affect physiologic function at the cellular and organ level. Deficiencies of micronutrients can cause mental retardation in the case of low iodine intake and other fetal developmental problems, such as neural tube defects, which are associated with a deficiency of folic acid. There are less data about the role of macronutrients or diet in its entirety on perinatal outcomes. The intrauterine environment may even affect the phenotype of the infant, which has implications for the adult health of the child.

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Research increasingly shows that diet can affect fertility, particularly ovulatory infertility. Weight loss of around 5% of body weight and/or increased exercise among women with polycystic ovarian syndrome, the most common cause of ovulatory dysfunction, can restore normal menstrual function and improve fertility.18 Research from a prospective cohort of the Nurses’ Health Study indicates that for a woman with irregular ovulation, attaining a healthy weight or losing as little as 5% to 10% of her weight and regularly taking a supplement of folic acid in a multivitamin will make her 40% less likely to experience ovulatory infertility.19,20 Being overweight or underweight has been shown to suppress ovulation, because both conditions affect hormone levels. Having 5% of protein intake from a vegetable source and replacing fat-free dairy with whole milk dairy are both associated with improved fertility.21 Finally, a Mediterranean-type diet (see the article by Skerrett and Willett5 in this issue for a full description) is associated with a substantially reduced risk of infertility.19 These data and recommendations have been summarized in an easy-to-read format for professionals and consumers alike in The Fertility Diet.22

Women who are either obese or underweight at the start of their pregnancies have worse pregnancy outcomes. Underweight women are at increased risk of fetal growth restriction. Many of these women have a history of eating disorders and require special care and counseling in pregnancy (discussed in Harris’s23 article). Obese women are more likely to develop gestational diabetes and hypertensive disorders and have an increased risk of stillbirth as well as indicated preterm birth. There is also evidence that the myometrial muscle in obese women does not contract optimally, which may explain an increased proportion of inductions, cesarean births, and postpartum hemorrhage. Encouraging women to attain a healthy weight when they are not pregnant is an important health promotion strategy for midwives. The article by Graves24 included in this issue reviews practical management strategies to improve midwives’ skills in helping women lose weight.

EFFECT OF NUTRITION DURING PREGNANCY ON PERINATAL OUTCOMES

One of the most common misconceptions is that caffeine can cause miscarriage. Recent research indicates that caffeine does not cause infertility or miscarriage. A comprehensive survey of the literature involving 15 published studies on caffeine and pregnancy outcomes that examined the role of possible bias in studies concluded that there is no good evidence that moderate caffeine intake in early pregnancy is associated with miscarriage.25 A recent prospective cohort study of more than 2400 clinically recognized pregnancies also found no association with miscarriage at moderate caffeine intake levels (i.e., median intakes: 350 mg/day prepregnancy intake).

Table 1. Recommended and Actual Current Status of Micronutrients in US Women 20 to 39 Years of Age by Race/Ethnicity According to the National Nutrition and Health Examination Survey, 1999–2002

<table>
<thead>
<tr>
<th>Micronutrient (Measurement)</th>
<th>Adequate Levels in Women</th>
<th>All Women 20–39 Years of Age</th>
<th>Non-Hispanic White</th>
<th>Non-Hispanic Black</th>
<th>Mexican</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A (mcg/dL)</td>
<td>&gt;20</td>
<td>49.2</td>
<td>52.2</td>
<td>42.3</td>
<td>44.3</td>
</tr>
<tr>
<td>Vitamin E (mcg/dL)</td>
<td>&gt;500</td>
<td>900</td>
<td>1010</td>
<td>886</td>
<td>972</td>
</tr>
<tr>
<td>Vitamin B12 (pg/mL)</td>
<td>&gt;400</td>
<td>453</td>
<td>412</td>
<td>505</td>
<td>461</td>
</tr>
<tr>
<td>Folate as RBC folate</td>
<td>220</td>
<td>235</td>
<td>247</td>
<td>196</td>
<td>235</td>
</tr>
<tr>
<td>Vitamin D 25(OH)D (ng/mL)</td>
<td>20–32</td>
<td>21.1</td>
<td>25.5</td>
<td>11.0</td>
<td>18.8</td>
</tr>
<tr>
<td>Iron as serum ferritin (ng/mL)</td>
<td>&gt;15</td>
<td>30.4</td>
<td>32.0</td>
<td>26.6</td>
<td>23.3</td>
</tr>
<tr>
<td>Iodine—Urinary excretion (mcg/L)</td>
<td>100–200</td>
<td>133</td>
<td>181</td>
<td>118</td>
<td>167</td>
</tr>
<tr>
<td>Iodine during pregnancy—</td>
<td>150–249</td>
<td>181</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RBC = red blood cell.

*Years 2003-2004.11

Source: Adapted from the Centers for Disease Control and Prevention.10,11

504 Volume 55, No. 6, November/December 2010
and 200 mg/day at 16 weeks’ gestation, which is equivalent to 1.1–1.7 7-oz cups of brewed coffee. In addition, the only randomized trial on caffeine intake in the second half of pregnancy and outcomes of birthweight and gestational age found no effect.

**Fetal Growth**

Inadequate maternal intake, along with poor placental perfusion/implantation, can limit nutrition to the fetus, restricting fetal growth. From the Dutch experience of severe calorie restriction in World War II and information from developing countries, maternal undernutrition and fetal growth restriction are clearly associated. The original weight gain guidelines for pregnant women from 1990, reiterated in 2009, stress that underweight women require a larger weight gain to decrease the risk of preterm birth. However, a question arises: can some fetuses still be “undernourished” and therefore be at risk for fetal growth restriction, even in the presence of adequate calories? Is a healthy diet that maintains physiologic function also important? No studies have decisively elucidated this difference.

**Preterm Birth**

Some of the causal pathways to preterm birth may have an infectious or immune dysfunction etiology, and premature contractions may be mediated by an imbalance in inflammatory eicosanoids. Therefore, diets that may decrease inflammatory eicosanoids or have other beneficial health effects may help. To date, randomized trials using specific supplements, such as antioxidants of vitamin C and E, have not been effective in preventing preterm birth. However, the results of a randomized trial in South Carolina of a multiethnic pregnant population of more than 600 women taking 4000, 2000, or 400 IU of vitamin D3 were recently reported. The number of preterm births (at 32 and 37 weeks’ gestation) among women taking 4000 IU were half of those taking the currently recommended 400-IU dose, and the women had 30% less morbidities including 25% fewer infections with no reported adverse effects.

A randomized trial in Norway found that women who ate a Mediterranean-type diet rich in fruits and vegetables, lean choices of protein, omega-3s in the form of fatty fish, whole grains, and increased monounsaturated fats had significantly different consumption than control women of all macronutrients and nearly all vitamins and micronutrients except iron. This difference in diet resulted in lower total cholesterol levels and a remarkable 90% decreased preterm birth risk (7.4% vs 0.7%). The biologic mechanism for the influence of diet on preterm birth may be related to improved fetoplacental circulation. Women randomized to the Mediterranean-type diet had lower peripheral vascular resistance as documented by mid trimester umbilical uterine artery Doppler flow studies, and therefore better fetomaternal circulation. However, only one of two recent cohort studies of healthy pregnant women with normal body mass indices found a significant decrease in early (<35 weeks) preterm births associated with a Mediterranean diet.

**Fasting**

Meal frequency may also affect pregnancy outcomes, particularly preterm birth. Ludwig and others have shown that glucose and insulin levels should be maintained in a narrow range for ideal physiologic function. Rapid peaks and falls in glucose and insulin levels lead to abnormal hormone production and increase oxidative stress, which can lead to chronic disease. Pregnancy is characterized by a prolonged increase in glucose and insulin levels after a meal followed by a rapid change to a fasting level with low glucose levels. This fasting state in pregnancy, when there is a rapid switch from using glucose to lipids for energy, has been termed a state of “accelerated starvation.” Therefore, skipping meals or prolonged periods between food intake can result in deleterious effects for both mother and fetus.

A prospective cohort study of more than 2500 women examining the role of infection and nutrition on perinatal outcomes found that women who ate less frequently were more likely to have heavier prepregnant weights, be older, eat fewer calories, and be slightly more at risk for preterm birth, particularly premature rupture of the membranes. A similarly designed study examining the role of chronic and physical stress in preterm birth measured corticotrophin-releasing hormone levels at three separate times of gestation. Fasting of 13 hours or more at 18 to 20 weeks and at 28 to 30 weeks was associated with increased corticotropin-releasing hormone levels and preterm birth (odds ratios of 2.5 and 1.7, respectively). Some pregnant women choose to observe religious fasting, even though their religion exempts them. An increase in spontaneous term births has been observed following the 24-hour Yom Kippur fast. Pregnant woman who chose to observe the Ramadan abstinence (no food or drink during daylight hours) had a higher incidence of gestational diabetes (GDM), required induction nearly twice as often, and had higher rates of cesarean birth. Women who chose to fast and were at 30 weeks’ gestation or more had maternal glucose levels and fetal heart rate tracings examined during fasting and again after eating in the evening. During the fasting state, fetuses exhibited decreases in movement, breathing movements, and fewer heart rate accelerations when compared to fetal behavior in the fed state. It appears there is good reason that the Institute of Medicine’s *Nutrition During Pregnancy and Lactation* recommended three meals a day and at least two snacks.

**Bacterial Vaginosis**

A recent prospective cohort study of more than 500 pregnant women at greater than 16 weeks’ gestation, half of
who were black and half who were white, assessed both maternal vitamin D levels and the presence of bacterial vaginosis in early pregnancy. Vitamin D has been shown to affect immune system function, and low levels have been correlated with tuberculosis infection. Therefore, it was postulated that bacterial vaginosis, a chronic condition with a higher prevalence in blacks, may be affected by vitamin D levels. Results showed a strong association between serum vitamin D levels and the prevalence of bacterial vaginosis among women in their first trimester. Of note, among the non-Hispanic black women in this study, only one had adequate vitamin D serum levels (≥32 ng/mL or 80 nmol/L) and more significantly, 74% were moderately to severely deficient (≤15 ng/mL or 37.5 nmol/L). Vitamin D levels may partially explain racial differences in bacterial vaginosis and resultant preterm birth.

Preeclampsia

A decrease in preeclampsia, good in itself, might also decrease the prematurity rate. Although preeclampsia’s complete etiology is still unclear, it is known that abnormal placenta resulting in poor remodeling of the spiral arteries is involved, perhaps related to genetics, immune dysfunction, and/or abnormal inflammatory changes. The abnormal structure of the spiral arteries along with oxidative stress from an imbalance of prooxidant and proinflammatory eicosanoids may create subsequent inflammatory changes and endothelial activation that account for the vascular vasospasm, capillary leaking, and coagulation changes that are the classic symptoms of this disease. Women with preeclampsia have more thromboxane A2 than prostacyclin, the reverse of that found in women who do not have preeclampsia. As discussed previously, the proportion and type of food consumed may influence which eicosanoids are produced. Using this theory, studies have examined the use of antioxidants (vitamins C and E), omega-3s, and calcium to prevent preeclampsia. It had been noted that women with preeclampsia and their placentas have lower concentrations of antioxidants and increased measures of lipid oxidative stress. However, a Cochrane review of 10 randomized trials using antioxidants (vitamin C and/or E supplementation during pregnancy) did not find a significant reduction in the incidence of preeclampsia. A recent trial of vitamin C and E supplements in women with chronic hypertension or a history of preeclampsia failed to show any decrease in the incidence of preeclampsia and, in fact, women in the treatment group had an increased risk of premature rupture of membranes.

Trials using either fish oils or other agents that promote cAMP enhancing eicosanoids, such as evening primrose oil, have had conflicting results. A metaanalysis from 2006 did not find an effect between supplementation and a decreased risk of preeclampsia overall, although in the subgroup of singleton pregnancies it may be protective (relative risk [RR] = 0.67; 95% confidence interval [CI], 0.43–1.04). There have been criticisms of some of these trials, which are more fully explained in the article by Jordan et al. in this issue.

On the other hand, randomized trials of calcium supplementation have confirmed what was noted in observational studies: women who have high calcium intakes had a lower incidence of preeclampsia. A metaanalysis of 12 randomized trials revealed that calcium supplementation of 1500 to 2000 mg decreased the risk for preeclampsia by 30% (RR = 0.70; 95% CI, 0.57–0.86). The effect was greatest for women with daily calcium intakes less than 900 mg. In addition, the World Health Organization trial of pregnant women with low calcium intakes showed calcium supplemented women had fewer preterm births.

Data collected from women giving birth in the communal community in rural Tennessee, known as “the Farm,” who all followed a vegan diet with soy protein supplemented with vitamin B12 are intriguing. While pregnant, the women also took vitamin/mineral and iron supplements. Their diet was therefore somewhat similar to the Mediterranean diet with perhaps the exception of less monounsaturated fats. Although this is a unique population of young, healthy, white individuals, their preeclampsia rate of 0.35% was remarkably low given an incidence of 2.6% in the US population in a similar time period.

Gestational Diabetes

Body mass index before pregnancy is strongly associated with the development of GDM. One prospective cohort study did not find a correlation between GDM and intake of types of fats, carbohydrates, whole grains, meats, or glycemic load in early gestation. A cross-sectional study found women with GDM had lower intakes of fruits and vegetables. A prospective study aimed at identifying factors that cause preterm birth found that women with higher fat intakes had an increased risk for GDM, but the authors did not distinguish the type of fat ingested—an important omission, because a study of Chinese pregnant women found that intake of polyunsaturated fats was inversely related to glucose intolerance and GDM.

A metaanalysis of randomized trials on diet and GDM identified only three studies, with a combined total of 107 women; two trials studied the effect of a low–glycemic index diet and the third studied the effect of a high–fiber diet. The low–glycemic index diet trials showed lower fasting glucose levels, fewer large for gestational age infants, and fewer infants with a high ponderal index in women who followed the low glycemic diet when compared to women with high glycemic diets. These effects may be important, given the evidence that ponderal index may be an indicator of obesity in adulthood. The women in the
high fiber–diet trial did not show significant differences in the incidence of GDM, but the number enrolled in the trial was small.

MATERNAL DIET DURING LACTATION AND INFANT HEALTH

The latest recommendations from the American Academy of Pediatrics and European pediatric societies conclude that avoidance of certain foods during pregnancy has no effect on the development of allergies in infants.62 Exclusive breastfeeding for 4 to 6 months is clearly beneficial for infants at risk for asthma or eczema, but avoiding nuts, egg, milk, and fish in the maternal diet during lactation may not confer any added benefit. However, a 16-year follow-up of children in a randomized trial of prenatal fish oil supplementation showed a large protective effect against development of asthma in the children whose mothers received the fish oil.63

CLINICAL IMPLICATIONS

Because patterns of eating—which and how much food is ingested, how often over time—can have powerful long-term effects on both mother and infant, a clinician must include some time to assess and possibly modify those patterns (nutritional assessment and counseling). But what should clinicians do and say? Regrettably, very little high-quality research has investigated what specific nutrition counseling works the best. Some general recommendations are presented here and summarized in Box 2.

Good nutrition in pregnancy starts with good nutrition during the preconceptional period. Ideally, women should start their pregnancy with a normal body mass index. Multivitamin supplements are recommended for all reproductive age women to ensure adequate folate intake at the time of conception. Although women could take folate alone, Table 1 shows that women residing in the United States have borderline low levels of other micronutrients. A Mediterranean-type diet may be helpful. Low in processed foods and processed grains, and rich in monounsaturated fats, fruits, and vegetables, it tends to have a low glycemic load. Using data from prospective studies about dietary factors associated with chronic diseases, such as heart disease, cancer, and diabetes, McCoullough and Willett proposed the healthy eating pyramid, essentially a Mediterranean diet, to help prevent these diseases (see the article by Skerett and Willett in this issue for further details). As noted previously, such a diet may decrease the incidence of preterm birth. A low–glycemic index diet or the Mediterranean diet may also decrease the incidence of insulin resistance in pregnancy.

Assess a woman’s normal diet (see Siega-Riz on assessing diets), calculate her body mass index, and then give her a target weight gain range for the pregnancy (see Siega-Riz on target weight gain in pregnancy). A study that included diverse practice settings found that one-third of the women reported not remembering being told by their provider how much weight they should gain.65 Women who gained less than the recommended range tended to have providers who recommended a weight that was too low, or who gave them no target weight. A woman’s dietary history should provide an approximate assessment of the adequacy of her vitamin and micronutrient intake. Table 2 lists the recommended daily reference intakes of vitamins and micronutrients for pregnant and lactating women.66,67

Assess a woman’s willingness to make any needed change in her diet. A fuller discussion of potential diet

<table>
<thead>
<tr>
<th>BOX 2. SUMMARY OF DIETARY RECOMMENDATIONS IN PREGNANCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Preconceptional daily intake of folic acid in a multivitamin to ensure adequate folate at time of neural tube development</td>
</tr>
<tr>
<td>● Gain the recommended weight for body mass index by eating the following:</td>
</tr>
<tr>
<td>○ Three meals a day and two snacks to avoid prolonged periods of fasting</td>
</tr>
<tr>
<td>○ A diet rich in fruits and vegetables (five per day) and monounsaturated fats with adequate protein</td>
</tr>
<tr>
<td>○ Fiber-rich carbohydrates and limit carbohydrates with a high glycemic index (e.g., fruit juices and sodas)</td>
</tr>
<tr>
<td>○ At least two servings of omega-3 rich fish (with low mercury level) a week or use omega-3 supplements</td>
</tr>
<tr>
<td>● Ensure adequate intake of these micronutrients and minerals:</td>
</tr>
<tr>
<td>○ Vitamin A as β-carotene and limit food sources of preformed vitamin A, such as liver (&lt;4 oz per week) or cod liver oil</td>
</tr>
<tr>
<td>○ Vitamin D from sunshine exposure; if not feasible, supplement with vitamin D₃ (1000–4000 IU depending on geography, body mass index, and skin type)</td>
</tr>
<tr>
<td>○ Women adhering to strict vegan diets will need vitamin B₁₂ supplements</td>
</tr>
<tr>
<td>○ Iodine through diet or a multivitamin</td>
</tr>
<tr>
<td>○ Iron through diet, multivitamin, or additional low-dose supplement if anemic</td>
</tr>
<tr>
<td>○ Calcium through diet with higher levels suggested for women at risk for preeclampsia</td>
</tr>
<tr>
<td>● Avoid foodborne illnesses that can cause maternal or fetal disease by eating:</td>
</tr>
<tr>
<td>○ Well-cooked meat, poultry (including eggs), and fish</td>
</tr>
<tr>
<td>○ Only pasteurized dairy and fruit juices</td>
</tr>
<tr>
<td>○ Avoid soft cheeses, processed meats, and raw sprouts</td>
</tr>
</tbody>
</table>
Table 2. Recommended Daily Dietary Reference Intakes of Vitamins and Micronutrients in Pregnancy and Lactation

<table>
<thead>
<tr>
<th>Vitamin/Micronutrient</th>
<th>Pregnancy</th>
<th>Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A, mg</td>
<td>770</td>
<td>1300</td>
</tr>
<tr>
<td>Thiamin (vitamin B1), mg</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Niacin (vitamin B3), mg</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Riboflavin (vitamin B2), mg</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Folate, mcg</td>
<td>600</td>
<td>500</td>
</tr>
<tr>
<td>Vitamin B12, mcg</td>
<td>2.6</td>
<td>2.8</td>
</tr>
<tr>
<td>Vitamin C, mg</td>
<td>85</td>
<td>120</td>
</tr>
<tr>
<td>Vitamin D, IU</td>
<td>400–2000</td>
<td>400–6000</td>
</tr>
<tr>
<td>Vitamin E, mg</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Vitamin K, mcg</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>DHA, mg</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Biotin, mcg</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Choline, mg</td>
<td>450</td>
<td>550</td>
</tr>
<tr>
<td>Iodine, mcg</td>
<td>220</td>
<td>290</td>
</tr>
<tr>
<td>Iron, mg</td>
<td>27</td>
<td>9</td>
</tr>
<tr>
<td>Pantothentic acid, mg</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Zinc, mg</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>

DHA = docosahexaenoic acid.

Note: Recommended Dietary Allowance (RDA) used (if RDA is not established, adequate intake [AI] value provided) from all intake sources.

*aLower levels from the Institute of Medicine, but a higher range was recommended by Wagner et al.*

*bRecommendation of the International Society for the Study of Fatty Acids and Lipids.*

Source: Food and Nutrition Board, Institute of Medicine, unless otherwise indicated.

Changes may need to be postponed until the early symptoms of nausea and vomiting have passed. Tell her that she can avoid foodborne illnesses by consuming only fully cooked meats, poultry, fish, and eggs; avoiding unpasteurized dairy and fruit juices, soft cheeses, processed deli foods, and raw sprouts is also important, because it is nearly impossible to rinse out any bacteria. Encourage her to try to eat at least five servings of fruits and vegetables a day and to avoid fruit juices and sugary drinks.

Explore the possibility of eating a Mediterranean-type diet. Inform her that the fetus has a constant need for nutrition, which requires more frequent eating on her part, and recommend that she eat three meals and at least two snacks a day.

Although most women in the United States have adequate amounts of vitamins A and E, some subpopulations, especially non-Hispanic black women, are at more risk for both folate and iodine deficiency, two micronutrients that are important for normal fetal development. A brief review of the content of some prenatal vitamins revealed iodine levels varied from 0 to 175 mcg. The American Thyroid Association recommends that all pregnant women receive a prenatal vitamin that contains 150 mcg of iodine, but this recommendation has yet to be adopted nationally.

Providers working with populations at risk for iodine deficiency may want to recommend such a vitamin to their pregnant patients. On the other hand, iron supplementation beyond what is found in prenatal vitamins should not be routine. Excess iron has been shown to increase oxidative stress and result in poorer perinatal outcomes. If supplementation is needed, low doses of iron (20 mg) are as effective as 80-mg doses of elemental iron, probably because iron absorption is greatly enhanced during pregnancy and is much better tolerated.

Recent research indicates that vitamin D has a more pervasive and more complex role in physiologic processes than previously realized. As seen in Table 1, if 20 to 32 ng/mL is considered an adequate serum level for vitamin D (although some experts in this field are arguing for 40 ng/mL to be considered adequate), the majority of childbearing women in the United States appear to have inadequate levels. Although the current recommended levels of intake for this vitamin are being debated, many researchers now recommend a daily supplement of 1000 to 2000 IU of vitamin D as a minimum. However, obese individuals, those living in less sunny climates or with limited sun exposure, and those with darker skin may need even higher intakes to obtain adequate serum levels. The recently reported vitamin D trial showed no risks and many benefits to pregnant women supplemented with 4000 IU of D3. A cross-sectional study by Merewood et al. that adjusted for demographic variables and alcohol use found that women who were vitamin D–deficient (i.e., with <15 ng/mL) were four times more likely to have a primary cesarean birth. The authors propose that adequate vitamin D is required for effective uterine function during labor. Studies from South Carolina indicate that as much as 4000 to 6400 IU per day is needed by some women for their infants to obtain adequate levels while breastfeeding. Recommending a daily supplement of 1000 to 2000 IU of vitamin D may be beneficial for most pregnant women, with some women requiring higher doses.

The median intake of calcium for US women 19 to 30 years of age is only 843 mg, well below the recommended 1000 mg in pregnancy. Because research has shown that women supplemented with 1500 to 2000 mg of calcium had a decreased risk of preeclampsia, at-risk women should be counseled about ingesting even higher amounts of calcium than recommended. One serving of milk or yogurt has about 300 mg of calcium. Another excellent source is sardines, which are also rich in omega-3s and have low heavy metal contamination; one serving has 370 mg of calcium. Other low-cost options include calcium carbonate antacid tablets, which typically contain 200 mg of calcium. Because calcium can interfere with the absorption of some micronutrients, additional calcium should be taken at a time separate from a multivitamin supplement if feasible.

**CONCLUSION**

How does the overbooked clinician find time to do nutrition counseling? Having women complete a 24-hour
food diary before a scheduled visit saves time; it can be quickly scanned for the presence of at least five fruits and vegetables, adequacy of protein and desirable fats, the intake of calorie-dense, nutrient-poor foods, and meal frequency. The article by Siega-Riz’s gives further advice on efficient diet counseling in busy practice settings. Ideally, women with eating disorders and malabsorptive syndromes, such as inflammatory bowel disease, can be referred to a nutritionist for assessment and counseling. Low-income women are particularly vulnerable to dietary deficiencies. They should be referred to the Women, Infant, and Child (WIC) Nutrition Program which can provide food resources and excellent cultural-based nutrition education. Maintaining quality handouts from reputable organizations such as the Centers for Disease Control and Prevention or professional organizations (e.g., American College of Nurse-Midwives, this Journal’s Share with Women patient education handout series, or the American Congress of Obstetricians and Gynecologists) saves time and provides written material for women to review after their visit. Food, and patterns of eating, can indeed affect maternal and infant outcomes; therefore, clinicians are advised to continue to schedule time for nutrition assessment and counseling.

REFERENCES


31. Hollis BW, Wagner CL. Randomized trial of vitamin D and perinatal outcomes. Presented at the 14th Vitamin D Workshop, Brugge, Belgium, October 4-8, 2009.


