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Nutrition-Related Health Risks and Outcomes of WIC-Eligible Populations

INTRODUCTION

A comprehensive examination of nutrition-related factors relevant to proposing the WIC food packages must include consideration of a number of health risks. This chapter presents the epidemiological evidence that the Committee found to be relevant in applying the findings in Chapters 3 and 4. In particular, the Committee considered risks related to weight status (as discussed in numerous places throughout this report); micronutrients of special concern during reproduction and early childhood; food allergies; and selected environmental risks to the health of women, infants, and children.

MATERNAL NUTRITION-RELATED HEALTH RISKS AND OUTCOMES

Weight Status

Starting at a young age, women often struggle to maintain a healthy body weight, which is defined as a body mass index (BMI = weight kg/height m^2) in the range of 18.5 to 25.0. The growing rates of overweight and obesity among female adolescents and women, particularly those who are disadvantaged, have been well-documented and are of national concern (Flegal et al, 1998). Maternal weight status before, during, and after pregnancy has implications for reproductive health and infant outcomes, as well as chronic disease risk in the near- and long-term as described in previous reports from the Institute of Medicine (NRC, 1989a; IOM, 1990). Prepregnancy obesity has been associated with menstrual irregularities (Balen, et al, 1995), infertility problems (Zaadstra et al., 1993; Balen, et al, 1995), pregnancy complications (Naeye, 1990; Solomon et al., 1997; Cnattingius et al., 1998; Thadhani et al., 1999), adverse birth outcomes (Shaw et al., 1996, 2000), and postpartum anemia (Bodnar et al., 2001, 2002). Obesity is thought to develop from a complex interaction of genetic and environmental factors (NRC, 1989a; NIH, 1998), but scientific knowledge of how and why obesity develops is far from complete. However, the ultimate cause of obesity is positive energy balance. Although the overall WIC program is able to promote healthy body weight through many mechanisms such as encouraging daily physical activity at an appropriate level for each individual, food energy intake is the factor that can reasonably be addressed by the WIC food packages.

Low pregravid weight, variably defined, also has consequences of concern, including intrauterine growth retardation, small gestational age, and preterm birth (Wen et al., 1990; Abrams and Newman, 1991; Siega-Riz et al., 1996; Kramer et al., 1999). Therefore, women who are underweight prior to pregnancy continue to be of high priority for targeted nutrition interventions.

Pregnancy Weight Gain and Pregnancy-Related Weight Retention

In 1990, the IOM recommended ranges for pregnancy weight gain within categories of prepregnancy BMI (IOM, 1990). The current pregnancy weight gain recommendations have evolved from decades of observations made regarding birth outcomes; maintaining weight gains within the optimal range results in better overall infant outcomes (Siega-Riz et al., 1996; Abrams et al., 2000; Schieve et al., 2000). However, when weight gains exceed the upper limits recommended by the IOM, poor birth outcomes are observed at a higher frequency and maternal and fetal complications are increased (Witter et al., 1995; Johnson and Yancey, 1996).

Since release of the IOM report, several studies have examined the pattern of pregnancy weight gain compared with the recommendations. These studies show that most women do not follow the recommendations; in fact, many women gain more than recommended (Siega-Riz et al., 1994; Caulfield et al., 1996; Carmichael et al., 1997; Schieve et al., 1998; Cogswell et al., 1999).

Pregnancy-related weight retention has long-term implications and is a potential pathway leading to increased adiposity that persists beyond the reproductive years into menopause. Pregnancy weight gain above the recommended range is associated with post-pregnancy weight retention and increased adiposity (Gunderson and Abrams, 2000; Olson et al., 2003), particularly in women with lower incomes (Olson et al., 2003). Among women with high pre-pregnancy BMI, pregnancy-related weight retention is greatest, despite lower pregnancy weight gains (Gunderson et al., 2001).

Maternal Iron Deficiency

Reduction of iron deficiency among women of childbearing age is a goal of *Healthy People 2010* (DHHS, 2000a). The target for the reduction of iron deficiency[1] by 2010 is a prevalence of no more than 7 percent in non-pregnant females ages 12 through 49 years (Goal 19-12c) (DHHS, 2000c). A related goal is the reduction of anemia[2] among low-income pregnant females in the third trimester to a prevalence of no more than 20 percent (Goal 19-13) (DHHS, 2000c).

Laboratory data from NHANES 1999-2000 indicates that the prevalence of iron deficiency[3] was nine percent among adolescent females aged 12 through 15 years; 16 percent among adolescent females aged 16 through 19 years; and 12 percent among adult females aged 20

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[1] Laboratory tests used to define iron deficiency are serum ferritin, erythrocyte protoporphyrin, and transferrin saturation. Nonpregnant females ages 12 to 49 years were considered iron-deficient if two or more of the laboratory values were abnormal; notice that anemia was excluded from the criteria (DHHS, 2000d).

[2] Laboratory values used to define anemia were hemoglobin concentrations less than 11.0 g/dL (DHHS, 2000d).

[3] Laboratory tests used to define iron deficiency were abnormal values for at least two of the following three indicators: serum ferritin, transferrin saturation, and free erythrocyte protoporphyrin. Thresholds for the laboratory values were defined by NHANES III (Looker et al., 1997).

through 49 years (CDC, 2002). The prevalence of iron deficiency[3] was approximately two times higher among non-Hispanic black and Mexican-American females (19 to 22 percent) than among non-Hispanic white females (10 percent). In 1996, the prevalence of anemia[4] among low-income, pregnant women enrolled in public health programs was 8, 12, and 29 percent in the first, second, and third trimesters, respectively (CDC, 1998). Recently published analyses of data from NHANES 1988-1994 revealed that even though the prevalence of iron deficiency[5] was 4.7 percent among adolescents (ages 12-16 years), the rates of iron deficiency were higher among subgroups who were female, overweight, Mexican American, or from families with incomes below the poverty level (Nead et al., 2004). Iron deficiency remains prevalent among pregnant women in the U.S. because of low iron stores prior to pregnancy, high iron demands of the pregnancy state itself, and poor compliance with iron supplementation (Suitor and Gardner,1990; Looker et al., 1997; IOM, 2001). Anemia[6] has been weakly but consistently associated with increased risk of preterm delivery (Fedrick and Anderson, 1976; Kaltreider et al., 1980; Murphy et al., 1986; Klebanoff et al., 1989, 1991; Siega-Riz et al., 1998). Iron-deficiency anemia[7] in the first trimester also has been associated with preterm delivery and low birth weight (Scholl et al., 1992).

Among low-income, postpartum women, prevalence of iron-deficiency anemia[8] ranges from 19 to 33 percent (Bodnar et al., 2001; Swensen et al., 2001). The health effects of postpartum anemia have not been well studied but are assumed to be similar to the general effects of anemia such as fatigue, decreased work performance, and decreased exercise tolerance (Li et al., 1994; Cook, 1994; McKenzie, 2004). Postpartum anemia may lead to compromised iron status in subsequent pregnancies (Allen, 2000). Previous studies have indicated that the WIC Program may contribute to the adequacy of iron intake among low-income women (Rush et al., 1988a; Pehrsson et al., 2001).

Folate and Birth Defects

Well-designed studies have documented the relationship between low maternal folate stores and birth defects such as the neural tube defects of spina bifida and anencephaly (Daly et al., 1995). In response to this information, the RDA for folate for women of reproductive age was increased from 150-180 mcg (NRC, 1989b) to 400 mcg (IOM, 1998), an increase of over 100 percent. Over the last decade, a period of folate fortification of grain products, NHANES data have demonstrated increases in median serum folate levels ranging from 155 to 170 percent and in median red blood cell folate from 58 to 73 percent across different racial/ethnic groups (CDC, 2000). Concurrently the prevalence of neural tube defects has declined by 19 to 23

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[4] Laboratory tests used to define anemia were abnormal hematocrit and/or hemoglobin values.

[5] Laboratory tests used to define iron deficiency were transferrin saturation, free erythrocyte protoporphyrin levels, and serum ferritin levels. Individuals, ages 2 to 16 years of age for the complete dataset, were considered iron-deficient if two of the laboratory values were abnormal for age and gender.

[6] Laboratory tests used to define anemia were abnormal hematocrit or hemoglobin values. Cut points for the laboratory values were gestational age-specific (CDC, 1989).

[7] Laboratory tests used to define iron-deficiency anemia were abnormal hematocrit/hemoglobin values with serum ferritin concentrations less than 12 mcg/L.

[8] Laboratory tests used to define anemia were serum ferritin values, hemoglobin values or, in some cases, hematocrit values converted to hemoglobin values. Reference ranges for laboratory values were defined by CDC (1998) and values were adjusted for smoking and altitude of the clinic as recommended (CDC, 1998).

percent (Honein et al., 2001; Mathews et al., 2002; Williams et al., 2002; CDC, 2004)—somewhat less than the expected decline of 50 percent based on earlier estimates of folate intake that would be achieved as a result of the folate fortification initiative (CDC, 1992, 2004). Moreover, disparities persist and many women appear unaware of the connection of folate intake to birth outcomes. The latest March of Dimes Gallop Poll indicates that only 30 percent of women of childbearing age report taking a multivitamin containing folate on a regular basis and this percentage has not changed in the past few years despite public health messages (March of Dimes Birth Defects Foundation, 2003). Thus, women of reproductive age may fail to take a daily multivitamin supplement or other measures that may contribute to optimal folate status.

Nutrients and Improved Birth Outcomes

Preterm birth is a major contributor to infant mortality. Several nutrients have been implicated in the etiology of preterm birth. Evidence from observational studies suggests a role of low vitamin C intake in predisposing a pregnancy to preterm delivery through premature rupture of the membranes (Wideman et al., 1964; Casanueva et al., 1991; Siega-Riz et al., 2003). Adjusting for a number of nutritional and other risk factors, low folate intake was moderately associated with preterm delivery (Scholl, 1996; Siega-Riz and Laraia, 2004). Low levels of antioxidants such as vitamins A, C, and E[9] have been implicated in the etiology of preeclampsia and are now being tested in randomized studies (Roberts et al., 2003).

Maternal Vitamin D

Data for vitamin D intakes were unavailable in the original CSFII data set, and therefore could not be directly examined with the analytic approach used in Chapter 3. However, Moore et al. (2004) recently constructed a database for vitamin D intakes based on the CSFII and found that mean intakes from food sources were below the AI for nonpregnant, nonbreastfeeding adolescents (14 through 18 years of age) and for adult women of reproductive age (19 through 30 years or 31 through 50 years of age). There is some uncertainty about the adequacy of vitamin D intakes for adolescents and women (IOM, 2000a). This uncertainty is greater for women during pregnancy and lactation as these women were not included in the analyses by Moore et al. (2004). Vitamin D is a crucial nutrient in developing and maintaining bone health and it has been identified as a nutrient of public heath importance for all women (Calvo and Whiting, 2003).

NUTRITION-RELATED HEALTH RISKS AND OUTCOMES IN INFANTS AND CHILDREN

Weight Status

Currently in the U.S., over-consumption can be a concern if manifest in signs and symptoms of macronutrient- or micronutrient-specific toxicities, or by contributing to short- or long-term risk of certain chronic diseases (Wardley et al., 1997). Both the National Health and Nutrition Examination Survey (NHANES) and Pediatric Nutrition Surveillance System have documented an increase in the prevalence of overweight among preschool children (Mei et al., 1998; Ogden et al., 2002). An increase in overweight in even the youngest children is of concern,

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[9] Low values have been reported in the general population for circulating vitamin E (α-tocopherol) (Ford and Sowell, 1999).

not only because of its association with later overweight, but also because of associated short-term morbidity. For example, both overweight status at an early age and a high rate of increase in BMI appear to increase the risk of asthma during childhood (Gold et al, 2003). Childhood overweight is also associated with a number of comorbidities such as hyperlipidemia, hypertension, and type 2 diabetes (Must and Strauss, 1999; Dietz, 2001) as well as with higher morbidity and mortality in adulthood (Dietz, 1998a, 1998b).

Infancy may be a critical period for the development of overweight in childhood and its long-term health consequences. Early catch-up growth among children born small has been strongly associated with higher BMI, especially central obesity in early childhood (Whitaker et al., 1997; Ong et al., 2000), and with adult systolic blood pressure (Whitaker et al., 1997; Law et al., 2002). Furthermore, rapid weight gain from birth to four months of age has been associated with overweight at age seven years and in early adulthood (Law et al., 2002; Stettler et al., 2002).

Low birth weight, failure to thrive in infants, and underweight in children can be serious problems (AAP, 2004). The prevalence of undernutrition is low in the general U.S. population (Wang, et al., 2002); however, the low-income population (i.e., the WIC-eligible population) may be both most vulnerable to undernutrition and most vulnerable to significant impacts when undernutrition does occur.

In order to promote a healthy body weight for each infant and child, the overall energy balance between basal needs, growth, physical activity, and food energy intake must be considered in *prescribing* an appropriate food package. Thus, flexibility to promote food energy intakes over a healthy range at each age and stage of development should be considered in *formulating* the food package allowances from which a more specific prescription will be drawn for an individual infant or child.

Vitamin D in Bone Health

Although it is well known that low levels of vitamin D intake in children result in diminished growth and rickets (Curran et al., 2000), it was not possible for the Committee to directly examine vitamin D intakes for children in the CSFII because intakes of this nutrient were not quantified in the original data set (Tippett and Cypel, 1997). However, Moore et al. (2004) estimated vitamin D intakes for the CSFII participants and reported that mean intakes exceeded the AI for non-breastfeeding children 1 to 8 years of age. This indicates that vitamin D intakes are likely to be adequate among children in these age groups on a population basis. Nevertheless, a possible reemergence of vitamin D deficiency as a public health concern in the United States has been suggested. Vitamin D deficiency has been reported in population subgroups or the whole population in regions with seasonal variation in exposure to sunlight (Daaboul et al, 1997; Lawson and Thomas, 1999; Lawson et al., 1999; Kreiter et al., 2000; Dawodu et al., 2003). For example, a study in African-American breastfed infants and children (up to two years of age) in North Carolina illustrated that infants and children of some ethnic groups might be at higher risk for vitamin D insufficiency than previously assumed (Kreiter et al., 2000). The authors suggested this may be due to low vitamin D intake (Kreiter, et al., 2000). However, other authors have implicated other factors in the possible reemergence of vitamin D inadequacy (Daaboul et al, 1997; Blumsohn, 1999; Zlotkin, 1999; Welch et al., 2000; Seeler, 2001; Shaw and Pal, 2002; Dawodu et al., 2003). Thus, whether inadequate intakes of vitamin D are a public health concern remains controversial. Despite the controversy, a calcium- and vitamin D-rich diet during periods of peak bone mass accretion and having sufficient weight bearing exercise throughout life are the most promising interventions to promote bone health at this time (Raisz, 1999; New, 2001; Branca et al., 2001).

Iron Deficiency

Reduction of iron deficiency among young children is a goal of *Healthy People 2010* (DHHS, 2000a). The target for the reduction of iron deficiency [10] by 2010 is a prevalence of no more than 5 percent in children ages 1 through 2 years (Goal 19-12a) and no more than 1 percent in children ages 3 through 4 years (Goal 19-12b) (DHHS, 2000c).

Reports demonstrate a decrease in the prevalence of anemia[11] in U.S. children since the 1970s (DHHS, 2000c; Sherry et al., 1997, 2001). In 1999 and 2000, the estimated prevalence of iron deficiency[12] was 7 percent among toddlers ages 1 through 2 years and 5 percent among 3- through 5-year-olds (CDC, 2002). Recently published analyses of data from NHANES 1998-1994 revealed that even though the prevalence of iron deficiency[13] was only 2.3 percent among children ages 2 through 5 years of age, the rates of iron deficiency were higher among subgroups who were overweight, Mexican American, or from families with incomes below the poverty level (Nead et al., 2004). Differences in the prevalence of iron-deficiency anemia[14] among ethnic groups indicate the need to improve iron content and/or bioavailability, especially in diets of low income and minority children (Kwiatkowski et al., 1999). Previous studies have indicated that the WIC program may contribute to the adequacy of iron intake among low-income infants (Miller et al., 1985; Batten et al., 1990; Sherry et al., 2001; Ponza et al., 2004) and children (Brown and Tieman, 1986; Rush et al., 1988b; Rose et al., 1998; Sherry et al., 2001; Siega-Riz et al., 2004).

Possible Nutrient Deficiencies in Breastfed Infants

Because intake data for breastfed infants could not be included in the analyses in Chapter 3, special attention must be paid to other sources of intake data that include infants solely or partially breastfed. The Feeding Infants and Toddlers Study (FITS) examined nutrient intakes among a combined sample of both breastfed and non-breastfed infants ages 7 through 11 months (Devaney et al., 2004) and found low prevalences of dietary inadequacy for iron (7.5%) and zinc (4.2%), the only two micronutrients with an EAR for this age group. Among WIC participants of the same age, the prevalence of iron inadequacy was only 1 percent (Ponza et al., 2004). For all nutrients with an AI, mean usual intakes for this combined sample of breastfed and non-breastfed

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[10] Laboratory tests used to define iron deficiency are serum ferritin, erythrocyte protoporphyrin, and transferrin saturation. Individuals (children ages 1 through 4 years) were considered iron-deficient if two or more of the laboratory values were abnormal (DHHS, 2000d).

[11] Laboratory tests used to define anemia were abnormal hematocrit values. Reference ranges for the laboratory values were defined by CDC (1989, 1998).

[12] Laboratory tests used to define iron-deficiency were abnormal values for at least two of the following three indicators: serum ferritin, transferrin saturation, and free erythrocyte protoporphyrin. Reference ranges for the laboratory values were defined by NHANES III (Looker et al., 1997).

[13] Laboratory tests used to define iron deficiency were transferrin saturation, free erythrocyte protoporphyrin, and serum ferritin. Individuals, ages 2 through 16 years of age for the complete dataset, were considered iron-deficient if two of the laboratory values were abnormal for age and gender.

[14] Laboratory tests used to define anemia were hemoglobin values. Reference ranges for laboratory values were defined by CDC (1998). Anemia responded to iron therapy.

infants exceeded the AI at both age groups 4 through 6 months and 7 through 11 months, implying a low prevalence of inadequacy.

The Committee also considered clinical and analytical data that could suggest nutrient deficiencies in this vulnerable group. From chemical analyses of breast milk at various stages of lactation (Vaughan et al., 1979; Rajalakshmi and Srikantia, 1980; Ohtake and Tamura; 1993), the iron and zinc content is inadequate for infants 7 through 11 months of age (Krebs, 2000; Dewey, 2001; Krebs and Westcott, 2002). Therefore, foods supplying both iron and zinc are needed for 7- through 11-month old breastfed infants.

At the present time there are no data to suggest nutrient deficiencies are developing in breastfed infants, with the exception of the *continuing problem of iron deficiency* and the *risk of zinc inadequacy without appropriate complementary foods after six months of age* (Skinner et al., 1997; Krebs, 2000; Dewey, 2001; Krebs and Westcott, 2002), and the *possibility of vitamin D deficiency in specific populations* as noted above.

The committee will also consider guidelines for addition of complementary foods (Dewey, 2001; AAP, 2004) in designing the food package for older breastfed infants.

FOOD ALLERGIES

Food allergy or hypersensitivity is most common from birth to one year of age. About 5 percent of children are affected between birth and four years of age (AAP, 2004). By childhood and adolescence, the prevalence of food allergy declines to 1 to 2 percent. Foods that most commonly cause allergic reactions in children are eggs, cow's milk, soy, wheat, peanuts, tree nuts, fish, and shellfish (Twarog, 1998; AAP, 2004). In infants, 2 to 3 percent develop confirmed sensitivity to cow's milk protein (James and Sampson, 1992; Host, 2002). About 85 percent of those infants develop tolerance to milk products by four years of age (James and Sampson, 1992; Host, 2002). Allergy to soy also diminishes with age whereas allergies to peanuts, tree nuts, fish, and shellfish are generally lifelong (Twarog, 1998; Rudolph and Rudolph, 2003). Specifically, in the U.S., anaphylactic reactions to peanuts and foods containing peanuts in some form account for the largest number of fatal and near-fatal allergic reactions to food (Sampson et al., 1992; Bock et al., 2001; AAP, 2004).

ENVIRONMENTAL RISKS IN THE WIC POPULATION

Calcium to Mitigate Lead Exposure in Pregnant and Lactating Women

People are exposed to lead by breathing air, drinking water, eating food, or swallowing or touching dust or dirt that contains lead (ATSDR, 1999a). Lead is then stored in various body tissues including bone. During pregnancy and lactation, lead ingested by a mother or mobilized from bone can affect lead concentration in breast milk (Ettinger et al., 2004) and fetal (Gonzalez-Cossio et al., 1997; Hernandez-Avila et al., 2003) and infant growth (Sanin et al., 2001). Blood lead concentrations increase in pregnant women in a U-shaped pattern with higher values in the first and third trimesters (Hertz-Picciotto et al., 2000). Multiple factors, such as age, smoking, educational level, ethnic background, breastfeeding, and calcium intake, are associated with the blood lead concentration (Hernandez-Avila et al., 1996). Women breastfeeding more than 30 months over their lifetime, and those with higher dietary calcium intake had lower lead concentrations in their blood compared to women who breastfed for shorter cumulative duration and with lower calcium intakes (Hertz-Picciotto et al., 2000). The calcium intake effect was only in the later half of pregnancy, and showed a dose-dependent effect across a range of calcium intakes (from < 0.6 to > 2.0 g calcium per day) (Hertz-Picciotto et al., 2000). Data from women in Mexico City provide additional information relevant to immigrant populations participating in the WIC program and to women who may have had similar exposures in urban areas in the U.S. Maternal blood lead and umbilical cord blood lead were inversely associated with milk and orange juice intake during pregnancy, controlling for sociodemographic characteristics, lifetime exposure to vehicular traffic, and the use of lead-glazed ceramics (Hernandez-Avila et al., 1997). Among women who participated in a longitudinal, randomized, placebo-controlled, double-blind trial, supplementation of 1.2 g calcium[15] was associated with a 15 to 20 percent reduction in blood lead values over the course of lactation (Hernandez-Avila et al., 2003). Thus, from studies investigating a wide range of calcium intakes, adequate calcium intake appears to have the added benefit of decreasing blood lead values in pregnant and lactating women.

Dioxins and Dioxin-Like Compounds

Dioxins (chlorinated dibenzo-*p*-dioxins) and dioxin-like compounds (DLC) are low-level environmental contaminants, but their presence in animal feed and the human food supply is widespread (ATSDR, 1999b). DLC have a variety of potential toxic effects including developmental effects in the fetus and infant (ten Tusscher and Koppe, 2004). In the general population, DLC likely contribute to increasing risk for a variety of types of cancer (Kogevinas, 2000, 2001). Exposure to DLC is almost entirely through the food supply, and primarily from consumption of animal fat. In the current WIC food packages, animal fat may be found in milk, cheese, eggs, and tuna. DLC are long-lived, lipophilic compounds and can accumulate in body fat over the lifetime. While improvements in environmental and animal husbandry practices are the long-term solution to DLC contamination, in the short-term, a reduction in consumption of animal fat will reduce exposure to these toxicants (IOM, 2003b).

A substantial portion of lifetime exposure to DLC occurs prenatally and through breast milk. Due to the persistence of DLC, decreasing DLC exposure of the women only during pregnancy and lactation is relatively ineffective in lowering the exposure of the fetus or breastfeeding infant. Lowering body burdens in the population requires a reduction in consumption of animal fat throughout the reproductive life of girls and women (ten Tusscher and Koppe, 2004). Recommendations in a recent IOM report (IOM, 2003b) include increased awareness of exposure during early life and efforts to decrease the DLC exposure and lifetime accumulation in girls and young women. It has been proposed that a population-wide reduction in total lifetime body burden could be attained through reductions in the consumption of animal fat during both the pre-reproductive and reproductive life of girls and women (ten Tusscher and Koppe, 2004). This attention to early life DLC exposure in females is intended to reduce risk to the offspring, while continuing to support optimal growth and development of the young (or adolescent) mother and her fetus and to support breastfeeding as the optimal source of nutrition for infants. Additionally, the IOM report specifically recommends increasing the availability of low-fat and non-fat dairy products in federal programs targeted to children over the age of two years (IOM, 2003b).

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[15] Mean baseline intake of dietary calcium was 1,160 mg per day (± 761 SD, n=296) for supplement group and 1,137 mg per day (± 597 SD, n=321) for the placebo group.

FDA and EPA Fish Advisories

Fish is high in protein and other essential nutrients including omega-3 fatty acids, and it is part of a healthy diet. On the other hand, the consumption of large quantities of fish in which mercury has accumulated is hazardous to the fetus and the nervous system of young children. For this reason it is recommended that pregnant or nursing women and young children avoid some types of fish (i.e., shark, swordfish, king mackerel, and tilefish) and eat certain other fish and shellfish only in limited quantities. The following fish and shellfish currently have mercury levels that are low enough to allow consumption by these subpopulation groups in limited quantities: shrimp; salmon; pollack/pollock (i.e., bluefish, walleye); catfish; and canned light tuna (not albacore tuna, white tuna, or tuna steak). The level of mercury in the local rivers and lakes determines the mercury level and safety of locally caught fish (ATSDR, 1999c). It is advisable to check on the local conditions to determine the safety of locally caught fish or avoid intake. Because mercury accumulates in the body over time, the FDA recommends that women who are planning to become pregnant or who are pregnant eat no more than 12 ounces of fish a week on average and that children consume smaller quantities (CFSAN, 2001; EPA/FDA, 2004).

SUMMARY

This review of the literature of nutrition-related health risks for the population served by the WIC program indicates several areas of concern for *all groups*: obesity; poor iron status; and contamination of food with dioxin and methyl mercury. Low folate intake is a concern for *all women during their reproductive years* because of the importance of the peri-conception period in prevention of neural tube defects. Insufficient calcium intake for a *pregnant or breastfeeding woman* may be associated with potential lead toxicity for the fetus or infant. Low intake of vitamin D appears to be a concern for *all women of reproductive age*. These health concerns are summarized in Table 5-1.

TABLE 5-1 Summary of Health Concerns from Analysis of Nutrition–Related Health Risks and Outcomes in the WIC-Eligible Population

Topic	Health Concern	WIC Population Affected
Vitamin D	Low intake of vitamin D	All women of reproductive age
Folate	Low intake of folate	All women of reproductive age
Calcium	Low intake of calcium	Pregnant or breastfeeding women
Iron	Iron deficiency anemia persists	Women, infants, and children
Zinc	Low intake of zinc if complementary foods are inappropriate	Breastfed infants greater than 6 months of age
Obesity	Health effects of obesity	Women, infants, and children
Dioxin	Contamination of food with dioxin	Women, infants, and children
Methyl mercury	Contamination of food with methyl mercury	Women, infants, and children

The Committee is proposing that iron be considered a target nutrient even though intakes appear adequate in infants, children, and most women because the prevalence of anemia remains unacceptably high among these vulnerable groups (Bodnar, 2001; CDC, 2002). Although intake data were only available for formula-fed infants, iron remains a concern for both formula-fed and breastfed infants (AAP, 2004). Because the data with clinical measures of anemia are more recent than the intake data on iron and because breastfed infants were excluded from the analyses of intake data, the Committee gave extra weight to the physiological measures. It remains important that adequate intakes of iron be maintained in all individuals.

6

Proposed Approach for Selecting the WIC Food Packages

INTRODUCTION

This chapter describes the approach the Committee proposes to use in revising the WIC food packages. The proposed approach involves specifying criteria to be used in selecting the types and quantities of foods to be included in the WIC food packages; developing food packages that meet nutritional objectives and are cost neutral; and comparing alternative food packages in terms of risks and benefits.

IMPLICATIONS OF A SUPPLEMENTAL FOOD PROGRAM

The definition of "supplemental" food is central to decision-making about the composition of the WIC food packages. One basic way of looking at a supplemental food program is to consider how much of the total food energy need is supplied. As the packages are currently constituted, WIC foods could supply from one-third (in the case of adult women) to 100 percent (in the case of some formula-fed infants) of food energy needs (Kramer-LeBlanc et al., 1999). In the current environment in which food energy needs are almost always met, it is reasonable to focus on the other ways the WIC food packages are supplemental.

The WIC food packages are supplemental to the household's economic resources. The nutritious foods in the WIC package may replace other foods in the diet, resulting in greater nutrient density of the diet consumed (Rush et al., 1988c). By supplying some foods, the WIC program may free household funds, which are then used to purchase higher-quality foods for women and children (Basiotis et al., 1998; Wilde et al., 2000; Ikeda et al., 2002; Chandran, 2003).

The maximum allowances for formula for the youngest formula-fed infants approach, and in some cases exceed, their total nutrient and food energy needs. For older WIC participants, the WIC food package is intended to increase dietary quality by improving intakes of the target nutrients, as well as meeting some of the food energy needs.

Finally, the WIC program is conceptualized as a supplemental nutrition program designed to improve health outcomes. The Committee sees the role of the WIC food package as improving the diet in ways that could have both short-term and long-term benefits. These include improving reproductive outcomes; supporting the growth and development of infants, children, and adolescents; and promoting long-term health in all WIC participants.

PROPOSED CRITERIA FOR THE WIC FOOD PACKAGES

The Committee has considered evidence of three major types: analyses of the nutrient intake of WIC-eligible populations (considered in Chapter 3); analyses of the food intake of WIC-eligible populations (considered in Chapter 4); and nutrition-related health risks and outcomes of WIC-eligible populations (considered in Chapter 5). By integrating all three of these approaches, when possible, the Committee attempted to overcome the limitations of any one approach applied individually.

Based on the information presented in previous chapters, Box 6-1 presents six characteristics that the Committee proposes to use to select the types and quantities of foods to be proposed for inclusion in the WIC food packages. Most of these topics have been addressed previously in this report.

Criterion 1: The package reduces the prevalence of inadequate nutrient intakes and of excessive nutrient intakes. Nutrients of particular concern have been identified by considering two types of information: intake distributions that indicated that many people in the target groups were at risk of either inadequate or excessive intake of a nutrient (Chapter 3); and published scientific papers that identified inadequacy based on physiological or biochemical measures of nutrient status (Chapter 5). Both types of data have strengths and weaknesses, and the combination was deemed most appropriate for identifying nutrients of concern. However, nutrients with low intakes were highlighted even if there was no published clinical evidence of inadequacy, because it is possible that they play a role in the prevention of chronic disease. The panels that set the DRIs considered both acute and chronic diseases when determining the intake recommendations. This approach is consistent with that taken by the 2005 Dietary Guidelines Advisory Committee (2004), which has included guidance for those over two years of age regarding increasing intakes of the nutrients identified below. According to Public Law No. 101-445 (U.S. Congress, 1990), the *Dietary Guidelines for Americans* are to form the basis of federal food, nutrition, and information programs, including the WIC Program.

The term "nutrient of concern" signifies that, if feasible, the revised food packages will improve intake of that nutrient (or maintain appropriate intake of a nutrient in some cases). The nutrients of concern are summarized below:

- *Infants*
    - nutrients of concern with regard to inadequate intake for breastfed infants six months of age and older: iron and zinc
    - nutrients of concern with regard to excessive intake for formula-fed infants: zinc, preformed vitamin A (vitamin A from fortification of foods or from foods of animal origin), and food energy
- *Children, 1 through 4 years old*
    - nutrients of concern with regard to inadequate intake: iron, vitamin E, potassium, and fiber
    - prioritize vegetables as foods to provide some or all of these nutrients

BOX 6-1 Proposed Criteria for a WIC Food Package, if Consumed as Specified

1. The package reduces the prevalence of inadequate nutrient intakes and of excessive nutrient intakes.
2. The package contributes to an overall dietary pattern that is consistent with the *Dietary Guidelines for Americans* for individuals two years of age and older.
3. The package contributes to an overall diet that is consistent with established dietary recommendations for infants and children less than two years of age, including encouragement and support for breastfeeding.
4. The foods in the package are available in forms suitable for low-income persons who may have limited transportation options, storage, and cooking facilities.
5. The foods in the package are readily acceptable, commonly consumed, are widely available, take into account cultural food preferences, and maintain the incentive value of the food packages for families to participate in the WIC Program.
6. The foods will be proposed giving consideration to the impact of changes in the package on vendors and WIC agencies.

- nutrients of concern with regard to excessive intake: zinc, preformed vitamin A (vitamin A from fortification of foods or from foods of animal origin), sodium, and food energy

- *Adolescent and adult women of reproductive age*
  - nutrients of concern with regard to inadequate intake:
    - highest priority to calcium, iron, magnesium, vitamin E, potassium, and fiber
    - also consider vitamin A, vitamin C, vitamin D, vitamin B_6, and folate
  - prioritize fruits and low-fat or nonfat dairy products as foods to provide some of these nutrients
  - nutrients of concern with regard to excessive intake: sodium, food energy, and total fat (See note about added sugars in criterion 2 below.)
- *For all individuals over the age of 2 years*, limit saturated fat and cholesterol. While *trans* fatty acids increase the risk of coronary heart disease in adults, they have not been specifically identified as a hazard in infants and children. However, the recommendation to limit *trans* fatty acids from processed foods in the diet is presumed to apply to all individuals regardless of age.

Criterion 2: The package contributes to an overall dietary pattern that is consistent with the *Dietary Guidelines for Americans* two years and older. Packages that meet this criterion may reduce the risk of chronic diseases and will reinforce nutrition education messages. The food groups identified in Chapter 4 as being particularly low in the diets of the WIC population and the considerations evident from the environmental risks identified in Chapter 5 will be used to prioritize foods for the WIC packages.

- *Children, 1 through 4 years old:* In general, food group servings should be carefully reviewed/considered, giving particularly high priority to vegetables. Consider amounts of added sugars in proposed foods if necessary to promote energy balance. (See Chapter 3 for a description of the term "added sugars.")

- *Adolescents and women of reproductive age:* In general, food group servings should be carefully reviewed, giving particularly high priority to intakes of fruit and dairy products. Consider amounts of added sugars in proposed foods if necessary to promote energy balance.
- *For all ages*, consider dietary guidance from federal agencies and panels of the National Academies regarding food safety. For example, the foods in the package exclude the types of fish that are very high in methylmercury contamination, the types of fish/shellfish that are intermediate in methylmercury contamination are limited, and full-fat dairy products, which may contain dioxin and dioxin-like compounds, also are limited.

Criterion 3: The package contributes to an overall diet that is consistent with established dietary recommendations for infants and children less than 2 years of age, including encouragement and support for breastfeeding. The forms of the foods in the package should be suitable for a young child's age and stage of development. Consideration will be given to keeping juice intake within American Academy of Pediatrics recommendations, discouraging the early introduction of complementary foods, and avoiding excessive intake of food energy.

Criterion 4: The foods in the package are available in forms suitable for low-income persons who may have limited transportation options, limited safe storage facilities, and limited cooking facilities. Ideally, foods chosen for the WIC food packages should be available in neighborhood stores, be available in forms that require no refrigeration, and need a minimum of preparation. See Chapter 2 for additional considerations.

Criterion 5: The foods in the package are readily acceptable, commonly consumed, are widely available, take into account cultural food preferences, and maintain the incentive value of the WIC food packages for families to participate in the WIC Program. Information on common foods will be taken from publications such as NFS Reports No. 91-3 and 96-5 (Krebs-Smith et al., 1997; Smiciklas-Wright, 2002). The need to select food packages that are acceptable to diverse cultural groups is discussed in Chapter 2.

Criterion 6: The impact of changes in the package on vendors and WIC agencies will be considered. As discussed in Chapter 2, changing and/or adding greater flexibility to the WIC food package may increase the administrative load for both vendors of WIC foods and for the agencies who administer the WIC program. Potential administrative impacts will be considered when revising the WIC food packages.

The proposed priority nutrients and food groups are summarized in Table 6-1.

PROCESS FOR TRANSLATING THE CRITERIA INTO FOOD PACKAGES

Foods for the WIC food package will be chosen using the criteria outlined above, with a particular focus on the priority nutrients and types of foods that have been identified. The Committee will identify commonly consumed foods that provide priority nutrients and/or come from a priority food group. Nutrient profiles both of foods and of food packages will be calculated using the most recent USDA database (NDL, 2004) and the potential impact on nutrient inadequacies and excesses will be evaluated for a broad range of nutrients.

Public comments, including those presented at open sessions held by the Food and Nutrition Board, and those received in writing by the Food and Nutrition Board or in response to the Advanced Notice of Proposed Rulemaking (ANPRM) from USDA will be considered.

TABLE 6-1 Proposed Priorities for the WIC Food Packages

Participant Category	Proposed Priority Nutrients	Proposed Priority Food Groups	Nutrients of Concern with Regard to Excessive Intake	Nutrients to Limit in the Diet
Infants, less than 1 year of age, non-breastfed				
		N/A	Zinc Vitamin A, preformed [1] Food energy	
Infants, 6 through 11 months of age, breastfed				
	Iron Zinc	N/A		
Children, 12 through 23 months of age				
	Iron Vitamin E Potassium Fiber	Vegetables	Zinc Vitamin A, preformed [1] Sodium Food energy	
Children, 2 through 4 years of age				
	Iron Vitamin E Potassium Fiber	Vegetables	Zinc Vitamin A, preformed [1] Sodium Food energy	Saturated fat Cholesterol
Adolescent and adult women of reproductive age				
	Highest priority: Calcium Iron Magnesium Vitamin E Potassium Fiber *Also consider:* Vitamin A Vitamin C Vitamin D Vitamin B_6 Folate	Fruit Dairy products, low-fat or nonfat	Sodium Food energy Total fat	Saturated fat Cholesterol *Trans* fatty acids [2]

NOTE: N/A, not applicable from available data.

[1] The UL applies only to preformed vitamin A (i.e., retinol) ingested from the combined sources of animal-derived foods, fortified foods, and dietary supplements (IOM, 2001).

[2] *Trans* fatty acids have not specifically been identified as a hazard for infants and children, and thus are shown in the table as nutrients to limit only in the diets of adolescents and adults (IOM, 2002a). However, the recommendation to limit *trans* fatty acids from processed foods in the diet is presumed to apply to all individuals regardless of age.

Additional considerations that have been raised by various stakeholders are discussed in Chapter 2.

EVALUATING COST NEUTRALITY

In addition to the criteria listed above, the Committee will also consider the constraint of relative cost neutrality in recommending changes to the WIC food packages. For each proposed food package, the Committee will estimate the cost to the food program based on the quantities of component foods in each package, the weighted average price of those foods, the number of participants in the relevant participant category, and estimates of prescription rates for the participant categories. The average price of component foods will come from data from various sources, as appropriate and available to the Committee. These sources may include national-average price series data from the Bureau of Labor Statistics, market data from scanner sources (retail sales/price data such as InfoScan® from Information Resources, Inc., Chicago IL, or SCANTRACK® from ACNielsen, New York NY), and, if needed, Internet or local store price data. The calculated average price of each component food will be weighted to include allowed substitutions in ratios representative of prescription data or estimates drawn from existing studies of food purchases by low income households, national market share data, and other sources such as WIC state agency input and other research resources. For infant formula prices and other major food items (e.g., milk) the Committee may consider current market conditions and projections.

Projected food program cost will be compared to the available current food program cost. At present, the Committee intends to use the baseline year of FY02 because the most recent data available in final form are from this year. Costs applied to several alternative food packages will be compared.

PROPOSED METHODS FOR EVALUATING BENEFITS AND RISKS OF ALTERNATIVE WIC FOOD PACKAGES

An evaluation will be conducted to compare potential benefits and risks for the target population with various potential changes in the WIC food package. As alternative food packages are compared, potential benefits will be characterized as reductions in the prevalence of dietary inadequacy for the priority nutrients. Other potential benefits that will be considered in developing alternative WIC food packages include improved adherence to the *Dietary Guidelines* and other nutrition recommendations, which would ultimately result in improved health and development. Additionally, potential risks will be characterized as increases in the prevalence of inadequacy of nutrients other than the priority nutrients, increases in the risk of excessive nutrient intake levels, or failure to reduce the present apparent risk of excessive nutrient intake.

Other types of nutrition benefits and risks will not be considered explicitly in the evaluation. It is not feasible to estimate what long-term health benefits and risks would be associated with a change in specific foods offered in the WIC program. Those effects would be the result of whether the WIC food instruments are redeemed, how much is consumed by the WIC participant, and the long-term health benefits of consuming those foods. Furthermore, the DRIs and *Dietary Guidelines* already incorporate information on reduced risk of chronic diseases; that is, diets meeting these recommendations should result in long-term health benefits.

The evaluation will apply the framework proposed by the Institute of Medicine Subcommittee on the Uses and Interpretation of the DRIs (IOM, 2003a). Briefly, this framework considers improving the distribution of usual nutrient intakes as the ultimate goal of providing food assistance. Specifically, the goal is to achieve a usual nutrient intake distribution with an acceptably low group prevalence of inadequacy and a low prevalence of excessive intake levels. The proposed contents of the WIC food packages will be selected to achieve that goal.

When considering the benefits and risks of changes to the WIC food packages, it is important to note that the WIC program can control only what is offered to participants, not what they actually consume. To assess whether changes to the WIC food packages achieve an acceptable group prevalence of inadequacy, assessment of dietary intakes must occur. Ultimately, evaluation of the benefits and risks of changing the WIC food packages will come from data collection and analyses after the changes in the WIC food packages occur.

In the meantime, the Committee has the task to evaluate potential benefits and risks associated with changes in the WIC food packages for the target population. The Committee used a starting assumption that any changes in the WIC food packages will be reflected in intake by the targeted individual (infant, child, or woman of reproductive age). Thus, the evaluation of benefits and risks starts with the existing distribution of usual nutrient intake of WIC participants (which presumably reflects the existing intra-allocation of WIC foods[1]). Then, the effects of changes in the nutrient content of alternative WIC food packages is added to the existing distribution of usual intakes of WIC participants, assuming that these changes are consumed by the target individuals.

To illustrate how this framework will be applied, consider the priority nutrients identified by the nutrient intake analysis presented in Chapter 3 of this report. To summarize, vitamin E, calcium, magnesium, potassium, and fiber have the highest prevalence of inadequate intakes for low-income adolescents and women. If a goal is to reduce the prevalence of inadequacy to lower levels, a revised WIC food package might aim to include foods high in these nutrients. If the foods added to the WIC food package are consumed by WIC participants, then the distribution of usual nutrient intake will shift upward and the prevalence of inadequate intake will decline. This change in the prevalence of inadequate intake is the estimated benefit of the new WIC food package.

Changes in specific foods or the quantity of foods offered will alter the nutrient profile of the WIC food packages. Any reduction in intake levels associated with revised WIC food packages may lead to increases in the prevalence of inadequate intake, which is a risk of the revised food package. In addition, any changes in the WIC food package that are expected to result in a shift of the usual intake distribution need to consider increases in the risk of excessive intake levels.

Evaluating the effects of changes in the WIC food packages is an iterative, ongoing effort in which program sponsors set goals for usual intake, plan to achieve these goals, and assess whether the planned goals were achieved. The analyses of this subcommittee will be the first step in this process.

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[1] The Committee recognizes that all foods in a package may not be acquired and that some of the foods that are brought into the household might conceivably be shared with non-participant family members or others in the household or community. However, data on the proportion of WIC foods that are directly consumed by the targeted individual are not currently available for a national sample. Thus, the most logical assumption at this time is that changes in the food packages will directly affect the intake of the individual for whom the package is prescribed. Research into alternative assumptions would aid in future reformulations of the WIC food packages.

SUMMARY

The WIC program is based on the premise that inadequate nutrition during the critical growth and development periods of pregnancy, infancy, and early childhood places many low-income individuals at risk of adverse health outcomes. The WIC program is designed as a supplemental program to meet the special nutritional needs of these periods in order to prevent nutritional problems and to improve health. The WIC supplemental food packages should be selected to help achieve diets that have a low prevalence of inadequate or excessive intake and that meet other dietary recommendations associated with good health. To achieve these goals, the IOM Committee to Review the WIC Food Packages has conducted an analysis of usual intake distributions for WIC-income eligible populations, identified priority nutrients and priority food groups for participant groups, and developed a set of criteria to guide selection of foods to be proposed for inclusion in the WIC food packages. Using the criteria specified in Phase I of this project, the Committee will progress into Phase II and develop recommendations for revised cost-neutral WIC food packages to meet the dietary objectives for the women, infants, and children of the WIC program.

7

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Appendix A

Tables

INTRODUCTION

For the analyses presented in Chapter 3, the Committee conducted several breakdowns of the nutrient intake data for WIC-eligible populations. Some of these were not directly useful in the analyses for Phase I presented in this report. These data may well be useful in Phase II of the project. Additionally, the breakdown of WIC participants versus nonparticipants and infants at various age groups are likely to be of interest to the nutrition community.

TABLE A-1 Usual Intake Distributions of Selected Micronutrients, Protein, Potassium, and Sodium: WIC-Income-Eligible Infants, Age Under One Year, Non-Breastfeeding

Nutrient		Intake Distribution (percentiles and mean), 0 through 11 mos						AI		EAR	% < EAR
(units per day)	Population	10th	25th	Median	Mean	75th	90th	0-6 mos	7-11 mos	7-11 mos	7-11 mos
Calcium	Total	0.40	0.50	0.63	0.67	0.80	1.01	0.32	0.34	-	N/A
(g)	WIC participants	0.40	0.50	0.63	0.65	0.77	0.92	0.32	0.34	-	N/A
	Nonparticipants	0.42	0.52	0.68	0.73	0.90	1.12	0.32	0.34	-	N/A
Iron	Total	8.6	11.3	14.7	15.7	18.8	23.9	0.3	-	6.9	4.5%
(mg)	WIC participants	9.3	11.9	15.0	15.7	18.7	22.9	0.3	-	6.9	2.1%
	Nonparticipants	7.2	10.1	14.0	15.6	19.1	25.7	0.3	-	6.9	7.0%
Zinc	Total	4.3	5.3	6.5	6.8	8.0	9.6	2.0	-	2.5	0.3%
(mg)	WIC participants	4.3	5.4	6.7	6.9	8.0	9.6	2.0	-	2.5	0.3%
	Nonparticipants	4.2	5.1	6.4	6.6	7.8	9.3	2.0	-	2.5	0.1%
Magnesium	Total	50	67	92	101	124	163	30	75	-	N/A
(mg)	WIC participants	52	68	91	97	119	150	30	75	-	N/A
	Nonparticipants	49	64	94	106	139	179	30	75	-	N/A
Vitamin A	Total	432	525	663	704	840	1,025	400	500	-	N/A
(mcg as RAE)	WIC participants	446	540	675	711	843	1,016	400	500	-	N/A
	Nonparticipants	415	520	654	695	822	1,022	400	500	-	N/A
Vitamin C	Total	58	76	100	110	134	175	40	50	-	N/A
(mg)	WIC participants	60	79	105	115	139	180	40	50	-	N/A
	Nonparticipants	56	72	94	99	121	148	40	50	-	N/A
Vitamin E	Total	5.7	8.2	10.7	11.0	13.3	16.4	4.0	5.0	-	N/A
(mg)	WIC participants	6.1	8.3	10.6	11.1	13.5	16.7	4.0	5.0	-	N/A
	Nonparticipants	5.0	7.5	10.7	10.8	13.6	16.3	4.0	5.0	-	N/A
Vitamin B_6	Total	0.36	0.46	0.60	0.65	0.77	0.99	0.10	0.30	-	N/A
(mg)	WIC participants	0.37	0.46	0.59	0.63	0.75	0.93	0.10	0.30	-	N/A
	Nonparticipants	0.34	0.46	0.62	0.69	0.82	1.12	0.10	0.30	-	N/A
Protein [a]	Total	12	15	20	22	27	35	9.1	-	9.9	0.6%
(g)	WIC participants	12	15	20	21	26	33	9.1	-	9.9	0.4%
	Nonparticipants	12	15	20	23	29	39	9.1	-	9.9	0.1%

Potassium	Total	0.61	0.79	1.04	1.12	1.36	1.72	0.40	0.70	-	N/A
(g)	WIC participants	0.61	0.79	1.02	1.08	1.32	1.64	0.40	0.70	-	N/A
	Nonparticipants	0.64	0.82	1.09	1.17	1.45	1.82	0.40	0.70	-	N/A
Sodium	Total	0.16	0.22	0.34	0.50	0.61	1.05	0.12	0.37	-	N/A
(g)	WIC participants	0.17	0.23	0.34	0.49	0.59	0.99	0.12	0.37	-	N/A
	Nonparticipants	0.16	0.21	0.34	0.49	0.61	1.06	0.12	0.37	-	N/A

NOTE: AI = Adequate Intake, EAR = Estimated Average Requirement, N/A = not applicable, RAE = retinol activity equivalents, % < EAR = percentage with intakes less than EAR. The % < EAR is an estimate of the percentage with inadequate intake. For iron, the % < EAR is estimated using the probability approach (NRC, 1986; IOM, 2001). For calcium, the AIs presented are for non-breastfed infants. All other AIs presented are based on mean intakes of healthy breastfed infants. AIs for non-breastfed infants have not been set for these nutrients, although the bioavailability of some nutrients, especially iron and zinc (Lönnerdal et al., 1981; Pabon and Lönnerdal, 2000), is known to be lower in infant formula than in breast milk.

[a] The DRIs for protein include an AI of 1.52 g/kg body weight/d for infants age 0 through 6 months and an EAR of 1.1 g/kg/d for infants age 7 through 11 months. The determination of the percent less than the EAR for infants age 7 through 11 months is based on this EAR value.

DATA SOURCE: Intake data are from 1994-1996 and 1998 CSFII (FSRG, 2000); data set does not include intake from dietary supplements (e.g., multivitamin and mineral preparations) or sodium intake from table salt. The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. EAR and AI are from IOM (1997, 1998, 2000b, 2001, 2002a, 2004). Intake distributions were calculated using C-SIDE (ISU, 1997).

TABLE A-1a Usual Intake Distributions of Selected Micronutrients, Protein, Potassium, and Sodium: WIC-Income-Eligible Infants, Ages 0 Through 3 Months, Non-Breastfeeding

		Intake Distribution (percentiles and mean), 0 through 3 months						AI
Nutrient	Units (per day)	10th	25th	Median	Mean	75th	90th	0-3 mos
Calcium	g	0.34	0.41	0.51	0.55	0.65	0.81	0.32
Iron	mg	7.0	9.1	11.5	12.5	14.6	19.0	0.3
Zinc	mg	3.5	4.3	5.5	5.9	7.1	8.9	2.0
Magnesium	mg	35	43	55	61	71	92	30
Vitamin A	mcg as RAE	354	434	535	577	668	845	400
Vitamin C	mg	41	52	67	74	88	116	40
Vitamin E	mg	6.6	8.1	10.1	11.0	13.1	16.9	4.0
Vitamin B_6	mg	0.25	0.31	0.38	0.41	0.48	0.60	0.10
Protein[a]	g	9	11	14	14	17	21	9.1
Potassium	g	0.44	0.54	0.67	0.72	0.83	1.05	0.40
Sodium	g	0.12	0.15	0.19	0.21	0.25	0.32	0.12

NOTE: AI = Adequate Intake, RAE = retinol activity equivalents. For calcium, the AIs presented are for non-breastfed infants. All other AIs presented are based on mean intakes of healthy breastfed infants. AIs for non-breastfed infants have not been set for these nutrients, although the bioavailability of some nutrients, especially iron and zinc (Lönnerdal et al., 1981; Pabon and Lönnerdal, 2000), is known to be lower in infant formula than in breast milk.

[a] The AI for protein is 1.1 g/kg/d for infants ages 0 through 6 months.

DATA SOURCE: Intake data are from 1994-1996 and 1998 CSFII (FSRG, 2000); data set does not include intake from dietary supplements (e.g., multivitamin and mineral preparations). The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. AI are from IOM (1997, 1998, 2000b, 2001, 2002a, 2004). Intake distributions were calculated using C-SIDE (ISU, 1997).

TABLE A-1b Usual Intake Distributions of Selected Micronutrients, Protein, Potassium, and Sodium: WIC-Income-Eligible Infants, Ages 4 Through 6 Months, Non-Breastfeeding

		Intake Distribution (percentiles and mean), 4 through 6 months						AI
Nutrient	Units (per day)	10th	25th	Median	Mean	75th	90th	4-6 mos
Calcium	g	0.44	0.53	0.62	0.65	0.75	0.88	0.32
Iron	mg	10.3	12.8	15.6	16.3	19.0	23.1	0.3
Zinc	mg	4.5	5.5	6.6	6.8	7.9	9.3	2.0
Magnesium	mg	64	74	87	91	104	124	30
Vitamin A	mcg as RAE	503	599	710	719	830	947	400
Vitamin C	mg	82	99	121	127	148	180	40
Vitamin E	mg	7.5	9.4	11.7	12.0	14.1	16.8	4.0
Vitamin B_6	mg	0.42	0.48	0.56	0.57	0.64	0.73	0.10
Protein[a]	g	13	15	17	18	20	24	9.1
Potassium	g	0.72	0.84	1.00	1.02	1.18	1.36	0.40
Sodium	g	0.18	0.21	0.25	0.27	0.31	0.38	0.12

NOTE: AI = Adequate Intake, RAE = retinol activity equivalents. For calcium, the AIs presented are for non-breastfed infants. All other AIs presented are based on mean intakes of healthy breastfed infants. AIs for non-breastfed infants have not been set for these nutrients, although the bioavailability of some nutrients, especially iron and zinc (Lönnerdal et al., 1981; Pabon and Lönnerdal, 2000), is known to be lower in infant formula than in breast milk.

[a] The AI for protein is 1.1 g/kg/d for infants age 0 through 6 months.

DATA SOURCE: Intake data are from 1994-1996 and 1998 CSFII (FSRG, 2000); data set does not include intake from dietary supplements (e.g., multivitamin and mineral preparations). The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. AI are from IOM (1997, 1998, 2000b, 2001, 2002a, 2004). Intake distributions were calculated using C-SIDE (ISU, 1997).

TABLE A-1c Usual Intake Distributions of Selected Micronutrients, Protein, Potassium, and Sodium: WIC-Income-Eligible Infants, Ages 0 Through 6 Months, Non-Breastfeeding

		Intake Distribution (percentiles and mean), 0 through 6 months						AI
Nutrient	Units (per day)	10th	25th	Median	Mean	75th	90th	0-6 mos
Calcium	g	0.37	0.46	0.57	0.60	0.70	0.86	0.32
Iron	mg	7.9	10.0	13.1	14.4	17.3	22.2	0.3
Zinc	mg	3.9	4.8	6.0	6.3	7.5	9.2	2.0
Magnesium	mg	41	52	69	75	91	117	30
Vitamin A	mcg as RAE	416	501	609	642	752	915	400
Vitamin C	mg	51	66	88	98	119	156	40
Vitamin E	mg	7.0	8.7	10.8	11.5	13.6	17.0	4.0
Vitamin B_6	mg	0.30	0.37	0.46	0.48	0.57	0.70	0.10
Protein[a]	g	10	12	15	16	19	23	9.1
Potassium	g	0.50	0.63	0.81	0.86	1.04	1.28	0.40
Sodium	g	0.14	0.17	0.22	0.24	0.28	0.36	0.12

NOTE: AI = Adequate Intake, RAE = retinol activity equivalents. For calcium, the AIs presented in the table are for non-breastfed infants. All other AIs presented are based on mean intakes of healthy breastfed infants. AIs for non-breastfed infants have not been set for these nutrients, although the bioavailability of some nutrients, especially iron and zinc (Lönnerdal et al., 1981; Pabon and Lönnerdal, 2000), is known to be lower in infant formula than in breast milk.

[a] The EAR for protein is 1.1 g/kg/d for infants age 0 through 6 months.

DATA SOURCE: Intake data are from 1994-1996 and 1998 CSFII (FSRG, 2000); data set does not include intake from dietary supplements (e.g., multivitamin and mineral preparations). The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. AI are from IOM (1997, 1998, 2000b, 2001, 2002a, 2004). Intake distributions were calculated using C-SIDE (ISU, 1997).

TABLE A-1d Usual Intake Distributions of Selected Micronutrients, Protein, Potassium, and Sodium: WIC-Income-Eligible Infants, Ages 7 through 11 Months, Non-Breastfeeding

		Intake Distribution (percentiles and mean), 7 through 11 months						AI	EAR	% < EAR
Nutrient	Units (per day)	10th	25th	Median	Mean	75th	90th	7-11 mos	7-11 mos	7-11 mos
Calcium	g	0.46	0.58	0.73	0.76	0.90	1.09	0.34	-	N/A
Iron	mg	9.9	12.7	16.3	17.2	20.6	25.7	-	6.9	4.5%
Zinc	mg	4.9	5.9	7.1	7.2	8.5	9.8	-	2.5	0.3%
Magnesium	mg	81	100	124	129	154	184	75	-	N/A
Vitamin A	mcg as RAE	483	596	734	766	896	1,081	500	-	N/A
Vitamin C	mg	69	89	116	122	149	182	50	-	N/A
Vitamin E	mg	4.7	7.1	10.2	10.4	13.3	16.0	5.0	-	N/A
Vitamin B_6	mg	0.56	0.67	0.80	0.83	0.96	1.14	0.30	-	N/A
Protein[a]	g	17	22	28	29	35	43	-	9.9	0.4%
Potassium	g	0.95	1.13	1.37	1.41	1.64	1.92	0.70	-	N/A
Sodium	g	0.29	0.42	0.67	0.81	1.05	1.52	0.37	-	N/A

NOTE: AI = Adequate Intake, EAR = Estimated Average Requirement, N/A = not applicable, RAE = retinol activity equivalents, % < EAR = percentage with intakes less than EAR. The % < EAR is an estimate of the percentage with inadequate intake. For iron, the % < EAR is estimated using the probability approach (NRC, 1986; IOM, 2001). For calcium, the AIs presented are for non-breastfed infants. All other AIs presented are based on mean intakes of healthy breastfed infants. AIs for non-breastfed infants have not been set for these nutrients, although the bioavailability of some nutrients, especially iron and zinc (Lönnerdal et al., 1981; Pabon and Lönnerdal, 2000), is known to be lower in infant formula than in breast milk.

[a] The EAR for protein is 1.1 g/kg/d for infants ages 7 through 11 months. The determination of the percent less than the EAR is based on this EAR value.

DATA SOURCE: Intake data are from 1994-1996 and 1998 CSFII (FSRG, 2000); data set does not include intake from dietary supplements (e.g., multivitamin and mineral preparations) or sodium intake from table salt. The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. EAR and AI are from IOM (1997, 1998, 2000b, 2001, 2002a, 2004). Intake distributions were calculated using C-SIDE (ISU, 1997).

TABLE A-2 Usual Food Energy Intakes and Estimated Energy Requirements: WIC-Income-Eligible Infants, Under One Year of Age, Non-Breastfeeding

	Intake Distribution (percentiles and mean), 0 through 11 months					
	10th	25th	Median	Mean	75th	90th
Total						
Usual intake (kcal/d)	526	652	821	859	1,024	1,241
EER (kcal/d)	443	539	637	659	759	903
WIC Participants						
Usual intake (kcal/d)	528	657	824	855	1,010	1,210
EER (kcal/d)	463	548	650	670	769	901
Nonparticipants						
Usual intake (kcal/d)	550	671	829	861	1,016	1,214
EER (kcal/d)	432	508	608	629	727	854

NOTE: EER = Estimated Energy Requirement.

DATA SOURCE: Intake date are from 1994-1996 and 1998 CSFII (FSRG, 2000). The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. EER values are from IOM (2002a). Intake distributions were calculated using C-SIDE (ISU, 1997).

TABLE A-3 Usual Food Energy Intakes and Energy Requirements: WIC-Income-Eligible Children, 1 Through 4 Years, Non-Breastfeeding

	Intake Distribution (percentiles and mean), 1 through 4 years[a]					
	10th	25th	Median	Mean	75th	90th
Total						
Usual intake (kcal/d)	1,049	1,240	1,476	1,516	1,750	2,037
EER-Low active (kcal/d)	883	1,041	1,229	1,216	1,380	1,511
EER-Active (kcal/d)	889	1,053	1,323	1,301	1,523	1,676
WIC Participants						
Usual intake (kcal/d)	992	1,197	1,447	1,483	1,728	2,017
EER-Low active (kcal/d)	837	968	1,178	1,169	1,346	1,494
EER-Active (kcal/d)	835	979	1,233	1,240	1,486	1,636
Nonparticipants						
Usual intake (kcal/d)	1,085	1,268	1,494	1,536	1,761	2,042
EER-Low active (kcal/d)	932	1,083	1,254	1,244	1,394	1,517
EER-Active (kcal/d)	939	1,110	1,359	1,337	1,539	1,690

NOTE: EER = Estimated Energy Requirement.

[a] For children ages 1 through 2 years an EER was calculated for each individual using body weight and the age-appropriate Energy Deposition factor (IOM, 2002a). For children ages 3 through 4 years an EER was calculated for each individual using age, body weight, height, the age-appropriate Energy Deposition factor, and the sex- and age-appropriate PA coefficient (Physical Activity coefficient) for the indicated PAL (Physical Activity Level: Low Active or Active) (IOM, 2002a).

DATA SOURCE: Intake date are from 1994-1996 and 1998 CSFII (FSRG, 2000). The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. EER values are from IOM (2002a). Intake distribution was calculated using C-SIDE (ISU, 1997).

TABLE A-4 Usual Intake Distributions of Selected Micronutrients, Protein, Potassium, and Fiber: WIC-Income-Eligible Children, Ages 1 Through 4 Years

Nutrient (units per day)		Intake Distribution (percentiles and mean), 1 through 4 y						AI		EAR		% < EAR
	Population	10th	25th	Median	Mean	75th	90th	1-3 y	4 y	1-3 y	4 y	1-4 y
Calcium	Total	0.50	0.64	0.81	0.84	1.00	1.21	0.50	0.8	-	-	N/A
(g)	WIC participants	0.53	0.67	0.84	0.86	1.03	1.22	0.50	0.8	-	-	N/A
	Nonparticipants	0.49	0.62	0.79	0.82	0.99	1.19	0.50	0.8	-	-	N/A
Iron	Total	7.4	9.2	11.6	12.2	14.6	17.9	-	-	3.0	4.1	1.0%
(mg)	WIC participants	7.5	9.6	12.3	13.0	15.6	19.3	-	-	3.0	4.1	0.9%
	Nonparticipants	7.4	9.0	11.1	11.7	13.8	16.8	-	-	3.0	4.1	1.0%
Zinc	Total	5.6	6.7	8.2	8.6	10.0	12.0	-	-	2.5	4	0.1%
(mg)	WIC participants	5.5	6.6	8.2	8.6	10.1	12.2	-	-	2.5	4	0.2%
	Nonparticipants	5.8	6.9	8.2	8.6	9.9	11.8	-	-	2.5	4	0.1%
Magnesium	Total	132	158	191	197	230	269	-	-	65	110	0.7%
(mg)	WIC participants	134	162	196	202	235	276	-	-	65	110	0.4%
	Nonparticipants	130	156	188	194	226	265	-	-	65	110	0.9%
Vitamin A	Total	369	458	578	625	733	929	-	-	210	275	0.7%
(mcg as RAE)	WIC participants	370	464	587	643	753	971	-	-	210	275	0.6%
	Nonparticipants	366	453	574	615	730	913	-	-	210	275	0.7%
Vitamin C	Total	50	70	97	105	132	169	-	-	13	22	0.2%
(mg)	WIC participants	62	83	110	116	143	177	-	-	13	22	0.0%
	Nonparticipants	45	64	90	98	124	161	-	-	13	22	0.3%
Vitamin E	Total	3.2	4.0	5.0	5.4	6.4	8.0	-	-	5.0	6.0	55.4%
(mg)	WIC participants	3.1	3.9	5.1	5.7	6.8	9.0	-	-	5.0	6.0	52.2%
	Nonparticipants	3.3	4.0	4.9	5.2	6.1	7.3	-	-	5.0	6.0	58.9%
Vitamin B_6	Total	0.92	1.11	1.38	1.43	1.69	2.02	-	-	0.40	0.50	0.0%
(mg)	WIC participants	0.92	1.13	1.40	1.47	1.73	2.09	-	-	0.40	0.50	0.0%
	Nonparticipants	0.92	1.11	1.36	1.41	1.66	1.96	-	-	0.40	0.50	0.0%
Protein[a]	Total	37	44	53	55	64	75	-	-	11	15	0.0%
(g)	WIC participants	36	43	53	54	63	74	-	-	11	15	0.0%
	Nonparticipants	38	45	54	55	64	75	-	-	11	15	0.0%

Potassium	Total	1.4	1.7	2.0	2.1	2.4	2.9	3.0	3.8	-	-	N/A
(g)	WIC participants	1.4	1.7	2.1	2.1	2.5	2.9	3.0	3.8	-	-	N/A
	Nonparticipants	1.3	1.6	2.0	2.0	2.4	2.8	3.0	3.8	-	-	N/A
Total Fiber	Total	6	7	10	10	12	15	19	25	-	-	N/A
(g)	WIC participants	5	7	9	10	12	15	19	25	-	-	N/A
	Nonparticipants	6	8	10	10	12	14	19	25	-	-	N/A

NOTE: AI = Adequate Intake, EAR = Estimated Average Requirement, RAE = retinol activity equivalents, % < EAR = percentage with intakes less than EAR. The % < EAR is an estimate of the percentage with inadequate intake. For iron, the % < EAR is estimated using the probability approach (NRC, 1986; IOM, 2001).

[a] The EAR for protein is 0.88 g/kg body weight/d for children ages 1 through 3 years and 0.76 g/kg/d for children ages 4 through 8 years. The determination of the percent less than the EAR is based on these values.

DATA SOURCE: Intake data are from 1994-1996 and 1998 CSFII (FSRG, 2000); data set does not include intake from dietary supplements (e.g., multivitamin and mineral preparations). The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. EAR and AI are from IOM (1997, 1998, 2000b, 2001, 2002a, 2004). Intake distributions were calculated using C-SIDE (ISU, 1997). Breastfeeding children are excluded from this analysis.

Table A-5 Usual Intakes of Macronutrients and Added Sugars: WIC-Income-Eligible Children, 1 Through 4 Years,[a] Non-Breastfeeding

	Percent of Food Energy						
	Protein		Fat		Total Carbohydrate		Added Sugars[a]
	< 5%	> 20%	< 30%	> 40%	< 45%	> 65%	> 25%
Total	0.6%	2.0%	16.8%	12.2%	5.0%	1.7%	4.3%
WIC participants	0.3%	1.5%	20.0%	9.5%	3.7%	1.9%	2.8%
Nonparticipants	0.7%	2.2%	14.9%	13.6%	5.4%	1.5%	4.6%

[a] For added sugars, data were available only for children 2 through 4 years of age. The recommendation to limit added sugars to less than 25% of food energy intake is to be applied only to children 2 through 4 years of age.

DATA SOURCE: Intake date are from 1994-1996 and 1998 CSFII (FSRG, 2000). The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. EER values are from IOM (2002a). Intake distribution was calculated using C-SIDE (ISU, 1997).

Table A-6 Percentage of WIC-Income-Eligible Individuals with Usual Intakes Above the UL

	Infants, 0 through 11 mos			Children, 1 through 4 years			Women		
	Total	WIC	Non-WIC	Total	WIC	Non-WIC	14-18 y	19-44 y	P/L
Calcium									
UL (g/d)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
% > UL	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Iron									
UL (mg/d)	40	40	40	40	40	40	45	45	45
% > UL	< 1%	< 1%	1.8%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Zinc									
UL (mg/d)	4	4	4	7	7	7	34	40	40
% > UL	88.8 %	89.7%	91.6%	14.9%	16.9%	13.3%	< 1%	< 1%	< 1%
Vitamin A, preformed									
UL (mcg/d)	600	600	600	600	600	600	2,800	3,000	2,800
% > UL	39.1 %	43.6%	34.8%	16.4%	17.6%	16.3%	< 1%	< 1%	< 1%
Vitamin B_6									
UL (mg/d)	ND	ND	ND	30	30	30	80	100	100
% > UL				< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Vitamin C									
UL (mg/d)	ND	ND	ND	400	400	400	1,800	2,000	2,000
% > UL				< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Sodium									
UL (g/d)	ND	ND	ND	1.5	1.5	1.5	2.3	2.3	2.3
% > UL				86.3%	81.9%	89.2%	93.1%	72.4%	98.9%

NOTE: ND = not determined, P/L = pregnant or lactating, 14 through 50 years of age, UL = Tolerable Upper Intake Level (for infants, UL values presented in the table are for infants 0 through 6 months of age; for children, UL values presented in the table are for children 1 through 3 years of age).

DATA SOURCE: Intake date are from 1994-1996 and 1998 CSFII (FSRG, 2000); data set does not include intake from dietary supplements (e.g., multivitamin and mineral preparations) or sodium intake from table salt. The analysis sample from the CSFII data set included only respondents living in households with income less than or equal to 185 percent of the federal poverty threshold. UL values are from IOM (1997, 1998, 2000b, 2001, 2004). Breastfeeding infants or children were omitted from the analysis.

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Appendix B

Biographical Sketches of Committee Members

BARBARA L. DEVANEY, Ph.D., is an economist and senior fellow at Mathematica Policy Research, Inc. (Princeton, NJ). Dr. Devaney's expertise is in the areas of food assistance and child health programs and the nutrition policies that affect these programs. She has over 20 years of experience in designing and conducting program evaluations and has conducted numerous studies of the WIC Program, the Food Stamp Program, and school nutrition programs. She was the project director for the Feeding Infants and Toddlers Study (FITS) for the Gerber Products Company in which data on food and nutrient intakes of infants and toddlers were collected and analyzed (2001-2003). In addition, Dr. Devaney conducted analyses of the effects of WIC participation on infant mortality and very low birth-weight among Medicaid newborns, and has investigated the infant feeding practices, and health care utilization of infant WIC participants. Dr. Devaney has served on several Institute of Medicine panels including the Subcommittee on Interpretation and Uses of Dietary Reference Intakes and the Committee on Scientific Evaluation of the WIC Nutrition Risk Criteria. Dr. Devaney earned a B.A. degree in economics from Mount Holyoke College (South Hadley, MA) and a Ph.D. degree in economics from the University of Michigan.

GEORGE M. GRAY, Ph.D., is lecturer on risk analysis in the Department of Health Policy and Management in the School of Public Health at Harvard University. Dr Gray is also Executive Director of the Harvard Center for Risk Analysis. His primary research interests are risk characterization and risk communication (with an emphasis on agriculture, food safety, and chemicals in the environment). Other interests include the scientific basis of human health risk assessment, application of risk assessment to policy decisions, and risk/risk tradeoffs in risk management. Dr. Gray receives research support from numerous sources, including the National Food Processors Association Research Foundation. Dr. Gray has served on various panels including the Risk Assessment Task Force of the Society of Toxicology, the Food Advisory Committee of the Center for Food Safety and Applied Nutrition (CFSAN) at FDA, and the National Advisory Environmental Health Science Council of NIEHS. Dr. Gray earned a B.S. degree from the University of Michigan and M.S. and Ph.D. degrees from the University of Rochester.

GAIL G. HARRISON, Ph.D., is professor and vice-chair in the Department of Community Health Sciences at the School of Public Health of the University of California-Los Angeles

(UCLA). Dr. Harrison is also Senior Research Scientist in the UCLA Center for Health Policy Research and associate director of the Program for Healthy and At-Risk Populations in the Division of Cancer Prevention and Control, UCLA/Jonsson Comprehensive Cancer Center. Dr. Harrison's interests include pediatric and maternal nutrition; dietary and nutritional status assessment; food security; and international health and nutrition. Her recent research interests include assessment of variation in dietary intake patterns, cancer-protective interventions, estimation of dietary content of isoflavones, and changes in diet and prevalence of chronic diseases in developing countries. Dr. Harrison has been a member of the Food and Nutrition Board and has served on several Institute of Medicine panels including the Committee on Implications of Dioxin in the Food Supply, the Committee on Scientific Evaluation of WIC Nutrition Risk Criteria, the Committee on Food Consumption Patterns, and the Committee on International Nutrition Programs. She has served as a technical consultant to the WIC program of the Public Health Foundation of Los Angeles and to USDA's Agricultural Research Service and Economic Research Service. Dr. Harrison earned a B.S. degree in foods and nutrition from the University of California-Santa Barbara, an M.N.S. (nutritional sciences) degree from Cornell University, and a Ph.D. degree in biological anthropology at the University of Arizona. She was elected to the Institute of Medicine in 2003.

HELEN H. JENSEN, Ph.D., is professor in the Department of Economics in the College of Agriculture at Iowa State University (ISU). Dr. Jensen is also head of the Food and Nutrition Policy Division in the Center for Agricultural and Rural Development (CARD) at ISU. Her research focuses on nutrition policies, food assistance programs, food security issues, analysis of food demand, food hazard control options, food safety (with emphasis on the economics of food safety), and health economics. Dr. Jensen's current research includes participation in an evaluation of the nutrition education component of the WIC Program; her part in this competitive grant to the Iowa Department of Public Health from the Food and Nutrition Service of the USDA is analysis of the cost-effectiveness of the nutrition education intervention. Dr. Jensen has served on several National Research Council panels including the Committee on Assessing the Nation's Framework for Addressing Animal Diseases (where she is currently serving), the Committee on Biological Threats to Agricultural Plants and Animals, and the Panel on Animal Health and Veterinary Medicine. Dr. Jensen earned a B.A. degree in economics from Carleton College (Northfield, MN), an M.S. degree in agricultural and applied economics from the University of Minnesota, and a Ph.D. degree in agricultural economics from the University of Wisconsin-Madison.

LUCIA L. KAISER, Ph.D., R.D., is Cooperative Extension Specialist in the Department of Nutrition in the College of Agriculture and Environmental Sciences at the University of California—Davis. Dr. Kaiser's research interests include the impact of acculturation and food security on the child-parent feeding relationship among Latinos and evaluation of nutrition education. She served in WIC programs in California for 6 years as supervising public health nutritionist and regional nutrition consultant. Dr. Kaiser currently administers a USDA/Economic Research Service Small Grants Program to examine the impact of food assistance on nutrition. Dr. Kaiser earned a B.S. degree in biology from the College of William and Mary, and M.S. and Ph.D. degrees in nutrition from the University of California—Davis.

JEAN D. KINSEY, Ph.D., is professor of consumption economics in the Department of Applied Economics in the College of Agricultural, Food and Environmental Sciences at the University of Minnesota. Dr. Kinsey is also the Co-Director of The Food Industry Center that focuses on how various retailers in the food industry serve consumers and how retailers and suppliers interact in food distribution channels. The Food Industry Center at the University of Minnesota is one of 13 industry study centers funded by the non-profit Sloan Foundation. Dr. Kinsey's research interests include food consumption trends, consumer buying behavior, food safety and consumer confidence, demographic changes in households, food industry structure, trends in food distribution and retail sales, effects of electronic technology on efficiency in retail outlets, economic effects of health and safety regulations, and regulation in the food industry. Dr. Kinsey earned a B.A. degree in home economics from St. Olaf College (Northfield, MN) and M.S. and Ph.D. degrees from the University of California—Davis in consumer economics and agricultural economics, respectively. Dr. Kinsey was appointed a resident fellow at the National Center for Food and Agricultural Policy, Resources for the Future (1986-1987, Washington, DC); a distinguished fellow of the American Council on Consumer Interests (1997); and a fellow of the American Agricultural Economics Association (2000).

SUZANNE P. MURPHY, Ph.D., R.D., is a research professor at the Cancer Research Center of Hawaii at the University of Hawaii (Honolulu, HI) and director of the Nutrition Support Shared Resource at the center. Dr. Murphy's research interests include dietary assessment methodology, development of food composition databases (with emphasis on inclusion of ethnic foods), communication of nutrition principles (with emphasis on multi-cultural populations), and nutritional epidemiology of chronic diseases (with emphasis on cancer and obesity). She has served as a member of the National Nutrition Monitoring Advisory Council and as vice-chair of the 2000 Dietary Guidelines Advisory Committee. Dr. Murphy has served on several Institute of Medicine panels including the Subcommittee on Interpretation and Uses of Dietary Reference Intakes, which she chaired for two years; the Subcommittee on Upper Safe Reference Levels of Nutrients, and the Panel on Calcium and Related Nutrients. Dr. Murphy earned a B.S. degree in mathematics from Temple University, Philadelphia, an M.S. degree in molecular biology from San Francisco State University, and a Ph.D. degree in nutrition from the University of California-Berkeley.

ANGELA M. ODOMS-YOUNG, Ph.D., is an assistant professor of Public and Community Health in the School of Allied Health Professions of the College of Health and Human Sciences at Northern Illinois University (Dekalb, IL). Prior to her current position, Dr. Odoms-Young completed a Family Research Consortium Postdoctoral Fellowship focused on understanding family processes in diverse populations at the Pennsylvania State University and University of Illinois at Urbana-Champaign and a Community Health Scholars Fellowship in community-based research at the University of Michigan School of Public Health. Her research and teaching focus on race, poverty, and health; community-based participatory research; obesity prevention and management; religion and health (with emphasis on health issues impacting Muslim women); minority health (with emphasis on health disparities in minority populations and health perceptions among low-income families); health promotion (with emphasis on the lay health advisor model); and health education (with emphasis on communicating nutrition principles to minority families). Dr. Odoms-Young's research experience included participation in Welfare, Children and Families: A Three-City Ethnographic Study where she was interested in the influence of poverty on the nutrition and health beliefs of low-income women with young children. Dr. Odoms-Young earned a B.S. degree in foods and nutrition from the University of Illinois-Urbana/Champaign and M.S. and Ph.D. degrees from Cornell University in human nutrition and community nutrition, respectively.

KAREN E. PETERSON, Sc.D., R.D., is Associate Professor and Director of Public Health Nutrition in the Department of Nutrition with a joint appointment in the Department of Society, Human Development and Health in the School of Public Health at Harvard University. Her research focuses on biosocial and environmental determinants of body size and growth during critical periods of behavioral and biologic adaptation; and the application of these principles to the design and evaluation of surveillance systems and of community-based interventions addressing overweight and undernutrition among low-income, multi-ethnic populations in the U.S. and Latin America. Dr. Peterson served for seven years in the Massachusetts WIC Program as a nutritionist and as a program director. Her current research includes examination of dietary behaviors on weight statue of children and new mothers enrolled in WIC. Dr. Peterson earned a B.S. degree in foods and nutrition from the University of Utah, completed her dietetics internship at Peter Bent Brigham Hospital, Boston, MA, and received a D.Sc. degree in nutrition from the School of Public Health at Harvard University. She chaired the CDC-funded "Building Comprehensive Obesity Surveillance" national workgroup and is currently President of the Maternal and Child Health Council of the Association of Schools of Public Health and President of the Graduate Faculties of Public Health Nutrition.

ANNA MARIA SIEGA-RIZ, Ph.D., R.D., is associate professor in the Department of Maternal and Child Health and the Department of Nutrition in the School of Public Health at the University of North Carolina (UNC)—Chapel Hill. Dr. Siega-Riz is a fellow at the Carolina Population Center and director of the Nutrition Epidemiology Core for the Clinical Nutrition Research Center in the Department of Nutrition also at UNC—Chapel Hill. Her research focuses on reproductive and minority health (with emphasis on maternal nutritional status and how it affects birth outcomes). Dr. Siega-Riz expertise includes maternal and early childhood health, maternal nutrition (with emphasis on iron, zinc, folate, and vitamin C), reproductive epidemiology, and effects of participation in the WIC Program. She approaches her research from a multidisciplinary team perspective as an effective way to address complex problems such as pre-maturity, fetal programming, and racial disparities in reproductive outcomes. Dr. Siega-Riz earned a B.S.P.H. degree in nutrition from the School of Public Health at the UNC—Chapel Hill; an M.S. degree in food, nutrition, and food service management from UNC—Greensboro; and a Ph.D. degree in nutrition and epidemiology from the School of Public Health at UNC—Chapel Hill. She received the Mary C. Egan Award (2000; from the American Public Health Association-Food and Nutrition Section) which recognizes professional contributions and outstanding services of public health nutritionists.

VIRGINIA A. STALLINGS, M.D., is the Jean A. Cortner Endowed Chair in Pediatric Gastroenterology, director of the Nutrition Center, and deputy director of the Joseph Stokes Jr. Research Institute at Children's Hospital of Philadelphia. Dr. Stallings is also professor of pediatrics at the University of Pennsylvania School of Medicine. Her research interests include pediatric nutrition, nutrition science (with emphasis on evaluation of dietary intake and energy expenditure), and chronic disease (with emphasis on nutrition-related issues of children and adolescents with chronic illnesses). Dr. Stallings is on the board of the Dannon Institute and serves as a consultant on pediatric nutrition and educational issues to the Bristol-Myers/ Squibb Foundation and Mead-Johnson Nutritionals. Dr. Stallings has served on several Institute of Medicine panels including the Food and Nutrition Board, the Committee on the Scientific Basis of Dietary Risk Eligibility Criteria for the WIC Program, and the Committee on Nutrition Services for Medicare Beneficiaries. Dr. Stallings received a B.S. degree in nutrition and foods from Auburn University, an M.S. degree in human nutrition and biochemistry from Cornell University, and an M.D. degree from the University of Alabama School of Medicine. Her medical training was completed with a pediatric residency at The University of Virginia and a pediatric nutrition fellowship at the Hospital for Sick Children, Toronto, Ontario. Dr. Stallings is board certified in pediatrics and clinical nutrition.

CAROL WEST SUITOR, Sc.D., is a nutrition consultant who currently is technical editor/ writer for the year 2005 Dietary Guidelines Advisory Committee. Pervious consulting work includes assisting the March of Dimes' Task Force for Nutrition and Optimal Human Development; assisting the year 2000 Dietary Guidelines Advisory Committee; studying school children's diets in conjunction with Mathematica Policy Research Inc.; and serving on the Advisory Committee for the Harvard School of Public Health's Dietary Intake Grant (ERS/USDA). Dr. Suitor served as study director for the Institute of Medicine for 8 years; studies included Nutritional Status During Pregnancy and Lactation (4 studies), Scientific Evaluation of WIC Nutrition Risk Criteria, and Dietary Reference Intakes on the B Vitamins and Choline. At Georgetown University in the National Center for Education in Maternal and Child Health, Dr. Suitor managed projects on maternal and child nutrition. At the Harvard School of Public Health, she worked on the development and testing of instruments for collecting dietary information from low-income women. Dr. Suitor has served on several Institute of Medicine panels including the Committee on the Scientific Basis for Dietary Risk Eligibility Criteria for WIC Programs and the Committee on Evaluation of USDA's Methodology for Estimating Eligibility and Participation for the WIC Program. Dr. Suitor earned a B.S. degree in food and nutrition from Cornell University, an M.S. degree in nutrition from the University of California—Berkeley, and M.S. and Sc.D. degrees in maternal and child health from the School of Public Health at Harvard University.

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Appendix C

Acronyms and Abbreviations

AAP	American Academy of Pediatrics
ADA	American Dietetic Association
AI	Adequate Intake
AMDR	Acceptable Macronutrient Distribution Ranges
ARS	Agricultural Research Service, United States Department of Agriculture
ASCN	American Society for Clinical Nutrition
ATSDR	Agency for Toxic Substance and Disease Registry
BARC	Beltsville Agricultural Research Center, United States Department of Agriculture
BLS	Bureau of Labor Statistics
BMI	body mass index
C-SIDE	C compiler version of SIDE, C program language is the source code for C-SIDE
CDC	Center for Disease Control and Prevention
CDD	Chlorinated Dibenzo-p-Dioxin
CFR	Code of Federal Regulations
CFSAN	Center for Food Safety and Applied Nutrition
CNPP	Center for Nutrition Policy and Promotion, United States Department of Agriculture
CSFII	Continuing Survey of Food Intakes by Individuals
d	day
DHEW	Department of Health, Education and Welfare
DHHS	Department of Health and Human Services
DLC	dioxin-like compounds
DQI	Dietary Quality Index
DQI-R	Dietary Quality Index Revised
DRI	Dietary Reference Intakes
EAR	Estimated Average Requirement
EBT	electronic benefit transfer
EER	Estimated Energy Requirement
EPA	Environmental Protection Agency
ERS	Economic Research Service, United States Department of Agriculture
FASEB	Federation of American Societies of Experimental Biology
FDA	Food and Drug Administration
FITS	Feeding Infants and Toddlers Study

FNB	Food and Nutrition Board, Institute of Medicine
FNS	Food and Nutrition Service, United States Department of Agriculture
FSIS	Food Safety and Inspection Service
FSRG	Food Surveys Research Group, United States Department of Agriculture
FY	fiscal year
g	gram
GAO	General Accounting Office
HEI	Healthy Eating Index
IOM	Institute of Medicine, The National Academies
ISU	Iowa State University
kcal	kilocalorie
kg	kilogram
L	liter
LSRO	Life Sciences Research Office
mcg	microgram
mg	milligram
mos	months
n	number
N/A	not applicable from available data
NAS	National Academy of Sciences, The National Academies
NAWD	National Association of WIC Directors
ND	not determined
NDL	Nutrient Data Laboratory, United States Department of Agriculture
NFCS	Nationwide Food Consumption Survey
NHANES	National Health and Nutrition Examination Survey
NIH	National Institutes of Health, Department of Health and Human Services
NRC	National Research Council, The National Academies
NWA	National WIC Association
oz	ounce
PA	physical activity
PAL	physical activity level
PHS	Public Health Service
P/L	pregnant or lactating
RAE	retinol activity equivalent
RDA	Recommended Dietary Allowances
SD	standard deviation
SIDE	Software for Intake Distribution Estimation
SKU	stock-keeping unit
tsp	teaspoon
UL	Tolerable Upper Intake Level
USC	U.S. Code
USDA	U.S. Department of Agriculture
VRG	Vegetarian Resource Group
WHO	World Health Organization
WIC	Special Supplemental Nutrition Program for Women, Infants, and Children
y	year