PART D. CHAPTER 2: FOOD, BEVERAGE, AND NUTRIENT CONSUMPTION DURING PREGNANCY

INTRODUCTION

Pregnancy is a critical period of life for both a mother and her child. Although each pregnancy can be viewed as a discrete 40-week stage in the lifespan with distinct nutritional needs, the outcome of that pregnancy is influenced by the woman's health status before conception and it can, in turn, influence her future health trajectory.[1] The physiological and metabolic changes that occur during pregnancy[2] can predispose some women to developing transient (and sometimes life-threatening) chronic health conditions, such as gestational diabetes mellitus (GDM) and hypertensive disorders. In addition, excessive gestational weight gain (GWG) is relatively common, particularly in women with a high prepregnancy body mass index (BMI),[3] and retention of excess body weight postpartum places a woman at higher risk for chronic diseases in subsequent pregnancies[4] and later in life.[5,6] The Developmental Origins of Health and Disease (DOHaD) hypothesis posits that environmental exposures, including both under- and over-nutrition, during early developmental stages increase the risk of developing metabolic and neurodegenerative disorders during later life.[7,8]

Thus, a mother's health and nutritional status during the first 1,000 days of an infant and child's life, beginning at conception and continuing through the second year of life, are crucial for ensuring optimal physical, social, and psychomotor growth and development and lifelong health.[9] The intergenerational, or epigenetic, effects of intrauterine exposures[7] highlight the potential for long-term benefits to be gained from optimizing nutrition during pregnancy. Accordingly, understanding the relationship between consuming a healthy diet and preconception, pregnancy, and postpartum outcomes was the top priority recommendation put forth by the Health in Preconception, Pregnancy, and Postpartum Global Alliance.[10]

For the first time, the *2020-2025 Dietary Guidelines for Americans* will take a life course approach, with a new focus on the first 1,000 days of life. To support this new focus, this chapter of the 2020 Dietary Guidelines Advisory Committee's report describes the findings of the systematic reviews conducted to examine the relationships between aspects of the maternal diet, including folate and omega-3 fatty acid supplements consumed before and/or during pregnancy on both maternal (micronutrient status, GDM, hypertensive disorders, and GWG) and infant perinatal outcomes (gestational age and birth weight at delivery), as well as longer-term child outcomes, including neurodevelopment and the risk of food allergies and atopic allergic diseases. ***Part D. Chapter 3: Food, Beverage, and Nutrient Consumption During Lactation*** summarizes evidence on select topics pertaining to the dietary intake of women who are lactating and the associations with postpartum weight loss, human milk composition and quantity, and infant and child atopic and developmental outcomes. ***Part D. Chapter 4: Duration, Frequency, and Volume of Exclusive Human Milk and/or Infant Formula Feeding***, ***Part D. Chapter 5: Foods and Beverages Consumed during Infancy and Toddlerhood***, and ***Part D. Chapter 6: Nutrients from Dietary Supplements During Infancy and Toddlerhood*** describe evidence on the associations of consumption of human milk and infant formula, complementary foods and beverages, and iron and vitamin D supplements, respectively, with child outcomes. ***Part D. Chapter 14: USDA Food Patterns for Individuals Ages 2 Years and Older*** describes food patterns that provide sufficient nutrients to meet the Dietary Reference Intakes and *Dietary Guidelines for Americans* recommendations, while avoiding excessive energy intake, for all individuals ages 2 years and older, including those who are pregnant or lactating.

Background

In the United States, the health status of women of childbearing age falls short of recommendations for optimal pregnancy outcomes. Approximately, 50 percent of women ages 20 to 44 years have overweight or obesity.[11] Women are often motivated to improve their dietary intake during pregnancy to assure the best possible outcome for themselves and their child.[12] However, analysis of the nutrient intake of 1,003 women (ages 20 to 40 years) who were pregnant from the 2001-2014 National Health and Nutrition Examination Survey showed that many of these women did not meet the Estimated Average Requirement for key nutrients, including vitamins A, C, D, E, K, B_6, folate, choline, iron, potassium, calcium, magnesium, and zinc.[13] Nutrient supplements were consumed by approximately 69 percent of women who were pregnant, which reduced the prevalence of those at risk for inadequate intakes of these nutrients. However, supplement use places some women at risk for exceeding the upper levels of intake for folate and iron.[13]

Making dietary changes only after a woman knows that she is pregnant is too late to achieve optimal pregnancy and postpartum outcomes[1] because crucial aspects of the development of the brain and spinal column of the infant occur within the first 3 to 4 weeks post-conception, generally before a woman knows that she has conceived.[14,15] Because almost half of pregnancies in the United States are unplanned (with unplanned pregnancy rates as high as 75 percent among some age-race/ethnic groups), it is vital that all women, especially those of reproductive age, maintain optimal nutritional status throughout their lifetime.[16] This should include attention to both dietary quality and maintaining a healthy weight status.

A recent review of 60 studies representing nearly 1.4 million pregnancies demonstrated that high prepregnancy BMI is a key risk factor associated with adverse pregnancy outcomes for both the mother and the infant.[17] Women who are obese before pregnancy were at increased risk for excessive GWG, GDM, hypertensive disorders, and cesarean section[17] as well as perinatal complications, including infants who are large for gestational age at birth (LGA). Maternal obesity is both a risk factor for, and a consequence of, excessive GWG and/or excessive postpartum weight retention. The majority of women with overweight or obesity exceed GWG recommendations.[18,19] Fewer than half of women revert to pregravid weights following pregnancy, with about half of women retaining 10 or more pounds and nearly 1 in 4 women retaining 20 pounds or more at 12 months postpartum.[20-24] Weight status before pregnancy has been strongly associated with postpartum weight status[25] and may be more predictive of excessive postpartum weight retention than is total GWG.[18] Postpartum weight retention results in about 1 in 7 women moving from a normal weight classification (prepregnancy) to an overweight classification (postpartum).[19] Therefore, interventions to normalize maternal prepregnancy BMI and prevent excess GWG could be an effective approach to break the trajectory of adverse pregnancy outcomes and long-term detrimental health outcomes for the mother and child.[26,27]

Consistent with the DOHaD theory, children of women with high prepregnancy BMI, or who develop GDM or hypertensive disorders during pregnancy, are at greater risk of obesity and cardiometabolic diseases later in life.[28-31] Although mechanisms to explain these observations are still under investigation, recent studies have demonstrated associations between prepregnancy BMI and epigenetic changes in the child.[32,33] More research is needed, but these findings provide biological plausibility linking maternal BMI to child health.

Both hypertensive disorders and GDM are serious pregnancy complications that are on the rise in the United States. Hypertensive disorders affect up to 15 percent of pregnancies and account for almost 10 percent of maternal deaths and 15 percent of premature births.[34,35] Women who experience hypertensive disorders as well as their children are at increased risk of cardiometabolic disorders later in life.[36-38] Given that pregnancy-related deaths in the United States nearly doubled between 1987 and 2016, preventing disorders that contribute to hypertensive disorders is imperative.[39] GDM affects approximately 6 percent of pregnancies among U.S. women[40] and is associated with an increased risk of future type 2 diabetes and cardiovascular disease among mothers,[41] as well as increased risk of congenital anomalies, stillbirth, and LGA newborn infants. Infants born to mothers with GDM are at increased risk of childhood obesity and associated chronic conditions during their lifetime.[42,43]

Data available to describe relationships between diet during pregnancy and maternal and fetal outcomes focus on individual nutrients or classes of nutrients.[44,45] Although such studies are important for examining physiological underpinnings of relationships between food and beverage intake and health outcomes, this approach does not capture the complexity of actual diets, particularly the diversity and innumerable combinations of nutrients and beverages and food components consumed by women.[45-47] Accordingly, a systematic examination of the consequences of patterns of intake, both foods and beverages, before and during pregnancy, as well as the nutrient components of such patterns, is needed to create dietary guidance that is both meaningful and practical to the daily lives of women.[48]

Patterns of dietary intake before and during pregnancy may affect the risk of poor maternal outcomes, including GDM and hypertensive disorders.[49-52] For example, adherence to a low carbohydrate dietary pattern before pregnancy that includes primarily animal-derived protein and fat has been associated with an increased risk of developing GDM.[53] Conversely, the consumption of a Mediterranean-style diet during pregnancy may reduce the odds of developing GDM, particularly among women with pre-existing cardiometabolic risk factors, and may moderate GWG.[54,55] Furthermore, a Mediterranean-style diet during pregnancy may reduce the risk of metabolic syndrome postpartum.[56]

Birth weight is a key indicator of infant health and wellbeing that is strongly influenced by gestational age and sex of the infant. Preterm birth and low birth weight affect 1 in 8 to 1 in 10 infants born each year in the United States[57] and account for about half of all hospitalizations among infants.[58] Prepregnancy weight status and weight gain during pregnancy are key factors influencing infant birth size.[26] Both low and high birth weight for gestational age and sex predispose mothers and their infants to health risks.[17] Low birth weight (LBW) is defined as less than 2500 g (5.5 lbs) and very low birth weight as less than 1500g (3.3 lbs). Gestational age of less than 37 weeks is considered preterm.[59,60] Small for gestational age (SGA) is a low birth weight and/or length at least 2 standard deviations below the mean, for gestational age and sex.[61] High birth weight or LGA is defined as more than 4000g (8 lbs, 13 oz) at 40 weeks gestational age for both sexes.[62]

Some evidence indicates that specific dietary patterns are associated with increased or decreased risk of preterm delivery[28,46,63] and that supplemental nutrients may alter risk of fetal complications. For instance, supplementation with calcium ($\geq$1 gram per day [g/d]), vitamin D (10 to 15 micrograms per day [μg/d]), and a combination of the 2 nutrients during pregnancy was associated with a reduced risk of pre-eclampsia and preterm birth, particularly among women who had poor nutritional status entering.[64-66] Multi-micronutrient supplements containing iron and folic acid reduce the risk of LBW, SGA, and preterm birth.[67] Thus, the Committee sought to determine how dietary patterns, including frequency of eating and beverage intakes, are related to multiple components of pregnancy outcomes, including standardized birth weight, GWG, and gestational age at delivery. Although the influence of maternal dietary intake during pregnancy on birth weight has been considered in prior editions of the *Dietary Guidelines for Americans*, this is the first time that beverage intakes during pregnancy have been explicitly examined in relation to an infant outcome (birth weight standardized for gestational age and sex).

Neurodevelopment, which begins at conception, is often described as a scaffolding process characterized by the rapid evolution of increasingly complex neurologic circuits. Thus, optimal growth and development in the first 1,000 days demands that all obligatory components, including those provided by the diet, be available in sufficient quantities at the appropriate time.[9] Both the timing and tempo of growth are important, as many aspects of development are sequential and continually build upon previous processes.[9,68] Nutrients in commonly consumed foods that have a demonstrated time period of sensitivity that affect these developmental processes include protein, long-chain polyunsaturated fatty acids (LC-PUFA), zinc, copper, iodine, iron, folate, and choline.[69,70]

Optimal nutrition during the prepregnancy years of a woman's life is crucial to support healthy pregnancy outcomes and child neurodevelopment. Suboptimal nutritional status of women entering pregnancy, particularly of folic acid, may increase the risk of congenital anomalies such as neural tube defects.[71] Iron deficiency during pregnancy is associated with abnormal fetal development, and iron deficiency (in particular iron deficiency anemia) in early infancy is, in turn, associated with neurobehavioral deficits during infancy and early childhood, such as decreased attentiveness, slower speed of processing, and altered auditory and visual development. Many of these deficits may be irreversible with infant iron repletion,[70,72] although this remains controversial. LC-PUFAs, produced endogenously or consumed from the diet, are particularly important for myelination and the development of vision during the perinatal period.[9,69,70,73] Prenatal iodine deficiency may lead to irreversible neurocognitive defects and lower childhood IQ.[9,69,70,73] The Committee evaluated the evidence regarding maternal seafood consumption as well as supplemental omega-3 fatty acids and folic acid related to select child neurodevelopmental outcomes.

The prevalence of food allergy and other atopic conditions has been steadily rising worldwide with the highest incidence noted among younger children,[74] and increasingly recognized as a growing public concern.[75] In infants, the first known ingestion of a food may cause an allergic reaction, suggesting that sensitization of offspring with food allergens may occur *in utero*.[76] However, the effects of maternal allergen exposure and maternal sensitization with allergens on development of allergies in offspring remain incompletely understood.[77] A more diverse maternal diet is postulated to favorably affect child atopic outcomes through both direct and indirect mechanisms.[78] A diverse maternal diet may lead to low dose exposure of different food antigens that could directly affect development of immune tolerance in the child. In addition, diet diversity may indirectly affect allergy outcomes by providing nutrients associated with prevention of allergic diseases such as omega-3 fatty acids and dietary fiber.[79,80] Lastly, increased diet diversity leads to increased microbial diversity in infants during the introduction of solid food,[81] and increased microbial diversity[82] or abundance of certain bacteria[83] has been associated with reduced allergy outcomes. The Committee evaluated the association between maternal dietary intake including dietary patterns, and atopic diseases in the child.

Lastly, the Committee evaluated the effects of folic acid supplementation on both maternal and child outcomes. Folate is required as a one-carbon source for DNA and RNA synthesis, amino acid metabolism, and methylation. Folate is naturally present in some foods, added to others, and available as a dietary supplement. Food folates are in the tetrahydrofolate (THF) form and contain different numbers of glutamic acids depending on the type of food. Folic acid is the fully oxidized monoglutamate form of the vitamin that is used in fortified foods and most dietary supplements.[84]

Women who are pregnant are at risk of folate deficiency due to the expansion of the maternal blood supply and the growth of fetal and maternal tissues.[85] The Recommended Dietary Allowance (RDA) for adult women is 400 µg/d, and 600 µg/d for women capable of becoming pregnant. To meet this higher requirement, the recommendation is that women take 400 µg of folic acid daily from fortified foods, supplements, or both, in addition to consuming food folate from a varied diet.[86] In 1998, fortification of enriched cereal-grain products (140 µg/100 g product) became mandatory in the United States.[84] This fortification is estimated to provide 100 to 200 µg of folic acid per day and has been associated with a significantly reduced incidence of neural tube defects.[71,87] In April 2016, the Food and Drug Administration approved the voluntary addition of up to 154 µg folic acid/100 g to corn masa flour.[88] The Committee evaluated the evidence of associations between folic acid from supplements and fortified foods and maternal micronutrient status, risk of GDM and hypertensive disorders, and developmental milestones in the child, but was unable to assess associations between folate from fortified foods and these outcomes due to insufficient evidence. A recent Cochrane Review provides some guidance on the health outcomes associated with fortification of grain products with folic acid.[89]

Initially, the Committee was asked to investigate the relationships between 6 nutrients (folic acid, iodine, iron, vitamin B_{12}, vitamin D, and omega-3 fatty acids) from supplements and fortified foods and 5 potential maternal and fetal outcomes (micronutrient status, GDM, hypertensive disorders, human milk composition, and developmental milestones). Due to time constraints and, in some cases, existing systematic reviews or guidance that addressed some of the outcomes of interest, the scope of the Committee's reviews was reduced to focus on 2 of these nutrients, folic acid and omega-3 fatty acids. For folic acid, 5 outcomes were investigated, whereas for omega-3 fatty acids only the evidence for neurocognitive development of the child was reviewed. In addition, the Committee was not able to investigate the relationship between dietary patterns consumed during pregnancy and micronutrient status.

LIST OF QUESTIONS

1. What is the relationship between dietary patterns consumed during pregnancy and risk of gestational diabetes mellitus?
2. What is the relationship between dietary patterns consumed during pregnancy and risk of hypertensive disorders during pregnancy?
3. What is the relationship between dietary patterns consumed during pregnancy and gestational weight gain?
4. What is the relationship between frequency of eating during pregnancy and gestational weight gain?
5. What is the relationship between dietary patterns during pregnancy and gestational age at birth?
6. What is the relationship between dietary patterns consumed during pregnancy and birth weight standardized for gestational age and sex?
7. What is the relationship between beverage consumption during pregnancy and birth weight standardized for gestational age and sex?

8. What is the relationship between maternal diet during pregnancy and risk of child food allergies and atopic allergic diseases, including atopic dermatitis, allergic rhinitis, and asthma?
9. What is the relationship between seafood consumption during pregnancy and neurocognitive development of the infant?
10. What is the relationship between omega-3 fatty acids from supplements consumed before and during pregnancy and developmental milestones, including neurocognitive development in the child?
11. What is the relationship between folic acid from supplements and/or fortified foods consumed before and during pregnancy and 1) maternal micronutrient status, 2) gestational diabetes, 3) hypertensive disorders, 4) human milk composition, and 5) neurocognitive development in the child?

METHODOLOGY

All questions discussed in this chapter were answered using systematic reviews conducted with support from USDA's Nutrition Evidence Systematic Review (NESR) team. NESR's systematic review methodology provided a rigorous, consistent, and transparent process for the Committee to search for, evaluate, analyze, and synthesize evidence.

Questions 1, 2, 5, and 6 in this chapter were answered using existing NESR systematic reviews that were previously conducted as part of the Pregnancy and Birth to 24 Months Project, which was completed in 2019. The conclusion statements that answer these questions were taken directly from the existing systematic reviews and the wording reflects the findings of those reviews, which included articles published between 1980 and 2017. A description of the process the Committee used to determine that these existing systematic reviews were relevant to their questions and reflect the current state of the science is provided in ***Part C. Methodology***. In addition, detailed information about methodology used to complete these systematic reviews can be found at the following website: nesr.usda.gov/project-specific-overview-pb-24-0.

Questions 3, 4, and 7 through 11 in this chapter were answered using new NESR systematic reviews. The Committee developed a systematic review protocol for each question, which described how the Committee would apply NESR's methodology to answer the question. The protocol included an analytic framework and inclusion and exclusion criteria to guide identification of the most relevant and appropriate bodies of evidence to use in answering each systematic review question. Each analytic framework outlined core elements of the systematic review question (i.e., population; intervention and/or exposure and comparator [i.e., the alternative being compared to the intervention or exposure]; and outcomes), and included definitions for key terms, key confounders, and other factors to be considered when reviewing the evidence. The inclusion and exclusion criteria were selected a priori to operationalize the elements of the analytic framework and specify what made a study relevant for each systematic review question.

Next, NESR conducted a literature search to identify all potentially relevant articles, and those articles were screened by two NESR analysts independently based on the criteria selected by the Committee. For each included article, data were extracted and risk of bias assessed. The Committee qualitatively synthesized the body of evidence to inform development of a conclusion statement(s) and graded the strength of evidence using pre-established criteria for risk of bias, consistency, directness, precision, and generalizability. Finally, recommendations for future research were identified. A detailed description of NESR's systematic review methodology is provided in ***Part C. Methodology***, including standard inclusion and exclusion criteria applied in many of the Committee's systematic reviews. Complete documentation of each systematic review is available on the following website: nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews. Below is a summary of the unique elements of the protocols developed to answer the questions addressed in this chapter.

For all questions discussed in this chapter, the population of interest for the intervention or exposure was women who are pregnant. For the questions that addressed supplements and/or fortified foods, the population of interest also included women before pregnancy. The population of interest for outcomes varied depending on the outcome examined, as described below.

For Question 3, consumption of and/or adherence to a dietary pattern during pregnancy was the primary intervention or exposure of interest. The comparators of interest were consumption of and/or adherence to a different dietary pattern or different levels of consumption of and/or adherence to a dietary pattern. Dietary patterns were defined as "the quantities, proportions, variety, or combination of different foods, drinks, and nutrients in diets, and the frequency with which they are habitually consumed." To be included in the review on dietary patterns, studies needed to provide a description of the foods and beverages in the pattern. Dietary patterns considered in the review were measured or derived using a variety of approaches, such as adherence to a priori patterns (indices/scores), data-driven patterns (factor or cluster analysis), reduced rank regression, or other methods, including clinical trials.

Question 3 also examined diets based on a macronutrient distribution outside of the Acceptable Macronutrient Distribution Range (AMDR), at any level above or below, as an intervention or exposure of interest. The comparator of interest was consumption of and/or adherence to a macronutrient distribution of carbohydrate, fat, and protein within the AMDR. To be included in the review, articles needed to describe the entire macronutrient distribution of the diet by reporting the proportion of energy from carbohydrate, fat, and protein, and have at least one macronutrient proportion outside of the AMDR.

The Committee established these criteria to take a holistic approach to answer the scientific questions, and thus needed to examine the entire distribution of macronutrients in the diet, and not one macronutrient in isolation. These criteria allowed the Committee to consider both the relationships with health outcomes of consuming a diet with one macronutrient outside of the AMDR, and also how consumption of that macronutrient displaces or replaces intake of other macronutrients within the distribution. A study did not need to report the foods/food groups consumed to be included. The criteria were designed to cast a wide, comprehensive net to capture any study that examined carbohydrate levels less than 45 percent or greater than 65 percent of energy, fat levels less than 20 percent or greater than 35 percent of energy, and/or protein levels less than 10 percent or greater than 35 percent of energy. Furthermore, when describing and categorizing studies included in these reviews, the Committee did not label the diets examined as “low” or “high,” because no universally accepted, standard definition is currently available, for example, for “low-carbohydrate” or “high-fat” diets. Instead, the Committee focused on whether, and the extent to which, the proportions of the macronutrients were below or above the AMDR.

The outcome examined in Question 3 was GWG, which was defined as the change in maternal body weight from baseline (before or during pregnancy) to a later time point during pregnancy and/or right before delivery; weight gain in relationship to weight gain recommendations, based on prepregnancy BMI.

Two literature searches were conducted to identify all potentially relevant articles for this question. The first search was designed to capture all potentially relevant articles on dietary patterns published from January 2000 to June 2019. The second search was designed to identify all potentially relevant articles on diets based on macronutrient distribution published from January 2000 to November 2019, and to capture any additional articles on dietary patterns published between June and November 2019. Articles for this question were searched for and screened together with Question 1 on dietary patterns and postpartum weight loss in ***Part D. Chapter 3: Food, Beverage, and Nutrient Consumption During Lactation***. This was done to leverage the overlap in topical areas and to improve efficiency. The Committee searched for and included studies that were published starting in 2000 because the field of dietary patterns research is relatively new, particularly for the populations and outcomes of interest in the questions being addressed in this chapter. Previous systematic reviews on dietary patterns searched for literature starting in 1980, but relevant studies published before the year 2000 were uncommon. Therefore, the Committee determined that the preponderance of evidence for these new reviews would be captured by searching literature starting in the year 2000.

For Question 4, frequency of eating during pregnancy was the intervention or exposure and GWG was the outcome (see ***Part D. Chapter 13: Frequency of Eating*** for details about the methodology used to answer this question).

For Question 7, beverage consumption during pregnancy was the intervention or exposure and birth weight standardized for gestational age and sex was the outcome (see ***Part D. Chapter 10: Beverages*** for details about the methodology used to answer this question).

For Question 8, maternal diet during pregnancy was the intervention or exposure, including consumption of foods that may be considered allergens (e.g., cow milk products, eggs, peanuts, tree nuts, soybean) and foods that are not considered allergens (including but not limited to meat, vegetables, fruits). The outcomes for this question were food allergies and atopic allergic diseases, including atopic dermatitis/eczema, allergic rhinitis and asthma, in infants and toddlers (birth to age 24 months) and children and adolescents (ages 2 to 18 years). Maternal diet during lactation and food allergies and atopic allergic diseases is discussed in ***Part D. Chapter 3,*** Question 4. Food allergy was defined as a diagnosis based on either the gold standard of a double-blind, placebo-controlled oral food challenge, or as parental report of clinical history together with blood immunoglobulin E (IgE) levels 0.35 or greater kilo unit per liter (kU/L) and/or skin prick test wheal 3 or greater millimeters (mm). Because of difficulty diagnosing asthma during infancy and toddlerhood, only those studies that assessed asthma in children who were at least age 2 years or older were included. A literature search was conducted to identify all potentially relevant articles published from January 1980 to January 2020 or older were included. A literature search was conducted to identify all potentially relevant articles published from January 1980 to January 2020.

For Question 9, seafood consumption during pregnancy was the intervention or exposure and neurocognitive development in the child was the outcome (see ***Part D. Chapter 9: Dietary Fats and Seafood*** for details about the methodology used to answer this question).

For Question 10, omega-3 fatty acids from supplements before and during pregnancy was the intervention or exposure. Fortified foods were not considered for this question because supplements are generally the major source of omega-3 fatty acids. The outcome for this question was developmental milestones, including neurocognitive development in infants and toddlers (birth to age 24 months) and children and adolescents (2 to 18 years). This included developmental domains (i.e., cognitive, language/communication, movement/physical, and social-emotional development), academic performance, attention deficit disorder (ADD) or attention deficit/hyperactivity disorder (ADHD), anxiety, depression, and autism spectrum disorder (ASD). Omega-3 fatty acids consumed as supplements during lactation and developmental milestones is discussed in ***Part D. Chapter 3,*** Question 7. A literature search was conducted to identify all potentially relevant articles published between January 1980 and February 2020.

For Question 11, folic acid from supplements and/or fortified foods during pregnancy was the intervention or exposure. The outcomes and their relevant intermediate risk factor levels considered were as follows:

- Gestational diabetes mellitus: Fasting glucose, hemoglobin A1C, glucose tolerance/insulin resistance, oral glucose tolerance test, gestational diabetes.
- Hypertensive disorders during pregnancy: Blood pressure (systolic and diastolic); protein in the urine (proteinuria); hypertensive disorders, including eclampsia, preeclampsia, and gestational hypertension.
- Micronutrient status in the mothers: Assessment of folate (including but not limited to serum folate, RBC folate), vitamin B_{12}, hemoglobin, mean corpuscular volume, red blood cell distribution width.
- Human milk composition: Folate in human milk, including but not limited to, total folate, reduced folates, unmetabolized folic acid. Human milk quantity was not considered as an outcome for this question.
- Developmental milestones, as described above in Question 10.

In order to capture fortification studies, this question also included uncontrolled before-and after studies. In addition, cross-sectional studies were included for the human milk composition outcome alone, because of the dearth of longitudinal studies that addressed this outcome.

Folic acid from supplements and/or fortified foods during lactation and micronutrient status in mothers, as well as human milk composition and developmental milestones is discussed in

Part D. Chapter 3, Question 8. Three separate literature searches were conducted to identify all potentially relevant articles for Question 11. The first search was designed to identify articles on folic acid and micronutrient status or human milk composition, published from January 1980 to June 2019. The second search was designed to identify articles on folic acid and GDM or hypertensive disorders, published from January 1980 to July 2019. The third search was designed to identify articles on folic acid and developmental milestones, published from January 1980 to July 2019.

REVIEW OF THE SCIENCE

Question 1. What is the relationship between dietary patterns consumed during pregnancy and risk of gestational diabetes mellitus?

Approach to Answering Question: Existing NESR systematic review

Conclusion Statements and Grades

Limited but consistent evidence suggests that certain dietary patterns before pregnancy are associated with a reduced risk of gestational diabetes mellitus. These protective dietary patterns are higher in vegetables, fruits, whole grains, nuts, legumes, and fish, and lower in red and processed meats. Most of the research was conducted in healthy Caucasian women with access to health care. Grade: Limited

Evidence is insufficient to estimate the association between dietary patterns during pregnancy and risk of gestational diabetes mellitus. Grade: Grade Not Assignable

Summary of the Evidence

- This systematic review included 10 prospective cohort studies (PCSs) and 1 pilot randomized controlled trial (RCT), published between 1998 and 2016.[90]
- The studies used multiple approaches to assess dietary patterns. Five studies used indices/scores to assess dietary patterns, 4 studies used factor or principal component analysis (PCA), and 1 study used both an index/score and PCA. In addition, 1 RCT assigned subjects to one of 2 experimental diets.
- Overall, 8 of the 11 included studies found statistically significant associations between dietary patterns and GDM risk among healthy White women with access to health care.

Greater adherence to a protective dietary pattern before and during pregnancy was associated with a decrease in GDM risk of 24 percent to 56 percent. Higher adherence to a detrimental pattern was associated with an increase in risk of 23 percent to 63 percent.

- The time points at which diet was assessed before or during pregnancy was heterogeneous across studies. Five studies measured diet before pregnancy while the rest (n=6) assessed diet during pregnancy:
  - Greater adherence to a healthy diet assessed 2 to 10 years before pregnancy showed a consistent inverse association with the risk of GDM in all the studies. These findings are also in agreement with the evidence linking dietary patterns and type 2 diabetes mellitus risk in populations of women who were not pregnant.
  - Studies that assessed diet during pregnancy had mixed findings: 1) 3 studies showed an association with GDM, 2) 1 showed an inverse association with blood glucose, only, and not with GDM, 3) 1 showed an effect on blood glucose and insulin response but did not study GDM, and 4) one other study showed no association with GDM.
- Generalizability of the studies is limited to healthy White women who have access to health care. Women of other races and ethnicities and those of lower socioeconomic status are underrepresented in this body of evidence. A major reason for grading this evidence as "limited" was the lack of adequately powered randomized controlled trials, few cohorts contributing to the observational studies, issues with risk of bias including self-reported exposure and outcome, and limited generalizability.

For additional details on this body of evidence, visit: nesr.usda.gov/what-relationship-between-dietary-patterns-and-during-pregnancy-and-risk-gestational-diabetes#full-review

Question 2. What is the relationship between dietary patterns consumed during pregnancy and risk of hypertensive disorders during pregnancy?

Approach to Answering Question: Existing NESR systematic review

Conclusion Statements and Grades

Limited evidence in healthy Caucasian women with access to health care suggests that dietary patterns before and during pregnancy higher in vegetables, fruits, whole grains, nuts, legumes, fish, and vegetable oils and lower in meat and refined grains are associated with a reduced risk of hypertensive disorders of pregnancy, including preeclampsia and gestational hypertension.

Not all components of the assessed dietary patterns were associated with all hypertensive disorders. Grade: Limited

Evidence is insufficient to estimate the association between dietary patterns before and during pregnancy and risk of hypertensive disorders of pregnancy in minority women and those of lower socioeconomic status. Grade: Grade Not Assignable

Summary of the Evidence

- This systematic review includes 8 studies (sample size ranging from 290 to 72,072) within 4 cohorts and 1 RCT, published between 2005 and 2016.[90]
- The studies used multiple approaches to assess dietary patterns, which made it difficult to compare findings across studies. Three studies used indices/scores to assess dietary patterns, 4 studies used factor or PCA, and 1 RCT assigned participants to either an experimental or control diet.
- Despite this variability, 5 of the 8 included studies reported statistically significant associations between dietary patterns and hypertensive disorders risk among healthy White women with access to health care. An additional study showed an association between dietary patterns and blood pressure but not preeclampsia or gestational hypertension:
  - Dietary patterns characterized by higher intakes of vegetables, fruits, whole grains, nuts, legumes, fish, and vegetable oils were associated with a 30 percent to 42 percent decreased risk of hypertensive disorders and a 14 percent to 29 percent decreased risk of preeclampsia.
  - Two of the dietary patterns assessed were reported to be detrimental: traditional and processed food patterns, characterized by higher intakes of meats, potatoes, and processed foods. One was associated with a 21 percent increased risk of preeclampsia and the other was associated with an increased risk of high blood pressure during pregnancy.
- Generalizability of the included studies is limited to healthy White women who have access to health care. Women of other races and ethnicities and those of lower socioeconomic status are underrepresented in this body of evidence.
- The body of evidence had several limitations:
  - The evidence base included 8 studies from only 4 unique cohorts and 1 RCT.

- All but one of the studies were conducted outside the United States in samples that were predominantly White.
- Dietary patterns varied considerably across studies, making it difficult to compare findings.
- No adjustment was made for many key confounding factors.
- The data were primarily observational, limiting the ability to draw any casual inferences. The RCT was conducted among 240 women and was not powered to examine hypertensive disorders (addressed by the authors as “hypertensive complications”). Additionally, the timing of the intervention in the RCT may have been too late in pregnancy for an effect to be seen.

For additional details on this body of evidence, visit: nesr.usda.gov/what-relationship-between-dietary-patterns-and-during-pregnancy-and-risk-hypertensive-disorders#full-review

Question 3. What is the relationship between dietary patterns consumed during pregnancy and gestational weight gain?

Approach to Answering Question: NESR systematic review

Conclusion Statement and Grade

Limited evidence suggests that certain dietary patterns during pregnancy are associated with a lower risk of excessive gestational weight gain during pregnancy. These patterns are higher in vegetables, fruits, nuts, legumes, fish and lower in added sugar, and red and processed meat. Grade: Limited

Summary of the Evidence

- This systematic review included 26 articles, including 5 articles from 4 RCTs and 21 articles from 19 PCSs published between 2009 and 2019.[91-116]
- Articles included in this review assessed one of the following interventions/exposures during pregnancy:
  - Dietary patterns (24 studies).
  - Diets based on a macronutrient distribution outside of the AMDR (2 studies).
- Eight of the 15 articles that assessed maternal dietary patterns using an index/score method

showed an association with GWG:
  - Five of the 8 articles showed that greater adherence to a dietary pattern (identified as beneficial by the study) was associated with lower GWG.
  - Three articles showed that greater adherence to a dietary pattern (identified as beneficial by the study) was associated with greater GWG in all participants or only women with obesity.
- Four of the 5 articles that assessed maternal dietary patterns using a factor or cluster analysis showed an association between adherence to dietary patterns and GWG.
  - One article showed that greater adherence to a dietary pattern (identified as beneficial by the study) was associated with lower GWG.
  - Four articles showed that greater adherence to a dietary pattern (identified as detrimental by the study) was associated with higher GWG.
- One study that assessed maternal dietary patterns using reduced rank regression showed that greater adherence to a dietary pattern was associated with higher GWG.
- Two RCTs showed that participants randomized to a dietary pattern (identified as beneficial by the study) had lower GWG.
- One RCT and one PCS showed no association between maternal consumption of a diet higher in fat (i.e., more than 35 percent of total energy from fat, which is greater than the AMDR) and GWG.
- Although the dietary patterns examined were characterized by combinations of different foods and beverages, the patterns that were consistently shown to be associated with lower risk of excessive GWG were: higher in vegetables, fruits, nuts, legumes, and fish and lower in added sugar and red and processed meat.
  - Not all foods were part of the same dietary pattern. The evidence did not show a consistent association between grains or dairy and GWG.
- The ability to draw strong conclusions was limited by the following issues:
  - There were few RCTs and thus data were primarily observational in nature, limiting the ability to determine causal effects of dietary patterns on GWG.
  - Key confounders were not consistently controlled for in most of the studies.
  - Studies had risk-of-bias issues, including exposure misclassification, self-reported outcomes, and selection bias.
  - Most of the studies were not designed to assess the association between dietary patterns and GWG.

  - People with lower socioeconomic status (SES), adolescents, and racially and ethnically diverse populations were underrepresented in the body of evidence.

For additional details on this body of evidence, visit: nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews/pregnancy-and-lactation-subcommittee/dietary-patterns-pregnancy-gestational-weight-gain

Question 4. What is the relationship between frequency of eating during pregnancy and gestational weight gain?

Approach to Answering Question: NESR systematic review

Conclusion Statement and Grade

No evidence is available to determine the relationship between the frequency of eating during pregnancy and gestational weight gain. Grade: Grade Not Assignable

Summary of the Evidence

- This systematic review was undertaken to examine the relationship between the frequency of eating during pregnancy and gestational weight gain.
- Frequency of eating was defined as the number of daily eating occasions. An eating occasion was defined as an ingestive event that is either energy yielding or non-energy yielding.
- Gestational weight gain was defined as weight a woman gains during pregnancy.
- This review identified 0 studies published between January 2000 and September 2019 that met the inclusion criteria for this systematic review.

For additional details on this body of evidence, visit: nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews/frequency-eating-subcommittee/frequency-eating-gestational-weight-gain

Question 5. What is the relationship between dietary patterns consumed during pregnancy and gestational age at birth?

Approach to Answering Question: Existing NESR systematic review

Conclusion Statements and Grades

Limited but consistent evidence suggests that certain dietary patterns during pregnancy are associated with a lower risk of preterm birth and spontaneous preterm birth. These protective dietary patterns are higher in vegetables, fruits, whole grains, nuts, legumes and seeds; and seafood (preterm birth only), and lower in red and processed meats and fried foods. Most of the research was conducted in healthy, Caucasian women with access to health care. Grade: Limited

Evidence is insufficient to estimate the association between dietary patterns before pregnancy and gestational age at birth as well as the risk of preterm birth. Grade: Grade Not Assignable

Summary of the Evidence

- This systematic review included 10 PCSs and 1 RCT published between 2005 and 2016.[117]
- The studies used multiple approaches to assess dietary patterns:
  - Four studies used indices/scores to assess dietary patterns.
  - Four studies used factor analysis or (PCA).
  - One study used both indices/scores and PCA.
  - One RCT assigned subjects to 1 of 2 experimental diets.
  - One study did not use a formal method to arrive at a dietary pattern.
- Despite this variability, 5 of the 8 studies that assessed the relationship between dietary patterns during pregnancy and preterm birth found a statistically significant association. A sixth study found an association between dietary patterns during pregnancy and early preterm birth, but not preterm birth:
  - Highest adherence to a protective dietary pattern during pregnancy was associated with a preterm birth risk reduction of 9 percent to 90 percent.
  - Highest adherence to a detrimental dietary pattern during pregnancy was associated with an increase in preterm birth risk of 53 percent to 55 percent.

- Additionally, 4 of the 5 studies that assessed the relationship between dietary patterns during pregnancy and spontaneous preterm birth found a statistically significant association. The fifth study showed an effect modification by parity:
    - Highest adherence to a protective dietary pattern during pregnancy was associated with a spontaneous preterm birth risk reduction of 15 percent to 45 percent.
    - Highest adherence to a detrimental dietary pattern during pregnancy was associated with an increase in spontaneous preterm birth risk of 18 percent to 92 percent.
- The evidence was insufficient to estimate the association between dietary patterns during pregnancy and gestational age at birth when measured in days.
- Generalizability of the included studies was limited to healthy White women who have access to health care. Women of other races and ethnicities and those with lower socioeconomic status are underrepresented in this body of evidence.
- The ability to draw strong conclusions was limited by the following issues:
    - The data were primarily observational in nature, limiting the ability to determine causal effect of the dietary patterns.
    - The time points at which diet was assessed before or during pregnancy was heterogeneous across studies.
    - Outcome assessments were not uniform, and some studies used less robust methods than others.
    - Key confounding factors were not consistently controlled across studies.
    - Only 2 studies were conducted in the United States and 1 was primarily conducted in adolescent girls.
    - The study samples lacked diversity in terms of BMI, parity, age at conception, and smoking status

For additional details on this body of evidence, visit: NESR.usda.gov
https://nesr.usda.gov/what-relationship-between-dietary-patterns-and-during-pregnancy-and-gestational-age-birth#full-review

Question 6. What is the relationship between dietary patterns consumed during pregnancy and birth weight standardized for gestational age and sex?

Approach to Answering Question: Existing NESR systematic review

Conclusion Statements and Grades

No conclusion can be drawn on the association between dietary patterns during pregnancy and birth weight outcomes. Although research is available, the ability to draw a conclusion is restricted by inconsistency in study findings, inadequate adjustment of birth weight for gestational age and sex, and variation in study design, dietary assessment methodology, and adjustment of key confounding factors. Grade: Grade Not Assignable

Insufficient evidence exists to estimate the association between dietary patterns before pregnancy and birth weight outcomes. There are not enough studies available to answer this question. Grade: Grade Not Assignable

Summary of the Evidence

- This systematic review included 18 PCSs, 1 retrospective cohort study, and 2 RCTs published between 1986 and 2016.[117]
- The studies used multiple approaches to assess dietary patterns:
  - Nine studies used an index or score to assess dietary patterns.
  - Eight studies used factor analysis or PCA.
  - Two RCTs trials assigned subjects to 1 of 2 experimental diets.
  - One study did not use a formal method to arrive at a dietary pattern.
  - One study used both logistic regression and PCA.
- Many studies did not standardize for gestational age and/or infant sex when assessing birth weight:
  - Just one-third of studies (n=7) used both gestational age- and sex-specific cut-off values when defining SGA, LGA, appropriate for gestational age (AGA), or intrauterine growth restriction (IUGR).
  - Nine out of 21 studies reported birth weight, alone, without standardizing for gestational age or sex using z-scores.

- Study findings were highly inconsistent across the body of evidence. About half of the studies (n=10) found no association between dietary patterns and birth weight outcomes. The studies that observed an association showed limited consistency in direction of effect and the dietary patterns generated.
- The generalizability of this review has serious limitations. People with lower SES, adolescents, and racially and ethnically diverse populations were underrepresented in the body of evidence.
- The ability to draw strong conclusions was limited by the following issues:
  - Study findings lacked consistency.
  - The data were primarily observational in nature, making it difficult to determine causal effect of the dietary patterns.
  - Many studies did not adjust birth weight for gestational age and sex, and the standardized measures that were used were heterogeneous.
  - The timing of exposure assessment and the duration of recall periods varied across studies.
  - Key confounding factors were not consistently accounted for.
  - None of the studies assessed effect modification between dietary patterns and maternal prepregnancy BMI in the context of birth weight outcomes.
  - Few included studies were conducted in the United States.

For additional details on this body of evidence, visit: NESR.usda.gov https://nesr.usda.gov/what-relationship-between-dietary-patterns-and-during-pregnancy-and-gestational-age-and-sex#full-review

Question 7. What is the relationship between beverage consumption during pregnancy and birth weight standardized for gestational age and sex?

Approach to Answering Question: NESR systematic review

Conclusion Statements and Grades

Insufficient evidence is available to determine the relationship between consumption of dairy milk during pregnancy and birth weight outcomes. Grade: Grade Not Assignable

Insufficient evidence is available to determine the relationship between consumption of tea during pregnancy and birth weight outcomes. Grade: Grade Not Assignable

Insufficient evidence is available to determine the relationship between consumption of coffee during pregnancy and birth weight outcomes. Grade: Grade Not Assignable

Insufficient evidence is available to determine the relationship between consumption of sugar-sweetened beverages or low- or no-calorie sweetened beverages during pregnancy and birth weight outcomes. Grade: Grade Not Assignable

Insufficient evidence is available to determine the relationship between consumption of water during pregnancy and birth weight outcomes. Grade: Grade Not Assignable

Summary of the Evidence

- Nineteen studies published between January 2000 and June 2019 met the criteria for inclusion in this systematic review, including 1 RCT and 18 PCSs.[118-136]
- Many studies examined intake of multiple beverages.
- Evidence is summarized below by beverage type.

Dairy Milk

- Six studies examined the relationship between dairy milk consumption and birth weight outcomes. The body of evidence included 1 RCT and 5 PCSs.
- The search strategy focused on dairy milk, which included commercially available cow milk and soy beverages with varying fat and sweetener content. However, no studies examining soy beverages met the inclusion criteria.
- The body of evidence showed little consistency in the timing of exposure assessment (ranged from first through third trimesters) and the period of intake it represented (ranging from the previous 24 hours to average intake for the first half of pregnancy), which limited comparability across studies.
- Both continuous and categorical birth weight outcomes were examined:
  - Five studies assessed continuous birth weight.
  - Three studies assessed categorical birth weight outcomes.
- The 5 studies examining continuous birth weight found significant associations with milk intake, but in different directions. Four studies suggested that greater milk intake was related

to higher birth weight, but 1 study found the opposite.

- The 3 studies examining categorical birth weight outcomes had limited consistency in the outcomes measured and in findings:
    - Two of the 3 studies examined risk of SGA; 1 found greater milk intake was associated with lower risk, while the other did not find a significant relationship. One of those studies also evaluated risk of LGA and did not find a relationship with milk intake.
    - One study (the RCT) examined risk of LBW and found milk was related to lower risk.
- Overall, findings were inconsistent in both direction and statistical significance, limiting the ability to draw conclusions.
- This body of evidence had several limitations:
    - SES differed by geographic location, with the 2 studies conducted in Asia enrolling populations with substantially lower SES than did the European and Canadian studies, potentially limiting generalizability of those findings.
    - Two studies, including the RCT, had attrition rates of more than 25 percent, and neither provided information on the potential for selective attrition across intervention or exposure groups.
    - Outcomes examined, definitions used, and adjustment techniques varied across studies.
    - Many studies did not adjust for birth weight for gestational age and sex.
    - All studies failed to adjust for at least one key confounder.

Tea

- Eight PCSs examined the relationship between tea consumption and birth weight outcomes.
- Studies varied in the type of tea examined:
    - Three studies reported on overall tea intake.
    - Three studies reported on caffeinated tea only.
    - Three studies reported on specific types of tea (e.g., green, black, dark, oolong).
- Most studies examined tea intake in early pregnancy.
- Continuous birth weight was examined in 6 studies, and categorical birth weight outcomes were examined in 8.
- The 6 studies examining continuous birth weight reported mixed findings:
    - Three studies found tea intake at the highest amount related to lower birth weight.
    - Three studies found the relationship was not significant.
- The 8 studies examining categorical birth weight reported similarly mixed findings:
    - Of the 7 that examined risk of SGA or IUGR at birth, 3 found greater tea intake was

related to higher risk of SGA, while the relationship was non-significant for the remaining 4.
    - LBW was examined in 2 studies, and greater risk of LBW was significantly associated with greater tea intake in 1 study and was non-significant in the other.
- This body of evidence had several limitations:
    - The majority of participants were White, well-educated, and higher SES, potentially limiting generalizability.
    - Three studies examined only caffeinated tea, which may not accurately represent total tea intake and limited the ability to draw independent conclusions about the beverage as compared to caffeine.
    - Outcomes examined and the definitions used varied across studies
    - Studies inconsistently adjusted birth weight for gestational age and sex.
    - Two studies had attrition rates of more than 20 percent, and neither provided information on the potential for selective attrition across exposure groups.
    - Seven of the 8 studies failed to adjust for at least one key confounder, most commonly prepregnancy BMI and diabetes diagnosis.

Coffee

- Seven PCSs examined the relationship between coffee consumption and birth weight outcomes.
- The timing of exposure assessment showed little consistency (ranging from 5 to 39 weeks gestation).
- Continuous birth weight was examined in 5 studies, and categorical birth weight outcomes were examined in 6.
- The 5 studies examining continuous birth weight reported mixed findings:
    - Three studies found greater coffee intake was related to lower birth weight
    - Two studies found the relationship was not significant.
- The 6 studies examining categorical birth weight reported similarly mixed findings:
    - Of the 5 that examined risk of SGA or IUGR at birth, 2 found greater coffee intake was related to higher risk of SGA, while the relationship was not significant for the remaining 3.
    - LBW was examined in 3 studies. One found greater coffee intake was related to greater risk of LBW, while the other 2 were not significant.
- This body of evidence had several limitations:

- The majority of participants were White, well-educated, and higher SES, potentially limiting generalizability.
- Three studies examined only caffeinated coffee, which may not accurately represent total coffee intake and limited the ability to draw conclusions about the beverage as compared to caffeine.
- Outcomes examined and the definitions used varied across studies.
- Studies inconsistently adjusted birth weight for gestational age and sex.
- Seven of the 8 studies failed to adjust for at least 1 key confounder, most commonly prepregnancy BMI and diabetes diagnosis.
- Two studies had attrition rates of more than 20 percent, and neither provided information on the potential for selective attrition across exposure groups.

Sugar-Sweetened Beverages and Low- or No-calorie Sweetened Beverages

- Seven studies examined the relationship between birth weight outcomes and intake of sugar-sweetened beverages (SSB), low- or no-calorie sweetened beverages (LNCSB), or both:
  - Three studies examined SSB independently.
  - Two examined LNCSB independently.
  - Two examined combined SSB and LNCSB.
  - Two did not specify whether the exposure represented SSB only or SSB plus LNCSB.
- The 3 studies examining SSB independently:
  - Measured intake across early, mid- and late-pregnancy.
  - Examined both continuous (n=3) and categorical (n=2) birth weight outcomes and were inconsistent in both the direction and statistical significance of their findings.
    - For continuous birth weight, 1 study found a positive relationship, 1 a negative relationship, and the third found no relationship with SSB intake.
    - No categorical outcomes were examined in more than 1 study.
- The 2 studies examining LNCSB independently:
  - Measured intake across early, mid- and late-pregnancy.
  - Examined continuous birth weight and found mixed results. One study showed greater LNCSB intake was related to lower birth weight, while the other did not find a significant association.
- The 2 studies that combined SSB and LNCSB intake looked specifically at caffeinated versions of the beverages:

  - Both examined risk of SGA, with one finding a significant association between greater intake and greater risk of SGA while the other did not report a significant relationship.
  - One study also examined continuous birth weight and found combined caffeinated SSB and LNCSB intake in early and mid-pregnancy was related to lower birth weight, but intake at 30 weeks was not.
  - The 2 studies that did not clearly define the exposure variable and may have combined SSB and LNCSB intake defined the exposure as “cola” or “soda” and measured different outcomes.
    - One study found significant associations between greater intake and higher birth weight and higher risk of SGA, while the other found no relationship between intake and risk of IUGR.
- The body of evidence for SSB and LNCSB had several limitations:
  - The number of studies available for each beverage type was very small.
  - The exposure variable was poorly defined in multiple studies.
  - Three studies examined caffeinated versions of these beverages specifically, which may not represent complete intake of the beverage.
  - The studies showed little consistency in exposure assessment timing, outcome definitions, or direction of findings across studies.
  - Studies inconsistently adjusted birth weight for gestational age and sex.
  - Five studies had attrition rates of more than 20 percent for the full sample and did not include attrition rates by exposure group.

Plain Water

- Two PCSs assessed the relationship between water intake during pregnancy and birth weight outcomes.
- Exposure definitions made it difficult to determine whether the assessment included plain water intake only or also included water-based beverages, limiting the usefulness of the data.
- Both studies measured continuous birth weight and risk of SGA, and neither found a significant association with plain water intake for either outcome.
- This body of evidence had several limitations:
  - The number of studies available for this beverage type was very small.
  - Exposure definitions lacked clarity to confidently state they include plain water only.
  - Studies inconsistently adjusted birth weight for gestational age and sex.

For additional details on this body of evidence, visit: nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews/beverages-and-added-sugars-subcommittee/beverages-birth-weight

Question 8. What is the relationship between maternal diet during pregnancy and risk of child food allergies and atopic allergic diseases including atopic dermatitis, allergic rhinitis, and asthma?

Approach to Answering Question: NESR systematic review

Conclusion Statements and Grades

Food Allergy

Insufficient evidence is available to determine the relationship between lower or restricted consumption of cow milk products during pregnancy only, or during both pregnancy and lactation, and risk of food allergy in the child. Grade: Grade Not Assignable

Insufficient evidence is available to determine the relationship between peanuts, eggs, or wheat consumed during pregnancy and risk of food allergy in the child. Grade: Grade Not Assignable

Limited evidence suggests no relationship between soybean consumed during pregnancy and risk of food allergy in the child. Grade: Limited

No evidence is available to determine the relationship between dietary patterns or fish, tree nuts and seeds, and foods not commonly considered to be allergens such as meat, vegetables, and fruits consumed during pregnancy and risk of food allergy in the child. Grade: Grade Not Assignable

Atopic Dermatitis

Moderate evidence indicates that lower or restricted consumption of cow milk products during pregnancy does not reduce the risk of atopic dermatitis/eczema in the child. Grade: Moderate

Moderate evidence indicates that lower or restricted consumption of egg during pregnancy does not reduce the risk of atopic dermatitis/eczema in the child. Grade: Moderate

Insufficient evidence is available to determine the relationship between cow milk products and eggs restricted during both pregnancy and lactation and risk of atopic dermatitis/eczema in the child. Grade: Grade Not Assignable

Limited evidence suggests that fish consumed during pregnancy does not increase the risk of atopic dermatitis/eczema in the child. Grade: Limited

Limited evidence suggests that dietary patterns during pregnancy are not associated with risk of atopic dermatitis/eczema in the child. Grade: Limited

Insufficient evidence is available to determine the relationship between peanuts, soybean, wheat/cereal, yogurt and probiotic milk products, and foods not commonly considered to be allergens, such as meat, vegetables, and fruits, consumed during pregnancy and risk of atopic dermatitis/eczema in the child. Grade: Grade Not Assignable

No evidence is available to determine the relationship between tree nuts and seeds consumed during pregnancy and risk of atopic dermatitis/eczema in the child. Grade: Grade Not Assignable

Allergic Rhinitis

Insufficient evidence is available to determine the relationship between cow milk products (fermented or non-fermented) consumed during pregnancy only, or during both pregnancy and lactation, and risk of allergic rhinitis in the child. Grade: Grade Not Assignable

Moderate evidence indicates that lower or restricted consumption of eggs during pregnancy does not reduce the risk of allergic rhinitis in the child. Grade: Moderate

Limited evidence suggests that dietary patterns during pregnancy are not associated with risk of allergic rhinitis in the child. Grade: Limited

Insufficient evidence is available to determine the relationship between fish, peanuts, tree nuts, soybean, wheat, and foods not commonly considered to be allergens, such as meat, vegetables, and fruits consumed during pregnancy and risk of allergic rhinitis in the child. Grade: Grade Not Assignable

No evidence is available to determine the relationship between seeds consumed during pregnancy and the risk of allergic rhinitis in the child. Grade: Grade Not Assignable

Asthma

Limited evidence suggests that a lower consumption of cow milk products during pregnancy does not reduce risk of asthma in the child. Grade: Limited

Insufficient evidence is available to determine the relationship between cow milk products consumed during both pregnancy and lactation and risk of asthma in the child. Grade: Grade Not Assignable

Limited evidence suggests no relationship between eggs consumed during pregnancy and risk of asthma in the child. Grade: Limited

Limited evidence suggests no relationship between fish consumed during pregnancy and risk of asthma in the child. Grade: Limited

Insufficient evidence is available to determine the relationship between maternal dietary patterns or peanuts, tree nuts, soybean, and other foods such as wheat/whole grains, vegetables, fruits, beverages, and margarine consumed during pregnancy and risk of asthma in the child. Grade: Grade Not Assignable

No evidence is available to determine the relationship between seeds consumed during pregnancy and risk of asthma in the child. Grade: Grade Not Assignable

Summary of the Evidence

- This systematic review included 36 articles from five RCTs, one non-RCT, and 13 PCSs that assessed the association between maternal diet and risk of food allergy, atopic dermatitis/eczema, allergic rhinitis, and asthma in the child occurring from birth through age 18 years.[137-172] The articles were published between 1987 and 2020 and consisted of:
  - Thirty articles from 15 studies that included only women who were pregnant.
  - Six articles from 4 studies that included women who were pregnant and women who were lactating.

- Six articles from 2 RCTs and 2 PCSs examined maternal avoidance and/or consumption of cow milk products, eggs, soybean, wheat, and peanuts during pregnancy alone, or during both pregnancy and lactation, in relation to risk of food allergy in the child from birth through age 18 years.
- Twenty-five articles from 5 RCTs, 1 non-RCT, and 10 PCSs examined maternal dietary patterns and consumption and/or avoidance of cow milk products, eggs, fish, soybean, wheat, peanuts, tree nuts, and other foods not commonly considered to be allergens during pregnancy alone, or during both pregnancy and lactation, in relation to risk of atopic dermatitis/eczema in the child from birth through age 18 years.
- Sixteen articles from 4 RCTs and 6 PCSs examined maternal dietary patterns and avoidance and/or consumption of cow milk products, eggs, fish, soybean, wheat, peanuts, tree nuts, and other foods not commonly considered to be allergens during pregnancy alone, or during both pregnancy and lactation, in relation to risk of allergic rhinitis in the child from birth through age 18 years.
- Nineteen articles from 2 RCTs and 8 PCSs examined maternal dietary patterns and avoidance and/or consumption of cow milk products, eggs, fish, soybean, peanuts, tree nuts, and other foods during pregnancy alone, or during both pregnancy and lactation, in relation to risk of asthma in the child from age 2 through 18 years.
- No articles were identified that examined maternal consumption of seeds during pregnancy in relation to risk of atopic outcomes in the child from birth through age 18 years.
- The ability to draw strong conclusions was limited by the following issues:
    - Few RCTs have been conducted and thus, data were primarily observational in nature, limiting the ability to determine causal effects of consumption or avoidance of different foods during pregnancy and risk of atopic dermatitis, food allergies, allergic rhinitis and asthma in the child.
    - Key confounders were not consistently controlled for in most of the studies.
    - Studies had risk-of-bias issues, such as self-reported outcomes and selection bias.
    - People with lower SES, adolescents, and racially and ethnically diverse populations were underrepresented in the body of evidence.

See ***Part D. Chapter 3: Food, Beverage, and Nutrient Consumption During Lactation***, Question 4, for a review that addressed maternal diet during both pregnancy and lactation, and lactation only, and risk of child food allergies and atopic allergic diseases.

For additional details on this body of evidence, visit: nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews/pregnancy-and-lactation-subcommittee/maternal-diet-pregnancy-lactation-child-food-allergies-and-atopic-allergic-diseases

Question 9. What is the relationship between seafood consumption during pregnancy and neurocognitive development in the child?

Approach to Answering Question: NESR systematic review

Conclusion Statements and Grades

Developmental Domains

Cognitive development: Moderate evidence indicates that seafood intake during pregnancy is associated favorably with measures of cognitive development in young children. Grade: Moderate

Language and communication development: Limited evidence suggests that seafood intake during pregnancy may be associated favorably with measures of language and communication development in the child. Grade: Limited

Movement and physical development: Insufficient evidence is available to determine the relationship between seafood intake during pregnancy and movement and physical development in the child. Grade: Grade Not Assignable

Social-emotional and behavioral development: Insufficient evidence is available to determine the relationship between seafood intake during pregnancy and social-emotional and behavioral development in the child. Grade: Grade Not Assignable

Attention deficit disorder or attention-deficit/hyperactivity disorder-like traits or behaviors: Insufficient evidence is available to determine the relationship between seafood consumption during pregnancy and attention deficit disorder or attention-deficit/hyperactivity disorder-like traits or behaviors in the child. Grade: Grade Not Assignable

Attention deficit disorder or attention-deficit/hyperactivity diagnosis: No evidence is available to determine the relationship between seafood consumption during pregnancy and diagnosis of attention deficit disorder or attention-deficit/hyperactivity disorder in the child. Grade: Grade Not Assignable

Autism spectrum disorder: Insufficient evidence is available to determine the relationship between seafood consumption during pregnancy and autism spectrum disorder-like traits or behaviors or autism spectrum disorder diagnosis in the child. Grade: Grade Not Assignable

Academic performance: No evidence is available to determine the relationship between seafood intake during pregnancy and academic performance in the child. Grade: Grade Not Assignable

Anxiety: No evidence is available to determine the relationship between seafood intake during pregnancy and anxiety in the child. Grade: Grade Not Assignable

Depression: No evidence is available to determine the relationship between seafood intake during pregnancy and depression in the child. Grade: Grade Not Assignable

Summary of the Evidence

- This review included 26 articles from 18 PCSs published between January 2000 and October 2019.[173-198]
- The 2020 Dietary Guidelines Advisory Committee used the following seafood definition: marine animals that live in the sea and in freshwater lakes and rivers. Seafood includes fish (e.g., salmon, tuna, trout, and tilapia) and shellfish (e.g., shrimp, crab, and oysters).
- Developmental domains
    - Evidence from 21 articles from 15 PCSs indicated predominantly beneficial associations between seafood intake during pregnancy and measures of cognitive development, including milestone achievement and intelligence, particularly in young children.
    - Evidence from 15 articles from 12 PCSs suggested beneficial associations between seafood intake during pregnancy and measures of language and communication development. However, results were less consistent than for cognitive development. Furthermore, 8 articles assessed measures of verbal intelligence or verbal intelligence quotient (IQ), which may be less specific assessments of language and communication development.
    - Few detrimental associations between seafood intake during pregnancy and measures

of child cognitive or language development were found.
  - Heterogeneity in exposure and assessment methods, and ages of children at follow-up, made it difficult to determine a relationship between seafood intake during pregnancy and movement and physical development or social-emotional and behavioral development.
- Four articles, from 3 PCSs, found inconsistent results when examining the relationship between seafood intake during pregnancy and attention deficit disorder (ADD)-like or attention-deficit and hyperactivity disorder (ADHD)-like traits or behaviors in the child, with studies reporting either null or protective associations.
- Three PCSs assessed autism spectrum disorder (ASD)-like traits or behaviors or ASD diagnosis, but heterogeneity in outcome assessment methods and child age across the 3 PCSs made it difficult to determine a relationship between seafood intake during pregnancy and ASD-like traits or behaviors or ASD diagnosis.
- No studies that met inclusion criteria assessed the relationship between seafood intake during pregnancy and academic performance, anxiety, or depression in the child.
- Thirteen articles accounted for maternal mercury exposure and most found that controlling for mercury exposure strengthened or had little impact on the association between seafood intake during pregnancy and developmental outcomes.
- There were limitations in the evidence:
  - Heterogeneity in seafood intake categories used to compare seafood intake levels across studies made it difficult to assess precision and compare magnitude of associations.
  - Key confounders were not consistently accounted for and there was heterogeneity in exposures, outcomes and child age.

See ***Part D. Chapter 3: Food, Beverage, and Nutrient Consumption During Lactation***, Question 6, for a review that addressed maternal seafood consumption during both pregnancy and lactation and neurocognitive developmental outcomes in the child.

For additional details on this body of evidence, visit: nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews/dietary-fats-and-seafood-subcommittee/seafood-pregnancy-lactation-infant-neurocognitive-development

Question 10. What is the relationship between omega-3 fatty acids from supplements consumed before and during pregnancy and developmental milestones, including neurocognitive development in the child?

Approach to Answering Question: NESR systematic review

Conclusion Statements and Grades

Limited evidence suggests that omega-3 fatty acid supplementation during pregnancy may result in favorable cognitive development in the child. Grade: Limited

Insufficient evidence is available to determine the relationship between omega-3 fatty acid supplementation during both pregnancy and lactation, or during pregnancy only, and language and social emotional development in the child. Grade: Grade Not Assignable

Insufficient evidence is available to determine the relationship between omega-3 fatty acid supplementation during pregnancy and motor and visual development, academic performance, and the risk of attention-deficit disorder, attention-deficit/hyperactivity disorder, and autism spectrum disorder in the child. Grade: Grade Not Assignable

No evidence is available to determine the relationship between omega-3 fatty acid supplementation during both pregnancy and lactation, or during pregnancy only, and anxiety or depression in the child. Grade: Grade Not Assignable

Insufficient evidence is available to determine the relationship between omega-3 fatty acid supplementation during both pregnancy and lactation and cognitive development in the child. Grade: Grade Not Assignable

No evidence is available to determine the relationship between omega-3 fatty acid supplementation during both pregnancy and lactation and visual development, academic performance, or the risk of attention-deficit disorder, attention-deficit/hyperactivity disorder, or autism spectrum disorder in the child. Grade: Grade Not Assignable

Summary of the Evidence

Pregnancy Only, and Both Pregnancy and Lactation

- This systematic review included 31 articles from 14 RCTs and 1 PCS published between 1980 and 2020.[199-228]

- Studies included in this review assessed interventions/exposures during:
  - Pregnancy only: 11 RCTs (24 articles); 1 PCS (1 article)
  - Both pregnancy and lactation: 3 RCTs (6 articles)
- 11 of the 14 RCTs assessed cognitive development
  - Eight RCTs delivered omega-3 fatty acid supplements during pregnancy alone. Of those 8 RCTs, 5 studies (11 articles) reported at least one statistically significant finding that supplementation resulted in favorable cognitive development in the child. One study reported at least one statistically significant finding that supplementation resulted in unfavorable measures of cognitive development in the child. All 8 studies reported at least one statistically non-significant result. Overall, results were inconsistent across different measures both within and between studies.
  - Three RCTs delivered omega-3 fatty acid supplements during both pregnancy and lactation. Of those 3 RCTs, 1 study reported at least one statistically significant finding that supplementation resulted in favorable cognitive development in the child. All 3 studies reported at least one statistically non-significant result.
- For language, motor, visual, and social-emotional development, findings were inconsistent and therefore a conclusion statement could not be drawn. Although all studies reported at least one statistically non-significant result, the number and direction of statistically significant findings varied across the body of evidence.
- Only 1 study examined academic performance; therefore, a conclusion could not be drawn.
- No evidence was available on omega-3 fatty acid supplementation and anxiety or depression.
- Only 1 study (2 articles) assessed the risk of ADD or ADHD; therefore a conclusion could not be drawn.
- Only 1 RCT and 1 PCS study assessed risk of ASD, and both had methodological limitations; therefore, the evidence was deemed insufficient to draw a conclusion.
- The ability to draw strong conclusions was limited by the following issues:
  - Wide variation in the developmental domains assessed, as well as in the measures used to evaluate child performance in each of those domains, which limited the ability to compare results across studies.
  - Potential risk of bias due to missing outcome data. Further, a lack of pre-registered data analysis plans potentially increased the risk of bias selectivity in results presented.
  - Findings were mixed both within and between studies, and these inconsistencies could

not be explained by methodological differences.

- Although some studies published results from multiple follow-up assessments, an insufficient number of studies were available to investigate the relationship between omega-3 fatty acid supplementation and developmental milestones in the child for many exposure-outcome pairs. Additionally, several studies did not provide evidence of sufficient sample size to detect effects, either because the study did not achieve the required sample size estimated by power calculations or because the study did not report a power calculation. This is particularly true for the long-term outcome assessments.
- People with lower-SES, adolescents, and racially and ethnically diverse populations were underrepresented in the body of evidence.

See ***Part D. Chapter 3: Food, Beverage, and Nutrient Consumption During Lactation***, Question 7, for a review of omega-3 fatty acid supplementation during both pregnancy and lactation and neurocognitive outcomes in the child.

For additional details on this body of evidence, visit: nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews/pregnancy-and-lactation-subcommittee/omega-3-pregnancy-lactation-neurocognitive-development

Question 11. What is the relationship between folic acid from supplements and/or fortified foods consumed before and during pregnancy and 1) maternal micronutrient status, 2) gestational diabetes, 3) hypertensive disorders, 4) human milk composition, and 5) neurocognitive development in the child?

Approach to Answering Question: NESR systematic review

Conclusion Statements and Grades

Maternal Micronutrient Status

Strong evidence indicates that folic acid supplements consumed before and/or during pregnancy are positively associated with folate status (serum, plasma, and/or red blood cell folate). Grade: Strong

Insufficient evidence is available to determine the relationship between folic acid from supplements consumed before and/or during pregnancy and hemoglobin, mean corpuscular volume, and serum vitamin B_{12}. Grade: Grade Not Assignable

No evidence is available to determine the relationship between folic acid from supplements consumed before and/or during pregnancy and red blood cell distribution width. Grade: Grade Not Assignable

No evidence is available to determine the relationship between folic acid from fortified foods consumed before and/or during pregnancy and micronutrient status. Grade: Grade Not Assignable

Gestational Diabetes

Insufficient evidence is available to determine the relationship between folic acid from supplements and/or fortified foods consumed before and during pregnancy and the risk of gestational diabetes. Grade: Grade Not Assignable

Hypertensive Disorders

Limited evidence suggests that folic acid supplements consumed during early pregnancy may have a beneficial effect on reducing the risk of hypertensive disorders during pregnancy among women at high-risk (e.g., history of preeclampsia or prepregnancy BMI ≥25 kg/m^2) compared to no folic acid supplementation. Grade: Limited

Moderate evidence indicates that higher levels of folic acid supplements consumed during pregnancy compared to lower levels (including no folic acid supplementation) does not affect the risk of hypertensive disorders during pregnancy among women at low-risk. Grade: Moderate

No evidence is available to determine the relationship between folic acid from fortified foods consumed before and during pregnancy and the risk of hypertensive disorders during pregnancy. Grade: Grade Not Assignable

Human Milk Composition

No evidence is available to determine the relationship between folic acid from supplements or fortified foods consumed before and during pregnancy and human milk folate. Grade: Grade Not Assignable

Neurocognitive Development in the Child

Insufficient evidence is available to determine the relationship between folic acid supplementation before and/or during pregnancy and cognitive, language, and social-emotional development, and risk of autism spectrum disorder in the child. Grade: Grade Not Assignable

No evidence is available to determine the relationship between folic acid from supplements consumed before and during pregnancy and movement and physical development, academic performance, anxiety, depression, or the risk of attention-deficit disorder or attention-deficit/hyperactivity disorder in the child. Grade: Grade Not Assignable

No evidence is available to determine the relationship between folic acid from fortified foods consumed before and during pregnancy and developmental milestones, including neurobehavioral development, in the child. Grade: Grade Not Assignable

Summary of the Evidence

Maternal Micronutrient Status

- Nine studies were identified through a literature search from 1980 to 2019 which met the criteria for inclusion in this systematic review.[229-237]Studies included in this review assessed interventions and exposures before and/or during pregnancy: 6 RCTs, 2 PCSs, and 1 retrospective cohort study.
- Studies varied in intervention details, including:
  - Folic acid supplement type (folic acid or 5-methyltetrahydrofolate).
  - Dose and comparator:
    - Three RCTs and 2 cohort studies compared no folic acid supplementation to folic acid supplementation (RCTs: 350 µg/d to 1.0 mg/d; cohorts: 400 µg/d or dose unknown).
    - Two RCTs compared different levels of folic acid supplementation (330 µg/d vs 730 µg/d; 1.1 mg/d vs 5.0 mg/d).
    - One RCT compared folic acid to 5-methyltetrathydrofolate (5-MTHF) supplementation at the same dose (1.0 mg/d).
  - Duration (2, 3, 5.5, 7, or 12 months).
- Of the 5 outcome measures defined in the analytic framework, all but red blood cell (RBC) distribution width were reported in the body of evidence.

- All but 1 study found a significant association between folic acid supplementation and at least one outcome measure.
- All 9 studies (6 RCTs; 3 PCSs) assessed plasma or serum folate.
  - Of those, 6 found that supplementation was associated with higher values on at least 1 measure of plasma or serum folate and 2 found no association. Another study compared supplementation with folic acid vs 5-MTHF and found that both groups increased over time.
- Six studies (4 RCTs; 2 PCSs) assessed RBC folate.
  - Five found that supplementation was associated with higher values on at least 1 measure of RBC folate and 1 found no association.
- Three studies (2 RCTs; 1 retrospective cohort) assessed hemoglobin. The findings were inconsistent; therefore a conclusion statement could not be drawn.
- Of the 2 RCTs that assessed mean corpuscular volume (MCV), neither found a significant effect on MCV, but study limitations and the small number of studies provided insufficient evidence to draw a conclusion.
- Only 1 RCT assessed the effect of supplementation on vitamin B_{12}; therefore, a conclusion could not be drawn.
- The body of evidence had important limitations:
  - None of the studies preregistered data analysis plans, indicating a risk of bias due to selectivity in results presented.
  - The cohort studies did not adequately account for potential confounding.
  - Risk of bias due to classification of exposures or deviations from intended exposures was a concern for the cohort studies.
  - The study populations did not fully represent the racial/ethnic or socioeconomic diversity of the U.S. population.
  - No studies met the inclusion criteria that examined the effect of intake of folic acid from fortified foods on the outcome of interest.

Gestational Diabetes

- One non-RCT that met the criteria for inclusion in this systematic review was identified through a literature search from 1980 to 2019.[238]
- This study found that women who consumed folic acid supplementation based on genotype and stage of pregnancy had significantly fewer cases of gestational diabetes compared to women who did not consume folic acid supplements before or during pregnancy.

- The evidence had several limitations:
    - No baseline data on study groups were provided for comparison.
    - Intervention methods and adherence were not clear.
    - Results by subgroup were not reported.
    - Consistency could not be assessed with only 1 study.

Hypertensive Disorders

- Eight studies, including 3 RCTs, 2 non-RCTs, and 3 PCSs, met the criteria for inclusion in this systematic review, which were identified through a literature search from 1980 to 2019.[238-245]
- The 3 RCTs compared 5.0 mg/d of folic acid supplementation to a lower-dose of either 0.5 mg/d (2 studies) or 1.0 mg/d (1 study) from early pregnancy through delivery. The folic acid supplementation dose had no effect on incidence of gestational hypertension, preeclampsia, or eclampsia. None of the studies compared folic acid supplementation to a control group with no folic acid supplementation.
- The 2 non-RCTs found a statistically significant association of folic acid supplementation (15 mg/d of 5-MTHF in one study; 400-800 µg/d in another study) from early pregnancy through delivery on risk of gestational hypertension or preeclampsia compared to a control group with no folic acid supplementation. One non-RCT was among a high-risk population (women who had preeclampsia in their preceding pregnancy); the other had methodological limitations related to exposure, outcome assessment, and analysis.
- The 3 PCSs reported mixed results. One study found an association between folic acid use in the first trimester and lower incidence of preeclampsia in the full study sample, and specifically among those with a BMI ≥25 kg/m^2; another study found a statistically significant association between folic acid use at 12 to 20 weeks gestation and lower incidence of preeclampsia among high-risk women. A third study did not find a significant association between folic acid supplementation pre and/or post-conception (Four weeks before to 8 weeks after last menstrual period) and preeclampsia. In addition to problems related to confounding, these studies did not account for potential changes in folic acid supplementation during pregnancy.
- No articles were identified that met the inclusion criteria related to folic acid intake from fortified foods and risk of hypertensive disorders during pregnancy.

Human Milk Composition

- No studies related to folic acid intake from supplements during pregnancy which met the criteria for inclusion in this systematic review were identified through a literature search from 1980 to 2019.

Neurocognitive Development of the Child

- Six articles that met the criteria for inclusion in this systematic review were identified through a literature search from 1980 to 2019.[200,202,246-249] The articles report findings from 4 studies representing 4 outcome domains:
  - o Cognitive development: 1 RCT; 2 articles.
  - o Language and communication development: 1 PCS; 2 articles.
  - o Social-emotional development: 1 RCT; 1 article.
  - o ASD: 1 nested case-control study; 1 article.
- Generally, folic acid supplementation before or during pregnancy was either not associated with or had a beneficial association with the included outcomes.
- For cognitive development, findings were inconsistent; therefore a conclusion statement could not be drawn.
- For social-emotional development, only 1 study was available and it had some limitations; therefore, a conclusion could not be drawn.
- For language development, 2 articles were included from the Norwegian Mother and Child (MoBa) cohort. These articles reported a lower risk of severe language delay in children age 3 years whose mothers had taken folic acid supplements during early pregnancy compared to children whose mothers either did not take folic acid during pregnancy or took folic acid supplements later in pregnancy.
- For ASD, 1 nested case-control found a significant association between folic acid supplementation before pregnancy and during pregnancy and lower risk of ASD in children ages 8 12 years, compared to no folic acid supplementation. This was true for a number of subgroups within the sample, including children without siblings, males, females, children with low SES, children with both parents with psychiatric diagnosis, and children without intellectual disabilities.
- No evidence was found on whether folic acid supplementation before and/or during pregnancy was associated with other included outcomes: movement and physical development, academic performance, ADD or ADHD, anxiety, or depression
- No evidence was found on folic acid from supplements or fortified foods consumed before

and during pregnancy and lactation and developmental milestones, including neurocognitive development.

See ***Part D. Chapter 3: Food, Beverage, and Nutrient Consumption During Lactation***, Question 8, for a review that addressed maternal folic acid supplementation during lactation and selected health outcomes.

For additional details on this body of evidence, visit: nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews/pregnancy-and-lactation-subcommittee/folic-acid-pregnancy-lactation-health-outcomes

DISCUSSION

Although the 2015 Dietary Guidelines Advisory Committee report[250] included some discussion of nutrients of public health concern specific to women who are pregnant, and dietary patterns during pregnancy that are linked to risk of congenital anomalies, it did not include a substantial emphasis on food or beverage intake and maternal-fetal outcomes of pregnancy. The systematic reviews included in this report are the first to assess questions that specifically examine relationships between food and beverage patterns or micronutrients during pregnancy and maternal-fetal outcomes that affect large groups of women and their progeny. Four of the systematic reviews included in this body of evidence, specifically those that examined the impact of dietary patterns during pregnancy on maternal[90] and birth outcomes,[117] were undertaken by the USDA and Department of Health and Human Services as part of the Pregnancy and Birth to 24 Months (P/B-24) Project (P/B-24 TEC).[251] These previously completed systematic reviews were adopted by the 2020 Dietary Guidelines Advisory Committee as they directly addressed the questions we were given.

Dietary Patterns and Risk of Gestational Diabetes Mellitus

These reviews found that several dietary patterns consumed before pregnancy were associated with a reduced risk of GDM.[90] These dietary patterns shared several characteristics, including higher intakes of fruits, vegetables, whole grains, fish, nuts, and legumes. In contrast, dietary patterns characterized by inclusion of red and processed meats were associated with an increased risk for development of GDM.[90] The time interval between dietary data collection and outcome measurement ranged from several weeks to 2 to 10 years. However, longitudinal studies suggest that maternal dietary intake remains stable from prepregnancy throughout pregnancy.[252-254]

The Committee concluded that consistent evidence suggests that certain dietary patterns consumed before pregnancy are associated with reduced risk of GDM. This conclusion was graded as limited because much of the evidence was observational and only 7 distinct groups of women (6 PCSs of women who were pregnant and a pilot RCT with 1 group of women who were pregnant) were included. Only 2 PCSs were from the United States. These studies provided insufficient evidence to determine whether dietary intake during pregnancy was associated with GDM risk.

Dietary Patterns and Risk of Hypertensive Disorders During Pregnancy

Five of the 8 included studies showed significant associations between dietary patterns consumed before and during pregnancy and risk of hypertensive disorders.[90] The dietary patterns associated with reducing the risk of hypertensive disorders were characterized by food components similar to those related to lower risk of GDM (e.g., higher in vegetables, fruits, whole grains, nuts, legumes, and fish). Consumption of these patterns before and during pregnancy was associated with a 14 percent to 29 percent reduction in the risk of preeclampsia and a 30 percent to 42 percent decreased risk of hypertensive disorders, although not all components of the assessed dietary patterns were associated with all hypertensive disorders outcomes.[90] Although the associations between certain dietary patterns and reduced risk of hypertensive disorders were consistent, the strength of the evidence was judged to be limited and only applicable to healthy White women with access to health care. Evidence was insufficient for women of other races and ethnicities and those of lower SES. In addition, issues with methodology, measurement and limited representation of diverse groups of women hampered the ability to draw robust generalizable conclusions.

Dietary Patterns and Gestational Weight Gain

Weight gain during pregnancy can contribute both positively and negatively to maternal and fetal outcomes. The 2009 Institute of Medicine (IOM) report on weight gain during pregnancy outlined gestational weight gain (GWG) recommendations based on prepregnancy BMI.[26] However, 23 percent of women gain less, and 47 percent exceed recommended levels during pregnancy.[255] GWG exhibits a U-shaped curve with regard to risk of poor fetal outcomes. Gaining less weight than recommended increases the risk of SGA and preterm birth.[255]

Excessive GWG increases the risk of GDM, hypertensive disorders, macrosomia in the infant, and cesarean delivery.[255-257] Dietary interventions, with or without physical activity interventions, can modify GWG.[258] However, most interventions have focused on restricting energy intake or modifying glycemic index, rather than on examining how dietary patterns affect GWG.

The systematic review for dietary patterns and GWG included 26 articles (4 RCTS and 19 PCSs from 23 distinct groups of women). Dietary patterns included in this review were assessed using a variety of methods including experimental diets (3 studies), macronutrient distribution (2 studies), index/score analysis (15 studies), factor analysis and principal component analysis (PCA) (5 studies), and reduced rank regression (1 study). Among the 15 studies that used an index or score to assess dietary patterns, 8 of the studies found an association with GWG; five of these studies found that greater adherence to a "beneficial" dietary pattern was associated with lower GWG, while 3 studies found that greater adherence to a "beneficial" dietary pattern was associated with higher GWG, particularly in women with obesity. Examples of beneficial dietary patterns were similar to those that were associated with reduced risk of hypertensive disorders and GDM, and included the Dietary Approaches to Stop Hypertension (DASH) diet and similar patterns. The patterns were higher in vegetables, fruits, nuts, legumes, and fish, while being lower in added sugars and red and processed meats. The DASH-style diet has been found to improve fasting blood glucose levels of women who are pregnant.[259] The 7 studies using an index or score to assess dietary patterns that did not find an association between dietary patterns and GWG suffered from a variety of methodological issues including the lack of control for any key confounders, heterogeneity in timing of assessment of exposure, and/or they were not designed to assess the association between dietary patterns and GWG.

Among the studies using factor analysis or PCA to assess dietary pattern, one study found that greater adherence to a healthy dietary pattern was associated with lower GWG while four suggested that adherence to a less healthy dietary pattern was associated with greater GWG. The 3 RCTs using an experimental diet all found that adherence to Mediterranean or DASH dietary patterns was associated with lower GWG, with 2 showing effects throughout pregnancy and one showing a lower rate of GWG only through the end of the second trimester. The studies that examined macronutrient distributions outside the AMDR did not find associations between percent of energy derived from fat intake and GWG.

The evidence for the current review was graded as limited due to a small number of RCTs compared to observational studies, the lack of control for key confounders by many of the studies, and the lack of racial/ethnic and socioeconomic diversity in the study participants. In addition, many studies relied on self-reported data and were not specifically designed to examine the relationship between dietary patterns and GWG. Moreover, not all studies stratified women by prepregnancy BMI status, which is a significant confounder in the relationship between GWG and prenatal diet quality.[260] Despite these limitations, the evidence suggested that beneficial dietary patterns may help prevent excess or inadequate GWG, at least in some women.

Frequency of Eating and Gestational Weight Gain

Frequency of eating is a component of dietary patterns that may play a role in maternal-fetal outcomes of pregnancy. The 1992 Implementation Guide for the 1990 IOM GWG guidelines[261,262] recommended that women who are pregnant eat 3 meals and 2 or more snacks each day, but this was not included in the more recent GWG recommendations.[26] This eating pattern aims to ensure that women are able to consume the extra nutrients needed during pregnancy, while minimizing common gastrointestinal complaints, namely nausea and indigestion. These recommendations also are consistent with the current typical eating pattern for Americans.

The Committee examined the association between frequency of eating and GWG (see ***Part D. Chapter 13: Frequency of Eating***). However, no studies published between January 2000 and September 2019 met the inclusion criteria for this systematic review. Existing literature suggests that eating patterns change during pregnancy, moving from a main-meal focused pattern during the second trimester to a snack-dominant pattern by the beginning of the third trimester.[263] Additionally, less frequent consumption of meals and/or snacks[264] and differences in the timing of eating occasions during the day[265] are associated with a higher risk of preterm birth. For example, consumption of a 3-meal a day pattern resulted in lower risk of preterm birth compared to a frequent “snack” meal pattern or an “evening meal” pattern characterized by large night-time meals and morning snacks.[265] More research is needed to determine how frequency and content of eating and drinking occasions changes throughout pregnancy, and how these changes affect GWG, to further efforts to promote optimal maternal-fetal outcomes and to reduce poor outcomes such as preterm birth, SGA, and LGA. Food insecurity has been associated with higher GWG, so future studies must account for food insecurity as a potential underlying cause of reduced frequency of eating.[266]

Dietary Patterns and Gestational Age at Birth

Two systematic reviews undertaken by the Pregnancy and Birth to 24 Months Project examined the relationship between dietary patterns consumed before and during pregnancy and gestational age at birth, including preterm birth and birth weight, standardized for gestational age and sex.[117] Ten percent of infants born in the United States are born prematurely[57] and 8 percent of infants are born at a low birth weight (<2500 g) each year[57]; preterm birth is the leading cause of low birth weight. While the rate of LBW had dropped between 2006 and 2012, there has recently been a 4 percent increase in LBW rates in the United States.[57] It has been estimated that 47 percent of hospital stay costs for infants and 27 percent of total pediatric hospital stay costs are due to preterm birth and LBW.[58] Preterm birth accounts for 36 percent of all infant deaths, carries an annual societal economic cost of more than $26 billion, and may result in immediate as well as lifelong disabilities.[267]

Ten PCSs and 1 RCT examined dietary patterns consumed during pregnancy and gestational age at birth and most found an association with altered risk of preterm birth and spontaneous preterm birth. Based on this evidence, the Pregnancy and Birth to 24 Months Project concluded that limited but consistent evidence suggests that certain dietary patterns during pregnancy are associated with a lower risk of preterm birth and spontaneous preterm birth. These protective dietary patterns are higher in vegetables, fruits, whole grains, nuts, legumes and seeds, and seafood (preterm birth, only), and lower in red and processed meats and fried foods.[117] The range of risk reduction varied 10-fold (9 percent to 90 percent) for preterm birth, but was more moderate and consistent for spontaneous preterm birth (15 percent to 45 percent). The only RCT in the review found an increase of approximately 4 days in gestational age between controls and women consuming the healthier intervention diet.[268] Dietary patterns characterized by high intakes of fried foods, red and processed meats, fats, and sugars (e.g., Western diet) were associated with a 53 percent to 55 percent increased risk of preterm birth (and a potentially higher risk of spontaneous preterm birth of 18 percent to 92 percent). Most of the research was conducted in healthy White women with access to health care, however. Therefore, the conclusion is limited in that it may not be generalizable to the entire population of U.S. women of reproductive age. It was not possible to draw conclusions about dietary patterns before pregnancy and preterm birth due to a lack of high-quality evidence. This is an area that requires further investigation.

Dietary Patterns and Birth Weight, Adjusted for Gestational Age and Sex

The systematic review examining dietary patterns before and during pregnancy and birth weight, adjusted for gestational age and sex, included 21 groups of women (19 cohorts and 2 groups of women enrolled in RCTs), with 7 studies conducted in the United States.[117] The significant methodological limitations and inconsistency in study design and outcome measurements for age- and sex-specific birth weight resulted in an inability to draw a conclusion about how dietary patterns before or during pregnancy relate to these outcomes. The studies enrolled women with a lower prepregnancy BMI than is typical for pregnant women in the United States.[269] Rates of smoking among participants, which is associated with reduced birth weight, varied substantially among studies in this systematic review and was not adequately accounted for in the analyses of the included studies. Of particular concern was the lack of adjustment of birth weight for gestational age or sex, and the timing of exposure and outcome assessments. Many studies did not use a standardized measure for outcomes such as SGA and LGA, and the definitions of these outcomes were quite heterogeneous. In addition, many of the studies included a relatively narrow range of birth weight.

Despite the limitations of the studies, the conclusions drawn from these systematic reviews are consistent with findings from other published systematic reviews and meta-analyses.[28,270,271] However, although proposed physiological mechanisms support the associations found between dietary intake before and/or during pregnancy and risk of outcomes found in this body of evidence, the mechanistic evidence is still exploratory in nature.[272-275]

Beverages and Birth Weight, Adjusted for Gestational Age and Sex

Beverage intake is an important topic to consider during pregnancy as beverages contribute substantially to intakes of water, energy, and nutrients among pregnant women (see ***Part D. Chapter 1: Current Intakes of Foods, Beverages, and Nutrients*** and ***Part D. Chapter 10: Beverages***) and have the potential to influence pregnancy outcomes. Women who are pregnant consume about the same volume of beverages as women who are not pregnant. However, they have a higher intake of water, milk, and diet beverages, a similar intake of sweetened beverages, and a lower intake of coffee and tea. The Committee reviewed the evidence for the relationship between beverage consumption during pregnancy and birth weight, standardized for gestational age and sex. Nineteen studies published between January 2000 and June 2019 met the criteria for inclusion in this systematic review, including 1 RCT and 18 PCSs. The studies examined milk, tea, coffee, SSB, LNCSB, or water during pregnancy in relationship to infant birth weight, expressed in varying ways, and with varying adjustments for gestational age and sex. Many of the studies examined more than one beverage. The timing of beverage exposure assessment and the period of intake represented varied substantially, ranging from 5 to 39 weeks of pregnancy, although many studies focused on intake during the first and second trimesters. Overall, the lack of control for the rest of the (non-beverage) diet in this body of evidence was a limitation. The body of evidence available was insufficient in scope and breadth and encompassed too many methodological limitations to determine a relationship between beverage intake in pregnancy and infant birth weight (standardized for gestational age and sex).

Maternal Diet and Food Allergy and Atopic Allergic Outcomes in the Child

Atopic diseases are some of the most common chronic conditions affecting the United States population. The National Institute of Allergy and Infectious Diseases (NIAID) estimates that approximately 5 percent of children and approximately 4 percent of adults in the United States have 1 or more food allergies,[276] which is similar to an overall prevalence of food allergy among U.S. infants and children ages 0 to 4 years of 6.6 percent reported by proxy using NHIS 2017 data.[277] However, the NHIS data are based on parental self-report, and the degree to which reported food allergies were diagnosed by a health provider (and if so, based on an actual allergic reaction vs testing results), parental impression, or a combination of factors, cannot be determined from these data. In addition, the NIAID estimated that approximately 30 percent of the U.S. population has atopic dermatitis.[278] The Centers for Disease Control and Prevention (CDC) estimates that approximately 8 percent of Americans have asthma,[279] and an additional 8 percent have hay fever (allergic rhinitis).[280] In this chapter and in ***Part D. Chapter 3: Food, Beverage, and Nutrient Consumption During Lactation***, the Committee describes its investigation of the relationship of maternal diet during pregnancy and lactation and risk of food allergies and atopic allergic diseases in children.

The systematic review to determine the relationship between maternal diet during pregnancy, or pregnancy and lactation, and the risk of 4 atopic manifestations (food allergies, atopic dermatitis/eczema, asthma, and allergic rhinitis) in the child from birth through age 18 years included 36 articles from 5 RCTs, 1 non-RCT, and 13 PCSs published between 1987 and 2020. Five RCTs and 1 non-RCT focused on avoiding specific foods or food groups, 8 PCSs assessed dietary patterns, and 22 articles from 13 PCSs examined the association between different consumption levels of a variety of foods and beverages and risk of atopic outcomes. Most intervention studies were specifically designed to assess the relationship between avoiding a food product during pregnancy and/or lactation and the atopic outcome, whereas observational studies compared different dietary patterns or intakes of the specific foods or food groups during pregnancy and/or lactation. The RCTs primarily recruited families who were at high risk of allergies. However, this was not the case with PCSs. The timing of study initiation and duration also varied between studies.

The Committee concluded that overall dietary patterns consumed during pregnancy are not associated with the risk of food allergies, allergic rhinitis, or atopic dermatitis/eczema in the child. The evidence pointed to a lack of association between restriction or avoidance of common food allergens in intervention trials or varying levels of intake in cohort studies and risk of various atopic diseases. For cow milk, moderate evidence indicated that lower or restricted consumption during pregnancy did not reduce the risk of atopic dermatitis/ eczema and limited evidence suggested that that lower or restricted consumption did not reduce the risk of asthma. For egg, moderate evidence indicated that lower or restricted consumption during pregnancy did not reduce the risk of atopic dermatitis/eczema or allergic rhinitis, and limited evidence suggested that lower or restricted consumption did not reduce the risk of asthma. Limited evidence from cohort studies also suggested no relationship between fish and soybean consumption during pregnancy and the risk of asthma and food allergies, respectively, in the child.

The ability to draw strong conclusions was limited by the study designs (primarily the observational nature of the studies), which constrained the ability to determine causal effects of consumption or avoidance of different foods on risk of atopic diseases. These studies cannot discriminate between exposures of the mother during pregnancy and/or lactation, or those directly affecting the child. It also was not possible to attribute child atopic outcomes in these studies to the timing of the dietary (pattern) exposure. In most studies, key confounders were not consistently controlled for, study populations lacked racial and/or ethnic diversity and lower-SES, and adolescent populations were underrepresented.

Taken together these conclusions support the conclusions of the AAP[281] and the European Academy of Allergy and Clinical Immunology (EAACI)[282] that evidence to support maternal dietary restrictions either during pregnancy or pregnancy and lactation to prevent atopic disease in the child is lacking.

Maternal Seafood Consumption and Neurocognitive Development of the Child

Consumption of seafood during pregnancy is a topic of considerable scientific and public interest.[283] The 2015-2020 Dietary Guidelines for Americans recommends that women who are pregnant consume at least 8 and up to 12 ounces of a variety of seafood per week, from choices that are lower in methylmercury. Evaluating seafood consumption is inherently a "net effects" evaluation that implicitly "reflect[s] the sum of benefits and risks from all of the constituents in the fish".[284] In terms of neurocognitive development, fish is the primary dietary source of long-chain polyunsaturated omega-3 fatty acids,[285] which are needed for brain development.[286] Thus, the benefits of seafood need to be weighed against the potential for negative health consequences due to possible contamination with heavy metals, chiefly methylmercury. Exposure to methylmercury is considered especially dangerous during critical windows of neurocognitive development in the first 1,000 days of life, though the risks have not been entirely characterized.[285]

The Committee's systematic review of seafood consumption during pregnancy and neurocognitive development of the infant and child yielded 26 PCSs from 18 cohorts published between January 2000 and October 2019 that addressed each neurocognitive component area. A majority of results suggested benefits in the area of cognitive development and language and communication development. Beneficial associations with cognitive development were observed across multiple cohorts, with the most consistent results observed among young children. Similarly, results were beneficial for language and communication, but were less consistent than for cognitive development. However, other domains, such as movement and physical development and social and behavioral development had a lower number of available studies and had considerable heterogeneity of outcome assessments or populations, rendering inconclusive findings that were unable to be graded. Additionally, insufficient data were available to grade evidence for the outcomes of academic performance, anxiety, and depression as well as ASD and ADD/ADHD.

Although the Committee's questions did not specifically focus on safety, it noted isolated negative (i.e., increased risk) associations of seafood intake and neurocognitive outcomes in 3 studies. In one of the studies,[186] a negative association was observed primarily between maternal prenatal intake of squid and shellfish and child performance on perceptual performance and numeric subscales. No negative associations were observed between total seafood consumption or consumption of large fish with neurocognitive outcomes. In another study, a negative association was observed between maternal fish intake and child psychomotor development. However, maternal fish intake was assessed using a non-validated questionnaire, the negative association was observed only in female children, and no adjustment was made for maternal mercury exposure. Despite these isolated negative associations, the overwhelming majority of studies showed a null or positive (i.e., favorable or beneficial) association.

Although the available scientific literature on the topic of seafood consumption during pregnancy and neurocognitive outcomes in the child has recently expanded, the totality of the evidence remains inconclusive due to several limitations. These limitations include: 1) lack of uniformity and usage of valid and reliable methods across studies to assess type, amount, frequency, source and preparation of seafood exposure at multiple time points during pregnancy, 2) the variety of measurement tools for neurocognitive development, as well as the wide range of outcomes included, 3) insufficient accounting for maternal methylmercury exposure in studies assessing child outcomes, and 4) lack of RCTs, primarily due to ethical considerations

These limitations made it difficult to draw firm conclusions about the relationships between seafood consumption during pregnancy and movement and physical development, social-emotional and behavioral development, attention deficit disorder/attention-deficit hyperactivity disorder-like traits or behaviors or diagnosis, and autism spectrum disorder in the child (see ***Part D. Chapter 9: Dietary Fats and Seafood*** for additional information about the methodology for this review).

This Committee's review could not address questions that differentiated the influence of maternal seafood intake during pregnancy on the child's neurocognitive development and the influences of direct seafood intake by the child after the introduction of complementary foods.

Omega-3 Fatty Acids from Supplements and Neurocognitive Development of the Child

In addition to considering seafood consumption, the Committee evaluated the impact of omega-3 fatty acid supplementation before and during pregnancy on neurocognitive outcomes of the child. Based on the evidence from 8 RCTs (17 articles) published between 2006 and 2019, the Committee concluded that omega-3 fatty acid supplementation during pregnancy may result in favorable cognitive development in the child. This conclusion statement was graded as "Limited." Overall, the studies had low risk of bias due to randomization, deviations from intended interventions, and outcome measurement for all studies. However, the results were mixed both within and between studies, which could have been due to the wide heterogeneity in the timing of the outcome assessment. Of the 8 trials with information on measures related to cognitive development, 2 conducted assessments only during infancy, 1 at age 1 week[210] and 1 at age 4 and age 6 months.[222] Thus, the results of those 2 trials could not be compared with results of the other 6 trials. Among the other 6 trials,[200-205,208,209,216,217,219-221,223,224,226] the maximum age at follow-up ranged from 5 to 12 years. Thus, the developmental domains assessed varied widely, as did the measures used to evaluate child performance in each of those domains. This variability limited the ability to compare results across studies. The dose and content of the supplements provided also varied; 3 trials[203-205,208,209,216,217,219] included both docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), with doses ranging from 500 to 2,200 mg for DHA and from 100 to 1,100 mg for EPA; 3 trials[200-202,220,221,223,224,226] used only DHA, with doses of 400 to 600 mg. Most of the interventions began at 18 to 22 weeks gestation, but one began at 14.5 weeks[203,204] and another at 16 weeks gestation.[220,221] Two studies, one in Australia[208,209,216,217] and one in Mexico,[223,224,226] had sample sizes of approximately 700 to 900,whereas the other 4 trials had sample sizes ranging from 72[205,219] to 161.[203,204] The studies provided little information on baseline omega-3 status, but most trials excluded women taking DHA-containing supplements (except 1 trial). [203,204] One of these 6 trials excluded women consuming more than 2 fish meals per week at enrollment (Perth).[205,219] Three trials provided information indicating that women had low DHA intake[223,224,226] or biochemical evidence from maternal or cord blood suggestive of low DHA status at baseline (DOMINO, KUDOS).[203,204,208,209,216,217]

Of the 6 studies with follow-up beyond infancy, 4 identified at least 1 significant difference in outcomes in favor of the group receiving omega-3 supplements. In the DOMINO trial in Australia,[208,209,216] these included: 1) being less likely to be rated as “delayed” on the Bayley Scores for Infant Development III (though not different in the average score) at age 18 months; 2) scoring better on one of the sustained attention tasks at age 27 months (though not on the other tasks); 3) scoring higher on training accuracy during the training trials for one of the assessments of working memory and inhibitory control (but not on the actual test trials); and 4) scoring higher for perceptual reasoning (but not other sub-scales) on the Wechsler Abbreviated Scale of other sub-scales on the Wechsler Abbreviated Scale of Intelligence) at age 7 years. On the other hand, children in the intervention group scored lower than those in the control group for assessments of executive function at age 4 years,[209,217] although those were both based on parental report. No significant differences were found on the remainder of the assessments, including a distractibility task at age 27 months, the Differential Ability Scales at age 4 years, and the TEACh Sky search test at age 7 years.[209,217]

In Mexico,[223] children in the intervention group scored better on one of the sub-scales (omissions) on the Kiddie Continuous Performance Test at age 5 years, but did not differ in the overall score or the other 3 sub-scales, nor on the McCarthy Scales of Children’s Abilities.

These children also did not differ on the Bayley Scales of Infant Development at age 18 months.[224] In the KUDOS trial in the United States,[204] children in the intervention group scored higher on one of the tests of executive function at ages 24 and 30 months, but otherwise did not differ on the other tests performed at any of the ages (10, 18, 24, 30, 36, 42, 48, 60, and 72 months). In another study in Australia,[205] children in the intervention group scored higher on eye-hand coordination at age 2.5 years, but not on the other sub-scales of the Griffiths Mental Development Scales. At age 12 years, no significant differences were seen in scores on the WISC or the Beery-Buktenica Developmental Test of Visual-Motor Integration, though only 48 children remained in the study.[219] In the other 2 trials, no significant differences by intervention group were detected at any age (6.5 to 8.5 years in the NUHEAL trial in Germany, Hungary, and Spain[200-202] and 9 months, 18 months and 5.75 years in a trial in Canada.[220,221]

The ability to draw stronger conclusions was limited by the heterogeneity and inconsistencies of the findings described above. In addition, several studies did not provide evidence of sufficient sample size to detect effects, either because the study did not achieve the required sample size estimated by power calculations or because the study did not report a power calculation. This is particularly true for the longer-term outcome assessments. Lastly, the generalizability of this body of evidence to the United States was low because lower-SES and adolescent populations were underrepresented and the studies lacked racial and ethnic diversity.

Insufficient evidence was available for the other outcomes examined to draw a conclusion regarding the relationship of prenatal omega-3 supplementation with language, motor, visual, or socio-emotional development, academic performance, ADD, ADHD, or ASD. No evidence for the relationship with anxiety or depression in the child was found.

The Committee also examined 3 RCTs that evaluated omega-3 supplementation during *both* pregnancy and lactation. The findings of those trials did not alter the conclusions described above for supplementation during pregnancy only (see ***Part D. Chapter 3***).

These conclusions are similar to those of a recent Cochrane review and meta-analysis ,[287] which stated that "very few differences between antenatal omega-3 LCPUFA supplementation and no omega-3 were observed in cognition, IQ, vision, other neurodevelopment and growth outcomes, language, and behavior." The importance of an adequate supply of omega-3 fatty acids for brain development *in utero* is not disputed.[286,287] Both omega-3 and omega-6 fatty acids are involved in numerous processes for central nervous system development. Accumulation of DHA in the brain occurs rapidly during the second half of gestation, suggesting that this is a critical period for an adequate supply from the diet, adipose stores, or through synthesis from precursor fatty acids (e.g., alpha-linolenic acid). The effects of prenatal omega-3 supplements on neurocognitive development of the child thus likely depend on the adequacy of the maternal diet with respect to DHA and its precursors along with inherent synthetic capacity to generate LCPUFA from their precursors.[288,289] Thus, further evidence is needed from RCTs that are adequately powered and targeted at populations with low intakes of omega-3 fatty acids.

Folic Acid from Supplements and Maternal and Child Health Outcomes

Women who are pregnant can obtain folate through food forms of folate, folic acid in fortified grains, or folic acid in supplements. The Committee examined the relationship between folic acid from supplements consumed before and during pregnancy and maternal and child outcomes. None of the identified articles that examined the relationship between folic acid from fortified foods consumed before and during pregnancy met inclusion and exclusion criteria. The outcomes investigated were: 1) maternal micronutrient status, 2) GDM, 3) hypertensive disorders, and 4) developmental milestones, including neurocognitive development in the child. Associations between folic acid from supplements and/or fortified foods consumed during lactation and maternal micronutrient status and human milk composition are discussed in ***Part D. Chapter 3***.

Six RCTs, 2 PCSs, and 1 retrospective cohort study were included in the body of evidence. Micronutrient status was assessed by serum or plasma folate (which are short-term indicators of folate status), RBC folate (which is a longer-term and preferred biomarker of folate status[86]) and various hematological markers. In addition, due to the risk of folate supplementation masking vitamin B_{12} deficiency, serum or plasma B_{12} concentrations also were assessed.

Although the studies varied in timing of initiation of supplementation, dose, and the form of folate provided, the Committee concluded that folic acid supplementation before and/or during pregnancy is positively associated with folate status (serum, plasma, and/or RBC folate). This conclusion was graded as “Strong” because the 6 RCTs had low risk of bias, and were consistent, direct, and precise in the measurements and outcomes. The 3 observational studies were moderately consistent, and the results of the cohort studies mostly aligned with those of the RCTs. The generalizability of the results from the RCTs was diminished because only 1 of the 6 was conducted in the United States, and it had limited racial/ethnicity and socioeconomic diversity. Of the cohort studies, none reported either race/ethnicity or socioeconomic status.

For hematologic markers of folate status, the evidence was either insufficient (hemoglobin, mean corpuscular volume) or nonexistent (red cell distribution width). In addition, insufficient evidence was available to determine the relationship between folic acid from supplements consumed before and/or during pregnancy and serum/plasma vitamin B_{12} concentrations.

For hypertensive disorders, the evidence reviewed by the Committee included 3 RCTs, 2 non-RCTs, and 3 PCS. For GDM, 1 non-RCT conducted in China was included in this body of evidence. This study found that women who consumed folic acid supplements, based on *MTHFR* and *MTRR* genotype and trimester of pregnancy, had significantly fewer cases of GDM compared to women who did not consume folic acid supplements before or during pregnancy (0.27 percent vs 3.24 percent; $p<0.05$).[238] However, the study raised serious concerns regarding risk of confounding and participant selection, missing data, and an unclear study protocol. Therefore, the Committee concluded that insufficient evidence was available to determine the relationship between folic acid from supplements consumed before and during pregnancy and lactation and the risk of GDM.

For hypertensive disorders, 3 RCTs compared a high dose of folic acid (5.0 mg/d) to doses close to the RDA (0.5 or 1.0 mg/d) in low-risk women. All were conducted in Iran, where flour fortification with folate was not routine, and all found no association with risk of gestational hypertension or pre-eclampsia. One non-RCT compared 15 mg/d 5-MTHF to aspirin and found lower incidence of preeclampsia compared to no 5-MTHF.[241] The other[238] compared different doses of folic acid, but had serious methodologic limitations, as described above. The 3 PCSs compared no folate vs a folate supplement and showed no benefit[239] or found benefit only for high-risk women.[244,245]

The Committee concluded that the benefit of folic acid supplementation varied with maternal risk for hypertensive disorders. For women at high risk (e.g., prepregnancy BMI ≥35 kg/m^2, preeclampsia in a previous pregnancy), limited evidence showed that folic acid supplementation during early pregnancy reduced the risk of hypertensive disorders compared to no folic acid supplementation. However, for healthy women at low risk, moderate evidence supported no benefit of folic acid supplementation for hypertensive disorders. These studies have limitations regarding generalizability, as none were conducted in the United States and little data were provided on other participant characteristics.

Lastly, the Committee examined data on the relationship between folic acid supplementation before and during pregnancy and developmental milestones in the child, including neurocognitive development. Six articles from 4 studies were included in the body of evidence. In general, folic acid supplementation before or during pregnancy was either not associated with, or had a beneficial association with, the included outcomes. For cognitive development, findings were inconsistent and therefore a conclusion statement could not be drawn. For social-emotional development, only 1 study was reviewed and it had limitations. Therefore, a conclusion could not be drawn. For language development, 2 articles were included from the Norwegian Mother and Child (MoBa) cohort. These articles reported a lower risk of severe language delay in children age 3 years whose mothers had taken folic acid supplements during early pregnancy compared to children whose mothers either did not take folic acid during pregnancy or took folic acid supplements later in pregnancy.

For ASD, 1 nested case-control study found a significant association between folic acid supplementation before pregnancy and during pregnancy and lower risk of ASD in children ages 8 to 12 years, compared to no folic acid supplementation. This was true for a number of subgroups within the sample, including children without siblings, males, females, children of low SES, children with both parents reporting a psychiatric diagnosis, and children without intellectual disabilities.[248] Although these findings of reduced ASD with folic acid are promising, they are derived from single studies for each reported outcome. Therefore, the Committee concluded that insufficient evidence was available to determine the relationship between folic acid supplementation before and/or during pregnancy and cognitive, language, and social emotional development, and risk of ASD in the child. In addition, no evidence was available to determine the relationship between folic acid from supplements consumed before and during pregnancy and movement and physical development, academic performance, anxiety, depression, or the risk of ADD or ADHD in the child.

No studies that assessed the relationship between folic acid fortification before and/or during pregnancy and maternal and child outcomes were found. However, findings from a recent Cochrane systematic review showed improvements in folate status in women who were pregnant who consumed wheat and maize flour fortified with folic acid.[89] In 1 study, women who were pregnant (n=38) who received folic acid-fortified maize porridge had significantly higher erythrocyte and plasma folate concentrations compared to no intervention. However, in another study, women of reproductive age who were not pregnant (n=35) who consumed maize flour fortified with folic acid and other micronutrients did not have higher erythrocyte or plasma folate concentrations, compared to women consuming unfortified maize flour. In 2 non-RCTs, serum folate concentrations were significantly higher among women who consumed flour fortified with folic acid and other micronutrients compared to women who consumed unfortified flour. The authors concluded that fortification of wheat or maize flour with folic acid (i.e., alone or with other micronutrients) may increase erythrocyte and serum/plasma folate concentrations. Limitations of this review included the small number of available studies and low certainty of evidence due to how included studies were designed and reported.[89]

SUMMARY

This is the first Dietary Guidelines Advisory Committee to conduct a series of reviews focused on women who are pregnant. The 3 most recent Dietary Guidelines Advisory Committees have examined relationships between specific foods, food components, or nutrients and pregnancy outcomes, including: alcohol,[290-292] caffeine,[292] calcium,[292] dairy,[291,292] folate,[290-292] iron,[290-292] omega-3 fatty acids,[290,292] total protein,[292] seafood,[290-292] and vegetable and/or soy protein.[290] In addition, previous Committees examined relationships between pregnancy and maternal body weight,[290-292] physical activity,[290,292] and food safety.[290-292] The 2020 Committee re-examined seafood consumption, omega-3 fatty acids, folic acid supplements, and beverages (including caffeinated choices), but did not specifically examine alcohol, protein intake, body weight, food safety, calcium, dairy products, iron, or physical activity. This Committee also examined several new relationships, including those between dietary patterns and maternal and child outcomes, frequency of eating and gestational weight gain, and beverage consumption and infant birth weight. In addition, for the first time, the Committee examined relationships between maternal consumption of dietary patterns and/or specific foods and atopic conditions in children, including food allergies, allergic rhinitis, atopic dermatitis/eczema, and asthma.

The evidence reviewed by the Committee reinforces the importance of nutrition for women of reproductive age and women who are pregnant for optimal maternal and fetal outcomes. Women who are pregnant have higher a mean Healthy Eating Index (HEI) score (i.e., 62 out of 100), than do their peers who are not pregnant (i.e., 54). Focusing on the components of the HEI, women who are pregnant have lower HEI scores than their peers (i.e., women who are neither pregnant nor lactating and women who are lactating) for Added Sugars and the highest HEI component scores for Total Fruits, Total Vegetables, Dairy, Refined Grains, and Sodium among the 3 groups of women (**see *Part D. Chapter 1: Current Intakes of Foods, Beverages, and Nutrients*,** Question 3 for additional information about the HEI).

Mean usual intakes of select underconsumed and overconsumed nutrients by pregnant and non-pregnant, non-lactating women in the United States, based on the What We Eat in America, NHANES 2013-2016 data, are summarized in Table D2.1. The definitions of underconsumed and overconsumed nutrients or food components can be found in ***Part D. Chapter 1*** and in the footnotes of Table D2.1**.** Nutrients or ULfood components of public health concern are those that are underconsumed or overconsumed nutrients or food components with supporting evidence through biochemical indices or functional status indicators, if available, plus evidence

that the inadequacy or excess is directly related to a specific health condition (**see *Part D. Chapter***). Food components of public health concern among women who are pregnant include those for the entire population older than 1 year, including vitamin D, calcium, dietary fiber, and potassium, which are underconsumed and sodium, saturated fat, and added sugars, which are overconsumed. In addition, low iron intake is of public health concern among women who are pregnant, based on biomarker data that suggest low nutrient status.[13] Given the high prevalence of inadequate folate intakes observed in women who are or are capable of becoming pregnant and that nutrient's relationship to risk of neural tube defects, folate/folic acid should remain of concern among premenopausal women during the first trimester of pregnancy, when the neural tube is formed and closed. Folate/folic acid and iron are unique in that with the use of dietary supplements, 27% and 14% of women who are pregnant will exceed the UL for folic acid and iron, respectively, but without the supplements these women would be at risk for inadequacy (Table D2.1). Choline and magnesium are also underconsumed in the diets of women who are pregnant and should be considered for further evaluation, given limited availability of biomarker, clinical, or health outcome data (Table D2.1) Low iodine intake is potentially of public health concern among women who are pregnant, based on biomarker data that suggest low nutrient status. Taken together, these data suggest that, while women apparently seek to improve their diets during pregnancy, further improvements are needed to better align with dietary recommendations.

Table D2.1 Mean usual intake of select underconsumed and overconsumed nutrients, by pregnancy status, in the United States, 2013-2016[1]

		Pregnant		**Non-Pregnant[2]**	
		Food and Beverages (n=125)	Food, Beverages, and Dietary Supplements (n=119)	Food and Beverages (n=2060)	Food, Beverages, and Dietary Supplements (n=2019)
Potentially underconsumed:					
Choline (mg)	Mean (SE)	289 (12)	287 (13)	290 (4)	293 (4)
	% >AI (SE)	6† (1.7)	4† (1.8)	7 (1.1)	7 (1.0)
Dietary fiber (g)	Mean (SE)	18.1 (0.9)	n/a	15.4 (0.4)	n/a
	% >AI (SE)	11* (2.6)	n/a	7 (1.2)	n/a
Potassium (mg)	Mean (SE)	2457 (99)	n/a	2277 (42)	n/a
	% >AI (SE)	24 (5.1)	n/a	28 (2.6)	n/a
Vitamin D (µg)	Mean (SE)	5.0 (0.5)	15.1 (1.4)	4.0 (0.1)	13.2 (1.3)
	% <EAR (SE)	96† (1.8)	38 (5.5)	>97	73 (1.4)
Vitamin E (mg)	Mean (SE)	9.0 (0.6)	n/a	8.6 (0.2)	n/a
	% <EAR (SE)	82 (4.7)	n/a	85 (2.1)	n/a
Magnesium (mg)	Mean (SE)	291 (11)	308 (14)	270 (4)	284 (5)
	% <EAR (SE)	47 (5.5)	51 (5.2)	49 (2.2)	46 (2.1)
Vitamin C (mg)	Mean (SE)	93.6 (5.5)	158.1 (14.5)	72.5 (2.5)	122.3 (6.9)
	% <EAR (SE)	34 (3.9)	19 (3.9)	46 (2.5)	37 (1.9)
Vitamin A (ug RAE)	Mean (SE)	685 (53)	n/a	559 (15)	n/a
	% <EAR (SE)	32 (6.9)	n/a	46 (2.3)	n/a
Calcium (mg)	Mean (SE)	1018 (60)	1205 (75)	869 (11)	948 (13)
	% <EAR (SE)	25 (6.5)	17 (4.9)	44 (1.8)	38 (1.8)
Zinc (mg)	Mean (SE)	10.7 (0.6)	20.9 (1.7)	9.6 (0.1)	12.0 (0.3)
	% <EAR (SE)	21 (5.5)	17 (4.4)	14 (1.9)	12 (2.1)
Thiamin (mg)	Mean (SE)	1.56 (0.09)	2.57 (0.15)	1.41 (0.02)	3.01 (0.23)
	% <EAR (SE)	11† (4.3)	11† (3.9)	8 (1.6)	7 (1.3)
Copper (mg)	Mean (SE)	1.2 (0.05)	1.7 (0.12)	1.1 (0.02)	1.3 (0.03)
	% <EAR (SE)	9† (2.8)	11† (3.2)	11 (1.1)	10 (1.0)
Riboflavin (mg)	Mean (SE)	1.96 (0.10)	3.10 (0.20)	1.85 (0.03)	3.13 (0.15)

	% <EAR (SE)	6† (1.9)	6† (2.4)	3 (0.7)	<3
Vitamin B12 (µg)	Mean (SE)	4.57 (0.33)	25.92† (15.36)	4.15 (0.09)	55.57 (13.93)
	% <EAR (SE)	6† (2.5)	<3	7 (1.5)	5 (1.1)
Potentially underconsumed and overconsumed:					
Iron (mg)	Mean (SE)	14.5 (0.9)	30.7 (2.4)	12.4 (0.2)	16.2 (0.5)
	% <EAR (SE)[3]	n/a	n/a	n/a	n/a
	% >UL (SE)	<3	14† (3.5)	<3	<3
Folate (µg DFE)	Mean (SE)	527 (38)	1373 (97)	466 (8)	640 (15)
	% <EAR (SE)	31 (7.4)	22 (5.1)	18 (1.9)	14 (1.6)
Folic acid (µg)	Mean (SE)	193 (16)	691 (53)	158 (4)	261 (8)
	% >UL (SE)	<3	27 (5.4)	<3	<3
Potentially overconsumed:					
Sodium (mg)	Mean (SE)	3305 (134)	n/a	3191 (41)	n/a
	% >AI (SE)	>97	n/a	>97	n/a
	% >CDRR (SE)	88† (3.7)	n/a	85 (1.8)	n/a

AI=Adequate Intake; CDRR=Chronic Disease Risk Reduction; EAR=Estimated Average Requirement; UL=Tolerable Upper Intake Level

Underconsumed = A nutrient that is underconsumed by 5 percent or more of the population or specific groups relative to the EAR, AI, or other quantitative authoritative recommendations from the diet alone. Overconsumed = A nutrient that is consumed in potential excess of the UL, CDRR, or other quantitative authoritative recommendations by 5 percent or more of the population or in specific groups from the diet alone. For more information see: Table D 1.1 Framework to Begin the Process of Identifying Nutrients and Other Food Components as Underconsumed, Overconsumed, or of Potential Public Health Concern

[1]Adapted from What We Eat in America, NHANES 2013-2016 Usual Nutrient Intake from Food and Beverages, and Total Usual Nutrient Intake from Food, Beverages, and Dietary Supplements, by Pregnancy and Lactation Status for Females 20 to 44 years of age[293,294]

[2]Includes all women who are not pregnant and are not lactating.

[3]More than 35% of pregnant women had usual nutrient intake below the EAR for iron using data from WWEIA, NHANES 2001-2014[13]

†Estimate may be less reliable due to small sample size and/or large relative standard error

The evidence reviewed relating to healthy dietary patterns before and/or during pregnancy suggests a modest reduction in the risk of GDM, hypertensive disorders, excessive GWG, and preterm birth. There was remarkable consistency in the food components contained within these dietary patterns. These protective dietary patterns are generally higher in vegetables, fruits, whole grains, nuts, legumes and seeds, and seafood, and lower in red and processed meats. Thus, adherence to this dietary pattern has the potential to ameliorate the risk of the predominant complications of pregnancy, which result in adverse maternal and infant outcomes. Additionally, the food components of these beneficial dietary patterns are the same as the dietary components associated with overall chronic disease risk reduction (see ***Part D. Chapter 1*** and ***Part D. Chapter 8: Dietary Patterns***), suggesting that consistent advice on components of a healthy diet can be communicated to women of reproductive age prior to and during pregnancy. Although the foods that are characteristic of healthy dietary patterns before and during pregnancy are similar, evidence to suggest how often during the day women should consume foods and beverages to achieve optimal GWG was lacking. More information is needed to develop guidance in this area, especially in light of previous *Dietary Guidelines for Americans* recommendations regarding achieving healthy weight before pregnancy and achieving GWG within the 2009 IOM recommendations.[26]

Food Pattern Modeling exercises showed that each of the three Food Patterns styles (**Healthy U.S., Healthy Vegetarian,** and **Healthy Mediterranean**) described in ***Chapter 14: USDA Food Patterns for Individuals Ages 2 Years and Older*** is expected to meet nutrient needs for women who are pregnant with the possible exception of iron, choline and vitamins D and E. Thus, these patterns will provide many of the nutrients that are commonly underconsumed by women who are pregnant. Therefore, the Committee recommends that women who are pregnant choose foods consistent with these dietary patterns. In addition, they should specifically incorporate foods that are rich in iron, folate, choline and vitamins D and E, such as red meat, seafood, eggs, green leafy vegetables, fortified grains and fortified milk, nuts, seed and vegetable oils (see ***Part D. Chapter 1***).

This Committee's findings on folic acid supplements are consistent with those of previous Committees, namely that folic acid supplementation is associated with better maternal folate status during pregnancy and reduced risk of congenital anomalies in the child. The current review also suggests that folic acid supplementation may reduce the risk of hypertensive disorders among women at high-risk or with a previous history of these disorders. Given that preeclampsia is among the leading causes of maternal mortality, and both pre-eclampsia and congenital anomalies are linked to increased risk for preterm birth and infant mortality, folic acid status during pregnancy has important public health ramifications. Supplementation with 400 µg/day of synthetic folic acid plus dietary intake of an additional 200 µg/day was recommended by previous Committees. The U.S. Preventive Services Task Force[295] recommends that all women of reproductive age take a daily supplement containing 400 to 800 µg of folic acid, which is consistent with recommendations by the CDC and the IOM.[86,296] However, as noted in ***Part D. Chapter 1***, with the use of supplements, some women who are lactating are exceeding recommendations for folic acid intake. Given that this high intake has not been directly linked with clinical outcomes, it is not designated of public health concern, but warrants monitoring.

This Committee concurs with these recommendations and supports folic acid supplementation as the standard of care before and during pregnancy. The use of 5-MTHF (methylfolate) may be beneficial for some women who have the methylenetetrahydrofolate reductase polymorphism. However, not enough studies were available for review to make a recommendation specific to that supplemental form of the vitamin.[297,298] Dietary intakes of folate are generally low and folate status may be compromised in some groups of women (see ***Part D. Chapter 1***), so continued attention to intake is warranted. The Committee encourages all women of reproductive age to include foods high in folate, including those fortified with folic acid, as part of a healthy dietary pattern. These foods may include fortified whole grains, dark green and leafy vegetables, and legumes. However, in those women who are consuming substantial folic acid from fortified foods along with a supplement, the intake of folic acid may reach or exceed the Tolerable Upper Intake Level, as documented in ***Part D. Chapter 1***.

The 2010 Dietary Guidelines Advisory Committee concluded that moderate evidence indicated that intake of omega-3 fatty acids, in particular DHA, from *at least* 8 ounces of seafood per week for women who are pregnant or breastfeeding is associated with improved infant health outcomes, such as visual and cognitive development. The 2020 Committee found limited evidence suggesting that omega-3 fatty acid supplementation during pregnancy may result in favorable cognitive development in children, and that seafood intake during pregnancy may be associated favorably with measures of cognitive development and language and communication development in young children. In addition, the systematic reviews on dietary patterns suggest that seafood intake as part of a healthy dietary pattern, particularly intake of fish high in omega-3 fatty acids, before pregnancy may be related to reduced risk of GDM and hypertensive disorders, and consumption during pregnancy may be related to reduced risk of hypertensive disorders and preterm birth and better cognitive development in children. Seafood intake is low among women who are pregnant (***Part D. Chapter 1***) and should be encouraged in accordance with recommendations by the *2015-2020 Dietary Guidelines for Americans*,[292] Food and Drug

Administration, and the Environmental Protection Agency,[299] which are that women who are pregnant should consume at least 8 and up to 12 ounces of a variety of seafood per week, from choices that are lower in methylmercury and higher in omega-3 fatty acids. Additionally, women who are pregnant should limit intake of seafood choices that may be high in environmental contaminants.[284] Supplementation with omega-3 fatty acids during pregnancy may be beneficial to cognitive development in children. However, the evidence reviewed was heterogeneous and was not clear on the specific amounts of various omega-3 fatty acids that may be responsible for the benefits. Thus, the Committee was unable to make a specific recommendation about routine supplementation with omega-3 fatty acids during pregnancy.

A lack of evidence prevented the Committee from examining relationships between beverage consumption during pregnancy and infant birth weight. National guidance on recommended beverage intakes during pregnancy are currently lacking. This is especially needed with regard to SSB, which have been linked to poor diet quality and higher energy intake during pregnancy.[300] The American College of Obstetricians and Gynecologists (ACOG)[301] Committee on Obstetric Practice has stated that moderate caffeine intake (defined as up to 200 mg/day) appears to be safe during pregnancy. However, ACOG has no recommendations regarding SSB. Previous Dietary Guidelines Advisory Committees have examined caffeine intake specifically and recommended that women who are pregnant and consume caffeinated beverages do so in moderation and consult with their obstetric providers.

Systematic reviews performed by this Committee suggest that consumption of common allergenic foods (e.g., egg, cow milk) during pregnancy is not associated with an increased risk of food allergies, asthma, and related atopic disease outcomes in the child, nor is the restriction of these foods associated with a decreased risk of these conditions. These findings are similar to those of the AAP Committee on Nutrition and Section on Allergy and Immunology,[281] which published a clinical report that does not recommend maternal restriction as an atopy prevention strategy. Given current AAP recommendations and the systematic review results described in this chapter, the Committee does not support restriction of potential allergens in maternal diets before or during pregnancy, unless the woman is allergic to the foods. Rather, the findings of the Committee support the need for women to consume an overall healthy dietary pattern that includes these foods, as they are important sources of potential shortfall nutrients for women who are pregnant and lactating, such as protein, calcium, iron, vitamin D, magnesium, and choline.

Questions related to dietary supplements and/or fortified food sources of vitamins B_{12} and D, iron, and iodine remain unstudied by this Committee. Three of these nutrients (vitamin D, iron and iodine) are considered nutrients of public health concern (see ***Part D. Chapter 1***), with iron and iodine of particular concern during pregnancy due to the potential neurocognitive deficits in children that are associated with low intake and/or inadequate nutrient status.[9,69,70,73] Vitamin D deficiency has been associated with increased risk for GDM, preeclampsia,[64,302,303] SGA, and preterm birth, while vitamin D supplementation is associated with lower risk of preeclampsia. Vitamin B_{12} is a nutrient of potential concern among females of reproductive age because as many as 10 percent of adolescent girls and young women have inadequate intakes (see ***Part D. Chapter 1***). Iodine and vitamin D are nutrients that have few dietary sources in the absence of fortification, so consumption of fortified foods and supplements may be the primary way to achieve adequate intakes of these nutrients. Although iron is present in a wide variety of foods, the increased need during pregnancy is difficult to achieve through dietary intake alone. Thus, the IOM and the CDC recommend iron supplementation during pregnancy.[86,304] However, the U.S. Preventive Services Task Force and the ACOG recommended that only women who have iron deficiency should take iron supplements.[305,306] Given the importance of these nutrients to achieve optimal pregnancy outcomes, and the fact that they are all nutrients of concern among females of reproductive age, additional attention should be given to these nutrients during development of dietary guidelines by future Dietary Guidelines Advisory Committees.

Strategies for Women of Reproductive Age

A variety of strategies may help women of reproductive age and women who are pregnant achieve food and nutrient intakes that promote optimal pregnancy outcomes. These strategies include:

1. Encourage women to achieve a healthy weight before pregnancy, and to strive for GWG within the 2009 IOM recommendations. Previous Committees have made this recommendation, and this Committee concurs. The increased energy needs during pregnancy can best be met through the consumption of a varied, nutrient-dense diet.
2. Encourage women before and during pregnancy to choose dietary patterns that are higher in vegetables, fruits, whole grains, nuts, legumes, seafood, and vegetable oils, and lower in added sugars, refined grains, and red and processed meats. These dietary patterns protect against poor maternal-fetal outcomes in pregnancy and are consistent with general healthy dietary advice that is given on a population-level to achieve healthy weight and prevent chronic disease risk.

3. Encourage women to consume foods and beverages that are good sources of iron, folate, calcium, choline, magnesium, protein, fiber, and other potential shortfall nutrients identified in ***Part D. Chapter 1***.
4. Encourage women to not avoid potential allergenic foods during pregnancy unless it is medically warranted.
5. Encourage women to consume seafood in accordance with recommendations by the *2015-2020 Dietary Guidelines for* Americans,[292] the Food and Drug Administration, and the Environmental Protection Agency: at least 8 and up to 12 ounces of a variety of seafood per week, from choices that are lower in methylmercury and higher in omega-3 fatty acids.[299]
6. Encourage women who are or may be pregnant to follow guidance from the 2015 Committee[250] that "Women who are or who may be pregnant should not drink. Drinking during pregnancy, especially in the first few months of pregnancy, may result in negative behavioral or neurological consequences in the children. No safe level of alcohol consumption during pregnancy has been established.[307] The Committee was not asked to review evidence regarding alcoholic beverage consumption in pregnancy because the Departments noted that they would continue the use of existing guidance specifying specifies that women who are pregnant or might be pregnant should not drink alcohol. The Committee supports the continued use of this existing guidance.
7. Encourage women who are pregnant to select foods in accordance with food safety recommendations outlined in previous scientific reports of the Dietary Guidelines Advisory Committee and editions of the *Dietary Guidelines for Americans*, including avoiding unpasteurized milk and soft cheeses, undercooked meats, and limiting processed meats. The Committee did not review evidence regarding food safety during pregnancy because the Departments noted that they would continue the use of existing guidance developed for pregnant women. The Committee supports the continued use of this existing guidance. These recommendations can be provided through one-on-one education and through social marketing campaigns and other population-level communication strategies.

Support for Federal Agencies

1. The Committee supports Federal programs, such as the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), that serve women who are pregnant should encourage participants to take advantage of available nutrition counseling services. In addition, policy, systems, and environmental change strategies and competitive pricing of healthy food and beverage choices can help ensure that women of all economic strata can benefit. Similar healthy foods and beverages should be routinely stocked and distributed by food pantries and other food assistance venues and recommended by food assistance programs.
2. The Committee supports further development of surveillance systems and databases to report dietary and beverage intakes of diverse subgroups of women who are pregnant. This should include dietary systems that can show how fortified foods and supplemental sources of nutrients contribute to overall nutrient intake and dietary quality during pregnancy. In addition, the ability to link maternal dietary intake data to that of their children would strengthen the ability to determine how maternal dietary practices influence child health and development. The Committee encourages implementation of surveillance systems to gather more information about the contextual aspects of food and beverage intake, such as the frequency and/or timing of consumption, food security, economic status, and culture. This information is important to fully understand how and why women consume specific foods and beverages before and during pregnancy.

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