

Role of Maternal Nutrition on Fetal Health and Outcomes

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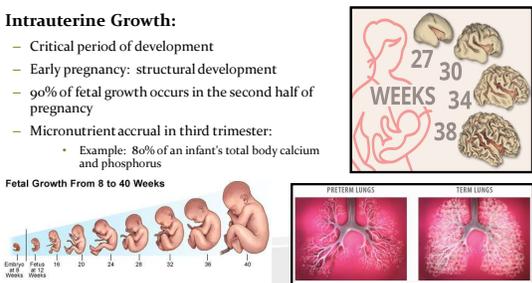
Objectives:

- ❑ Understand the importance of proper nutrition during pregnancy and lactation
- ❑ Provide practical applications for educating patients on maternal nutrition
- ❑ Understand dairy's role in minimizing nutrition gaps
- ❑ Consider nutrition considerations unique for this population

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Background: Intrauterine Growth

- **Intrauterine Growth:**
 - Critical period of development
 - Early pregnancy: structural development
 - 90% of fetal growth occurs in the second half of pregnancy
 - Micronutrient accrual in third trimester:
 - Example: 80% of an infant's total body calcium and phosphorus



Fetal Growth From 8 to 40 Weeks

PRETERM LUNGS TERM LUNGS

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The Placenta

- The lifeline of the fetus!**
 - Nutrient transfer
 - Oxygen exchange
 - Waste exchange
 - Buffer of negative insults
- Physiology**
 - Maternal and fetal blood to not intermix
 - Placental surface area increases from 5 to 11-12 m² from 28 weeks to birth
 - Maternal blood flow to the placenta is ~600-700 mL/minute at time of birth
- Development impacted by maternal factors**
 - Lifestyle factors (e.g. nutrition, smoking, etc.)
 - Health (e.g. infection, inflammation, etc.)
 - Additional variables

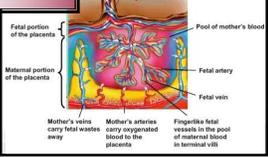
Did you know?



The placenta is an organ.



Placenta



Fetal portion of the placenta

Maternal portion of the placenta

Pool of mother's blood

Fetal artery

Fetal vein

Mother's veins carry fetal wastes away

Mother's arteries carry oxygenated blood to the placenta

Fingerlike fetal vessels in the pool of maternal blood in terminal villi

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Background: Infant Growth

- Growth is important!**
 - Birth weight triples by one year of age
 - Birth length doubles by one year of age
 - Brain grows from 25% to 75% the size of the adult brain by one year of age
- Consequences of altered nutrition and growth:**
 - Changes in developmental outcomes
 - Worsened health outcomes, especially in preterm infants
 - Changes in metabolic programming
 - Increased risk of later health consequences (obesity, hypertension, etc.)


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Maternal Health and Fetal Outcomes

- Altered weight gain during pregnancy (high or low)
- Pre-pregnancy BMI
- High blood pressure
- Diabetes
- Anemia
- Food poisoning
- Insufficient diet
- Chronic Disease/Inflammation
- Placental Insufficiency

→

- Miscarriage
- Preterm birth
- Low birth weight (<5.5 pounds)
- Small or large for gestational age
- Intrauterine growth restriction
- Altered body composition
- Altered metabolic programming
- Impaired nutrient status at birth
- Congenital anomalies
- Worsened long-term health or developmental outcomes

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Consider these infants...

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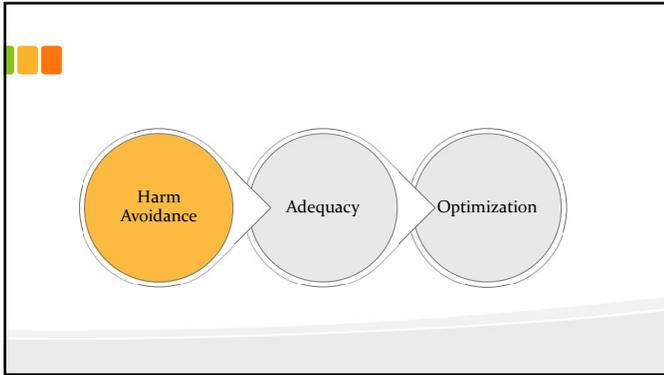
When is adequate perinatal nutrition the most important?

- The full 9 months of pregnancy!**
 - Mom's health and body to support the pregnancy
 - Consider inflammatory status
 - The placenta**
 - Development: until 18-20 weeks
 - Growth: the entire pregnancy
 - Embryogenesis: complete at 8 weeks
 - Greater fetal development of organs, tissues, and structures
 - Fetal growth (size, lean body mass, fat mass)
- Preconception**
- During Lactation:**
 - Exclusive breastfeeding recommended for the first 6 months of an infant's life

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Concepts of Maternal Nutrition to Promote Healthy Fetal Outcomes

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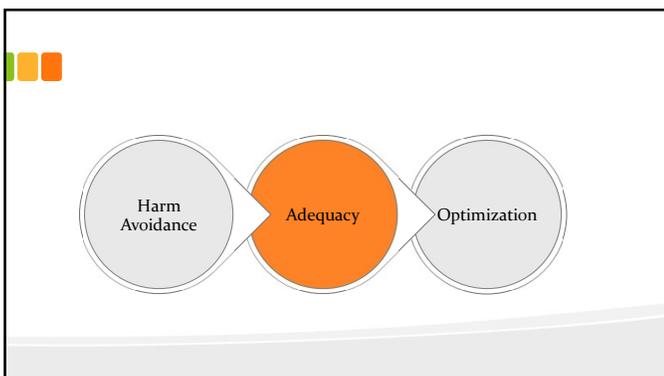
Avoid:

- **Unpasteurized juices, milk, or cider**
 - Soft cheeses made with unpasteurized milk
- **Deli or smoked meats, hot dogs unless reheated to 165°F**
- **Raw or rare-cooked foods (eggs, meat, seafood)**
 - Raw sprouts
- **Prepared salads like chicken, seafood, or ham salad**
- **High-mercury containing seafood:**
 - Mercury is a metal with toxic effects on the central nervous system
 - King mackerel, bigeye tuna, swordfish, shark, orange roughy, marlin, tilefish
 - **Best choices (lowest mercury content):** canned light tuna, salmon, catfish, cod, shrimp, tilapia, trout, oysters, herring (8-12 oz/week)
- **Careful with energy drinks and herbal teas**

Did you know?...

- ✓ Pregnant women are **10 times** more likely to get *Listeria* infection.
- ✓ Food poisoning increases the risk for miscarriage or preterm delivery.

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General Guidance

- Eat a variety of foods, especially of fruits and vegetables
- Choose whole over refined grains
- Choose a variety of lean proteins, avoiding risky foods
- Eat pasteurized, fortified dairy products or soy milk
- Consume healthy fats
- Limit or only moderate use of added sugars, sweetened beverages, and caffeine

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Pregnancy Nutrition: Macronutrients

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Macronutrient Needs

- **Energy:**
 - No increased needs in first trimester
 - Need an estimated 340 extra calories in second trimester
 - Need an estimated 452 calories in the third trimester
- **Carbohydrate (45-65% of energy intake):**
 - Consume minimum 175 grams to meet fetal brains needs for glucose
 - A ketogenic diet is not recommended
- **Protein (10-35% of energy intake):**
 - Needs increase by ~25 grams/day
 - Recommended intake of ~71 grams/day
- **Fat (20-35% of energy intake):**
 - ~1.4 grams/day intake from omega-3 fatty acids (minimum 300 mg/day of DHA)

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Historical Observations

- **Regions during World War II (Holland, St. Petersburg, & Japan)**
 - Extreme famine with average intake of ~1000 calories and 34 grams protein/day
 - Decline in pregnancies by over 50%
- **In offspring during infancy:**
 - Decline in birth weight by 372-535 grams (13 oz - 1.2 lbs)
 - Increased rate of low birth weight and small-for-gestational age infants
 - Increased neural tube defects
 - Increase infant morbidity and mortality
- **In offspring during adulthood:**
 - Increased schizophrenia and antisocial personality disorder
 - Increased cholesterol
 - Decreased glucose tolerance
 - Higher body weight and central body fat
 - Higher infertility

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Present Day Observations:

- Cohort of Midwestern mother-infant dyads at time of delivery (n=488)
- U.S. Household Food Security Questionnaire:
 - HIGH food security: 75%
 - MARGINAL food security: 11%
 - LOW food security: 9%
 - VERY LOW food security: 5%
 - *11% live in a food desert
- Omega 3 fatty acid intake (recommended 1.4 mg/day):
 - Average DHA intake: minimum 300 mg/day recommended
 - 131 mg/day average
 - 89% ate <300 mg/day
 - Lower intake associated with lower maternal education and lower socioeconomic status
 - High omega 3 fatty acid intake lessens inflammation

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Present Day Observations:

- Up to 10% of pregnancies are complicated by gestational diabetes
- In 2019, 29% of pregnant women were obese
- How does this impact infants?
 - Alterations in body composition at birth
 - Alterations in breast milk content (e.g. higher fat)
 - Increased inflammatory exposures to infant (in utero and from breast milk)
 - Long-term risk of metabolic and health complications in infant
 - Neurodevelopment



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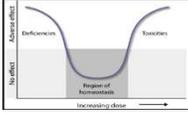
Pregnancy Nutrition: Micronutrients



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Micronutrients

- Essential vs. non-essential
- Consider dose + critical periods of development


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Folate

- Why is it important?**
 - Prevention of neural tube defects (**neural tube closure is complete by 4 weeks after conception**)
 - Spina bifida, anencephaly, encephalocele, autism
 - Heart defects
 - Cleft palates
 - Prevent anemia and promotes fetal growth
- Foods:**
 - Prenatal supplements
 - Whole grains, fortified grains and cereals
 - Not always added to gluten-free products
 - Leafy greens
 - Beans and legumes
 - Liver
 - Citrus fruits




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Vitamin A

- Why is it important?**
 - Needed for cell differentiation and rapid growth
 - Deficient or adequate status associated with malformations (lungs, brain, heart, facial features, ear canals)
 - Deficiency associated with anemia
 - Still present in the United States!
 - Vitamin A deficiency and insufficiency
 - 38% insufficient
 - 10% deficient
 - Odds of vitamin A insufficiency/deficiency were >2 times higher for non-whites/whites compared with whites
- Foods:**
 - Supplements
 - Dark orange or yellow vegetables
 - Meats
 - Milk
 - Spinach
 - Fruits & vegetables with pro-vitamin A carotenoids





Fetal Retinoid Syndrome

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Iron

- Why is it important?**
 - Iron deficiency is one of the most common nutrient deficiencies worldwide
 - Approximately 48% of pregnant women in the United States and 50% in developing countries
 - Typically defined as hemoglobin <10.5-11.0 g/dL, depending on trimester of pregnancy OR serum ferritin <15 ng/mL
 - Deficiency increases risk for preterm birth and infant low birth weight
 - May have up to 3-fold risk of infant anemia if mother is anemic
 - Iron associated with neurodevelopment in infants
- Foods:**
 - Prenatal supplements
 - Lean beef, oysters, tofu
 - Fortified cereals
 - Dark leafy greens
 - Beans and lentils

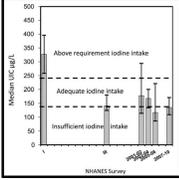




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Iodine

- Why is it important?**
 - Required for thyroid function, energy production, and fetal brain development
 - Deficiency can lead to hypothyroidism in offspring
 - Deficiency in infants can cause impaired (and irreversible) neurodevelopment
 - Deficiency (and long term effects) are preventable!
 - An emerging nutrient of concern!
 - Example: a 2021 article of U.S. pregnant women revealed 23% did not eat a sufficient amount of iodine
- Special Populations:**
- Foods:**
 - Iodized table salt
 - Seaweed
 - Fish
 - Dairy



NIH/NHES Survey

What Foods Provide Iodine?

FOOD	SERVING SIZE	IODINE AMOUNT PER SERVING	PERCENT DAILY VALUE*
Yogurt, Greek, plain, fat-free	6 ounces	87	58%
Skim-fat milk (1%)	1 cup	167	58%
Iodized table salt	1/4 tsp	76	51%
Soy beverage	1 cup	7	5%
Almond beverage	1 cup	2	1%

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Vitamin D

- Why is it important?
 - Low fetal levels if maternal levels are low (5-50% of pregnant women are deficient)
 - Associated with smaller infants
 - Infant more likely to have hypocalcemia after birth
 - Infants more likely to have poorly calcified bones and abnormal enamel
 - Low levels may impact risk for adverse pregnancy outcomes like preeclampsia, preterm birth, infection
 - Higher dosing in our Midwestern population of preterm infants resulted in improved DEXA bone mineral density scans at term-age
 - Supports immune function, respiratory health, and inhibits inflammation
- Foods:
 - Fortified milks
 - Cod liver oil
 - Supplements
 - *Sunlight



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Calcium

- Why is it important?
 - 84% of fetal bone mineralization occurs in the final trimester
 - Maternal intake is inversely associated with pregnancy outcomes (e.g. blood pressures, etc.)
- Foods:
 - Milk and fortified non-dairy milks
 - Cheeses
 - Yogurt
 - Tofu
 - Leafy greens and legumes



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"Antioxidants"

- Meet definition criteria from the National Institute of Health for nutritional "antioxidants"
- Consider that inflammation contributes to development of chronic disease
 - Inflammatory markers also cross the infant blood-brain barrier
- Local observations on vitamin E:
 - 43% (n=186) of moms ate below the Estimated Average Requirements
 - Intake varies by race and food security
 - Maternal and newborn blood levels are correlated
 - Infants have lower levels than mother
 - Levels are associated with clinical outcomes
 - Higher maternal and breast milk levels are associated with greater infant growth outcomes and Apgar scores
 - Maternal levels were different in moms with preeclampsia or c-section



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Multivitamin Supplementation:

- What does the research suggest?
 - In a 2019 Cochrane review and meta-analysis (most data from low-middle income countries):
 - Reduction in infants born low birth weight
 - Probable reduction in infants born small-for-gestational age
 - Probable reduction in preterm births
 - No benefit or harm on mortality
- Supplementation may benefit women who:
 - Do not ordinarily consume an adequate diet
 - Are pregnant with more than one baby
 - Smoke, drink, or use drugs
 - Are vegans
 - Have iron deficiency anemia
 - Have diagnosed nutrient deficiencies or a therapeutic need for a specific nutrient
 - **There are likely many other exceptions!**

Remember: pregnancy is a time of critical fetal growth and development.



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Food vs. supplements

- Consider:
 - Greater variety with food
 - Supplements do not contain all or sufficient nutrients
 - Non-essential nutrients may not be in supplements
 - Must consistently take supplements:
 - Varying reports from large cohort studies:
 - 97% of pregnant women were advised to take a supplement during pregnancy
 - 25-41% took supplement prior to pregnancy
 - 75-80% report taking supplement
 - Definition of supplement use may vary (e.g. just 4 times per week)



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Example:

Needs during Pregnancy	Supplement	Food	Milk
Vitamin D (600 IU)	100%	30%	25%
Calcium (1000 mg)	15%	*45%	*30%
Iodine (220 mcg)	52%	4%	38%
Vitamin A (770 mcg RAE)	50%	10%	10%

*consider bioavailability

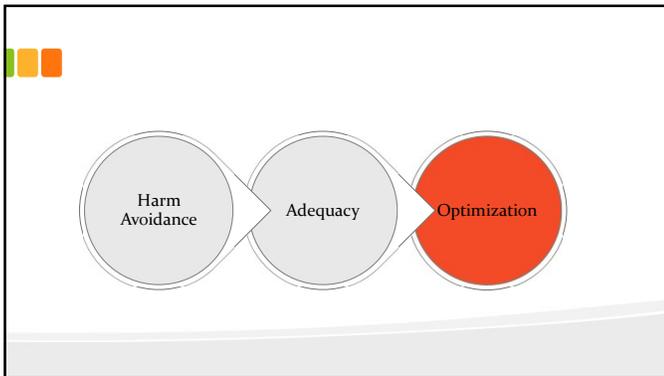


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Example:

vs.

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Non-Essential Nutrients

- Consider non-essential nutrients too!
 - Example: carotenoids
 - Fat-soluble nutrients
 - No recommended intakes, but have antioxidant properties

- Lutein + zeaxanthin
- Lycopene
- A-carotene
- B-carotene
- B-cryptoxanthin

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Why Consider These Nutrients?

Example: Lutein

- **Present in multiple areas of the body**
 - Accounts for 59% of the carotenoids in infant brain tissue
 - Highly concentrated in the eye and macula
 - More highly present in placental tissue than other carotenoids
- **Associated with:**
 - Neurodevelopment
 - Vision
 - Lung function
- **Perinatal considerations:**
 - Blood and breast milk levels correlated with mom's dietary intake
 - Local intake is low at 2.5 mg/day (recommend intakes ~6-10 mg/day)
 - Infants have lower levels than moms
 - Prevalent carotenoid in breast milk (42%)



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“Optimization” & Education



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ENJOY:

VEGETABLES	FRUITS	DAIRY	GRAINS	PROTEINS
 Carrots Cooked greens Pumpkin Spinach Sweet potatoes Red sweet peppers	 Apricots Bananas Cantaloupe Grapefruit Honeydew Mangoes Oranges Peaches Tomatoes	 Skim or 1% milk Soy milk Fat-free or low-fat yogurt	 Ready-to-eat cereal Cooked cereal	 Beans and peas Lean beef Lamb and pork Nuts and seeds Poultry Salmon, trout, herring, sardines and pollock
Benefits: Vitamin A & Potassium	Benefits: Potassium	Benefits: Calcium, Potassium, Vitamin A & Vitamin D	Benefits: Iron & Folic Acid	Benefits: Amino Acid

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Nutrient Needs

- Macronutrient needs:**
 - Requires an **additional 625 calories/day** for the first 6 months
 - Estimated -170 calories/day drawn from body stores, so -455 needed from dietary intake
 - Protein needs increased by ~30% for the first 6 months and by 25% after that
 - Fluids needs: 8-12 cups/day
- Micronutrient needs:**
 - Often higher needs than when not pregnant or lactating
 - Needs for each micronutrient may be higher or lower than during pregnancy
 - Many of the same considerations as in pregnancy
- Maternal diet impacts milk nutrient content**

	Not Pregnant	Pregnancy	Lactation
Vitamin A	700 mcg	770 mcg	1300 mcg
Iron	8 mg	27 mg	9 mg

 - Type of fatty acids
 - Carotenoid content, etc.
 - Severe deficiencies may lead to deficiencies in milk
 - And more!
 - *Remember: breastfed infants depend exclusively on breast milk for up to the first 6 months of life as their sole source of nutrition**

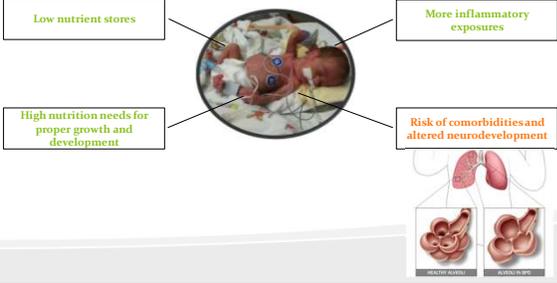
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Special Considerations



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Preterm Infants



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Example: Lutein

- **Remember:**
 - Lutein accounts for 59% of the carotenoids in infant brain tissue and is associated with cognition
 - Highly concentrated in the eye and promotes improved visual outcomes
 - Highly prevalent in breast milk
- **Consider:**
 - Preterm infants have underdeveloped eyes and brains
 - **Breast milk lutein levels are associated with maternal dietary intake:**
 - Lutein was the most prevalent carotenoid in 4 of 9 countries
 - **United States had the lowest content of lutein + zeaxanthin**

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Consider Social Determinants of Health

- Altered quality or quantity of dietary intake associated with socioeconomic status
 - Example: lower blood lutein levels in mothers with public compared to private health insurance
- Assistance programs:
 - Supplemental Nutrition Assistance Program (SNAP)
 - Women, Infants, and Children (WIC)
 - Food banks

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Educational Resources

- 2020-2025 Dietary Guidelines for Americans
 - https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf

Healthy U.S.-Style Dietary Pattern for Women Who Are Pregnant or Lactating

FOOD GROUP OR SUBGROUP*	CALORIE LEVEL OF PATTERN†					
	1,600	2,000	2,400	2,800	3,200	
Daily Amount of Food From Each Group (cup-equivalents and ounce-equivalents of dry foods)						
Vegetables (cup-equivalents)	2 1/2	2 1/2	3	3	2 1/2	2 1/2
Vegetable Subgroups & Weekly Amounts						
Dark Green Vegetables (cup-equivalents)	1 1/4	1 1/4	1 1/2	1 1/2	1 1/4	1 1/4
Red & Orange Vegetables (cup-equivalents)	1 1/4	1 1/4	1 1/2	1 1/2	1 1/4	1 1/4
White Potatoes (cup-equivalents)	1 1/4	1 1/4	1 1/2	1 1/2	1 1/4	1 1/4
Starchy Vegetables (cup-equivalents)	1 1/4	1 1/4	1 1/2	1 1/2	1 1/4	1 1/4
Other Vegetables (cup-equivalents)	1 1/4	1 1/4	1 1/2	1 1/2	1 1/4	1 1/4
Whole Grains (cup-equivalents)	3	3	3 1/2	3 1/2	3	3
Whole Grains (ounce-equivalents)	3	3	3 1/2	3 1/2	3	3
Protein (ounce-equivalents)	3	3	3	3	3	3
Protein (ounce-equivalents)	3	3	3	3	3	3
Protein Foods (Subgroup & Weekly Amounts)						
Meats, Poultry, Eggs (ounce-equivalents)	22	22	20	21	21	22
Seafood (ounce-equivalents)	8	8	8	10	10	12
Nuts, Seeds, Soy Products (ounce-equivalents)	4	5	5	5	5	5
DNA (grams/day)	24	27	29	31	34	36
Limit or Avoidance for Other (See Chart)†						
Limit on Calories for Other (See Chart)†	4%	12%	11%	10%	10%	10%

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Educational Resources

- MyPlate.gov
 - Sections on pregnancy and breastfeeding
 - MyPlate Plan app
 - Links to handouts such as the FDA "Advice About Eating Fish"

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Educational Resources

- Resources to optimize specific food groups
 - Example: Dairy Intake
 - Resource from the National Dairy Council:



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Final Thoughts & Conclusions

- Pregnancy is a critical period for fetal growth and development. Fetal programming, nutrition status, and birth outcomes can impact lifelong health and development.
- Ensuring appropriate nutrition is vital to supporting a health pregnancy and period of lactation
 - Remember, nutrition is modifiable!
- We can all play a role in educating and supporting moms during pregnancy and lactation to promote positive infant outcomes.



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