Pediatric Nutrition
CONTINUING EDUCATION FOR CLINICIANS

Nutrition in the First 1,000 Days: Iron

Presented by
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thriving in 1,000

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No relationships to disclose

Learning Objectives

Nutrition in the First 1,000 Days: Iron

- Understand how iron deficiency hinders brain development in the first 1,000 days
- Associate early iron deficiency with long-term consequences
- Optimally manage iron deficiency in pregnant women and infants

Iron’s Impact on Brain Development

First 1,000 Days of Life

- First 1,000 days of life refers to conception through the child's second birthday
- Optimal nutrition is essential during this period to support:
  - Fetal growth and development
  - Maternal health (including the postpartum period and lactation)
  - Fuel for the infant and toddler growth (until 2 years of age)

Beluska-Turkan K, et al. *Nutrients*. 2019;11:2891.

Never Too Early to Consider Nutrient Effects on Brain Development

- Early intervention is better
- “Early” might be earlier than first thought with respect to iron and protein
- Central nervous system development peak period is <12 months
- Important to optimize growth before 12 months—ideally, before 4 months—to allow full intellectual functioning later in childhood

Cusick SE, Georgieff MK. *Arch Pediatr Adolesc Med.* 2012;166:481-2.

Iron Is Essential to Mother and Child

- Iron is 1 of 9 nutrients important for healthy pregnancy and infant/toddler development
  - Carotenoids (lutein + zeaxanthin)
  - Choline
  - Folate
  - Iodine
  - **Iron**
  - Omega-3 fatty acids
  - Protein
  - Vitamin D
  - Zinc
- All these key nutrients should be included in maternal and infant diet
- Failure to provide some of these key nutrients during the first 1,000 days of life can result in a lifelong deficit in brain function
- Strong mother/infant iron relationship that affects status both in utero and in infancy

Schwarzenberg SJ, Georgieff MK. *Pediatrics.* 2018;141(2):e20173716.

Fetal Accumulation and Iron Needs During Pregnancy

- Iron sufficiency is essential to support a healthy pregnancy
  - Less prematurity
  - Less growth restriction
  - Better maternal outcomes
- Iron is vital for fetal/infant/toddler neurodevelopment

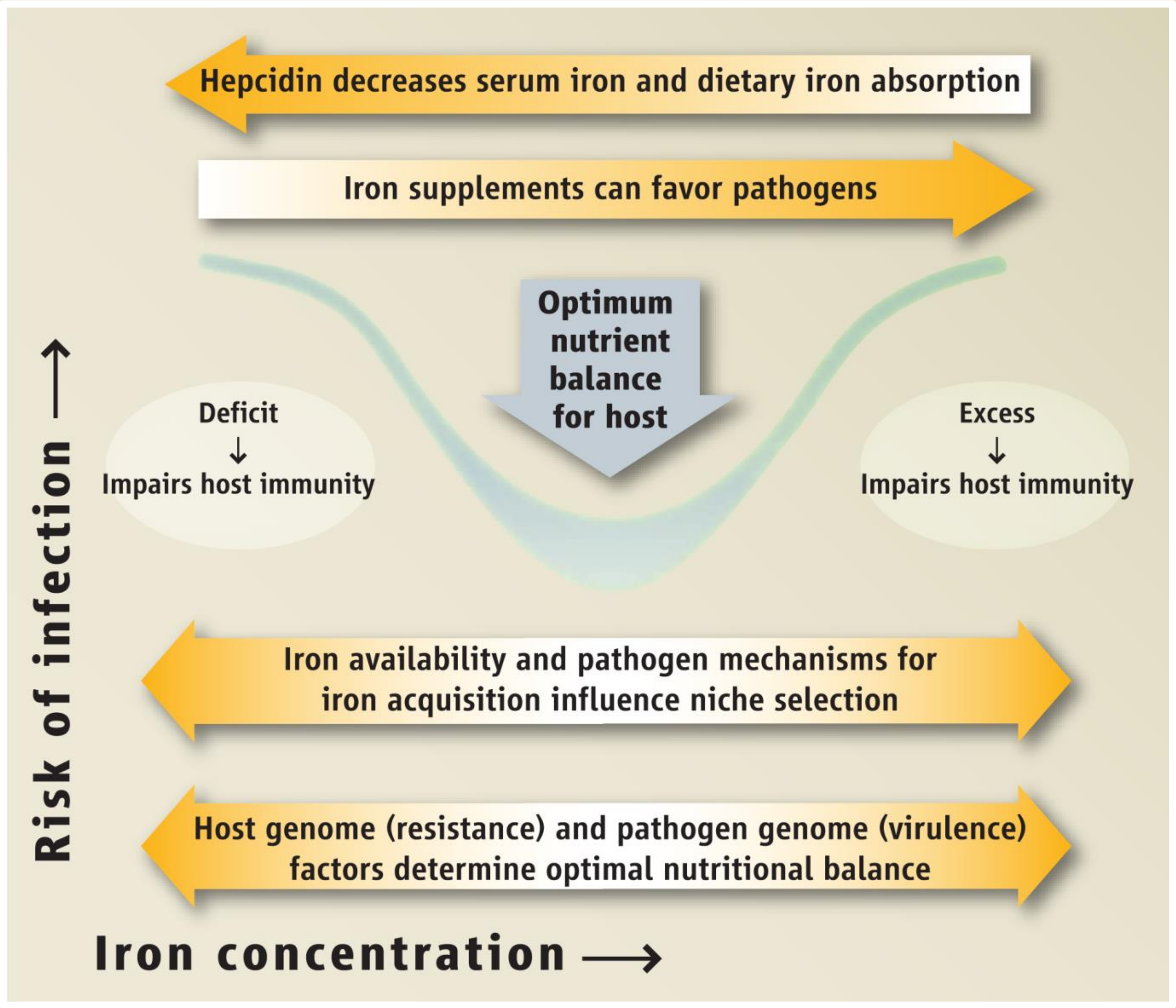
- What happens when you remove iron?
  - Why iron is needed for developing brain
  - What iron acutely does to the developing brain

1. Schwarzenberg SJ, et al. *Pediatrics.* 2018;141:e20173716.
2. Beluska-Turkan K, et al. *Nutrients.* 2019;11:2891.

U-Shaped Risk for Maternal Iron Status

U-shaped curve between risk of adverse birth outcomes and maternal hemoglobin concentrations during pregnancy

- Relations differ by trimester
- High Hb concentrations, especially in second trimester, associate LBW



Hb, hemoglobin; LBW, low birth weight.

Dewey KG, et al. *Am J Clin Nutr.* 2017;106:1694S-1702S.
Figure reproduced from Drakesmith H, Prentice AM. *Science.* 2012;338:768–72. Used with permission of the American Association for the Advancement of Science.

Iron: Critical Nutrient for the Developing Neonate

Iron is found in iron-cluster (eg, hydroxylases) and hemoproteins

- Tissue oxygen delivery (hemoglobin, myoglobin)
- Optimizes organ development and function
- Immune function
- **Brain development and function**
  - » Neurogenesis
  - » Myelination
  - » Cellular energetics
  - » Neurotransmitter metabolism (monoamines, glutamate)
  - » Growth Factors

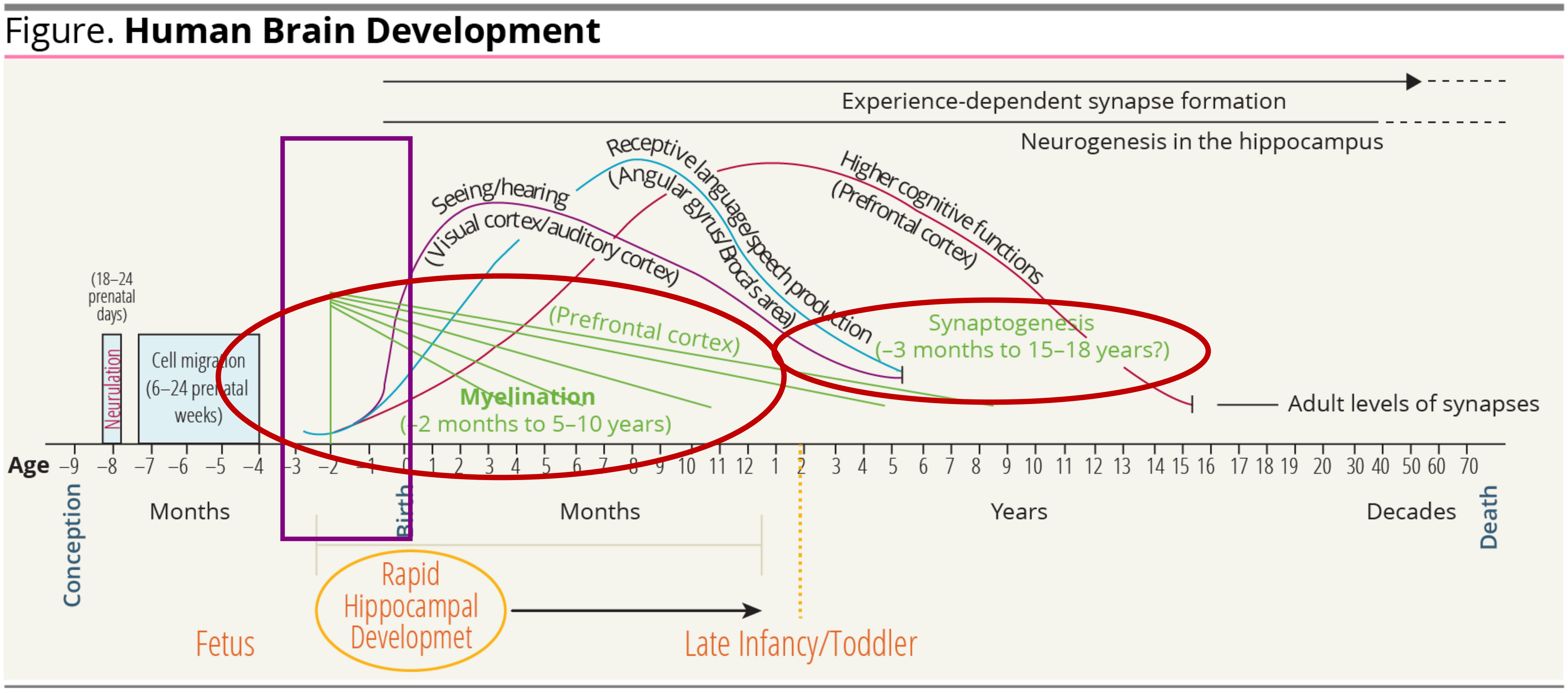
1. Beluska-Turkan K, et al. *Nutrients.* 2019;11:2891.
2. Cusick SE, et al. *J Pediatr.* 2016;175:16-21.

Iron's Role in Brain Function

- Myelination → Speed of processing
- Cellular energetics → Structural development (dendrites, synapses)
- Monoamine metabolism
  - Serotonin
  - Dopamine
  - Norepinephrine systems
    - » Dopamine and norepinephrine can affect motor control, sleep cycles and activity, and learning and memory
- Gene regulation → Synaptic plasticity

Georgieff MK, et al. *Annu Rev Nutr.* 2019;39:121-146; Georgieff MK, et al. *Acta Paediatr.* 2018;107:1310-1321; Schwarzenberg SJ, et al. *Pediatrics.* 2018;141:e20173716.; Cusick SE, et al. *J Pediatr.* 2016;175:16-21; Lozoff B, et al. *Nutr Rev.* 2006; 64:S34–S43; Beard JL. *J Nutr.* 2008;138:2534-2536.

Iron's Role in Brain Function: Timing is Important



Georgieff M, et al. *Pediatr Res.* 2005;57:99–103.

Neurodevelopmental Sequelae of Perinatal Iron Deficiency in Term Infants

- **General:** Low neonatal iron stores (<76mcg/L)
  - Poorer school-age neurodevelopment [1]
- **Hippocampus**: Cord ferritin <40 mcg/L
  - Impaired recognition memory [2]
- **Dopamine:** Iron-deficient infants born to IDA mothers
  - Altered temperament [3]
  - Linear relation between neonatal iron measures and temperament
  - Lower levels hemoglobin and serum iron related to higher levels of negative emotionality and lower levels of alertness and soothability

IDA, iron deficient anemia.

1. Tamura T, et al. *J Pediatr.* 2002;140:165-70.
2. Siddappa AM, et al. *Pediatr Res.* 2004;55(6):1034-41.
3. Wachs TD, et al. *Dev Psychobiol.* 2005;46(2):141-53.

Iron Deficiency Affects Bioenergetics

- Iron deficits in neonate → Long-term risks to neurodevelopment
- Compromises mitochondrial and cellular energetics
- More profound during development
  - Total-body oxygen consumption in infants is 3x greater than in adults
  - 60% of total body oxygen consumption is from the neonatal brain (3x greater than in adults)

1. Georgieff MK, et al. *Annu Rev Nutr.* 2019;39:121-146.
2. Georgieff MK, et al. *Acta Paediatr.* 2018;107:1310-1321.
3. Schwarzenberg SJ, et al. *Pediatrics.* 2018;141:e20173716.
4. Cusick SE, et al. *J Pediatr.* 2016;175:16-21.

Impact of Early Iron Deficiency On Long-Term Function

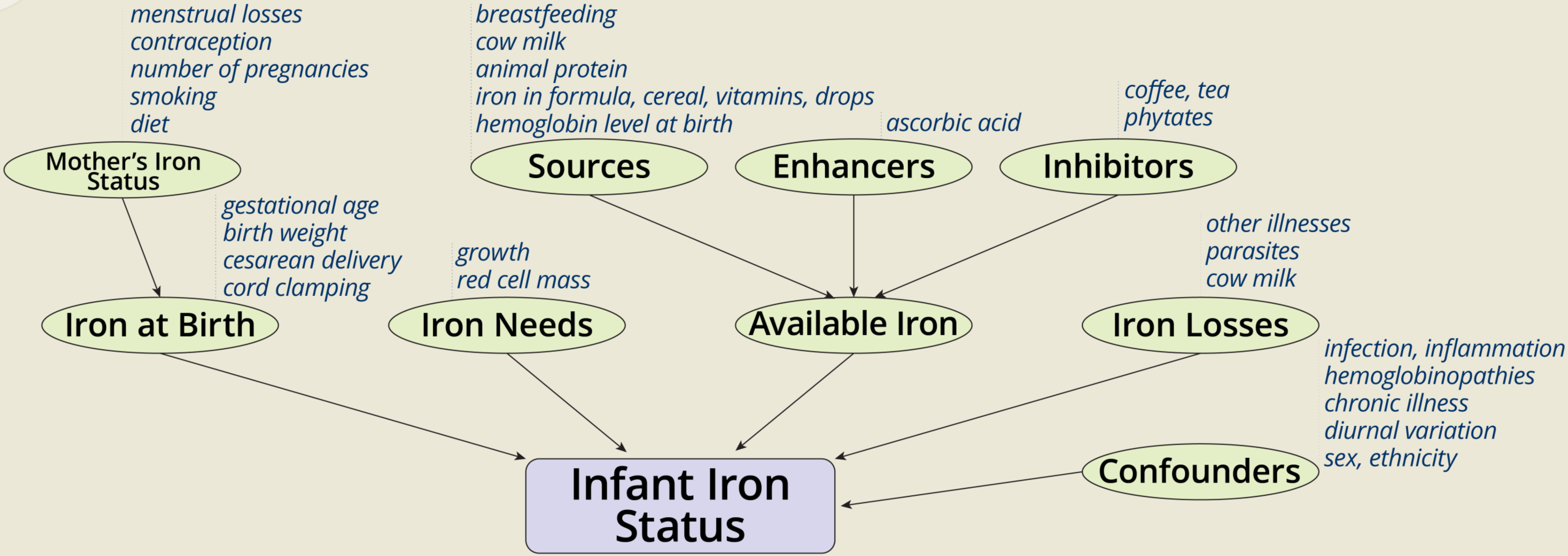
Baby comes with a history

Iron Deficiency: Acute vs Long-term Effects

- Cannot fully repair what has occurred early in the course due to iron deficiency
- Results based on different mechanisms
- **Acute effects:**
  - Motor control
  - Electrophysiologic abnormalities
- **Long-term effects:**
  - Cognitive delays
  - Neurobehavioral abnormalities

1. Schwarzenberg SJ, et al. *Pediatrics.* 2018;141:e20173716.
2. Beluska-Turkan K, et al. *Nutrients.* 2019;11:2891.

Factors Determining Infant Iron Status at 9 months



Lozoff B, et al. *Am J Clin Nutr.* 2006;84:1412–1421.

Neurobehavioral Sequelae of Postnatal Iron Deficiency in Infants

40+ studies demonstrate dietary ID between 6–24 months lead to:

- Behavioral abnormalities [1]
  - » Motor and cognitive delays while iron deficient
  - » Cognitive delays *19–23 years after iron repletion*

    Arithmetic, writing, school progress, anxiety/depression, social problems and inattention [1]
  - » Characteristic of monoamine and hippocampal dysfunction
- Electrophysiologic abnormalities (delayed ABR latencies)
  - » At 6 months while iron deficient [2]
  - » At 2–4 years after iron repletion [3]
  - » Characteristic of impaired myelination

ABR, auditory brainstem responses; ID, iron deficiency.

1. Lozoff B, et al. *Nutr Rev.* 2006;64:S34-43; discussion S72-91.
2. Roncagliolo M, et al. *Am J Clin Nutr.* 1998;68:683-90.
3. Sundagumaran H, et al. *Int J Pediatr Otorhinolaryngol.* 2019;117:78-81.

Nonanemic Iron Deficiency

- Total-body iron (TBI) stores is standard indicator to assess iron status in US adults
- Much less utilized in neonates and young children
- Elevated hemoglobin concentration in a neonate may be misinterpreted as iron sufficiency or overload
  - More likely represents shift of fetal iron into red cells due to fetal hypoxia
  - Results in brain iron deficiency = nonanemic iron deficiency
- Nonanemic iron deficiency is associated with neurodevelopmental consequences [1]–[4]

1. Georgieff MK, et al. *Annu Rev Nutr.* 2019;39:121-146.
2. Georgieff MK, et al. *Acta Paediatr.* 2018;107:1310-1321.
3. Schwarzenberg SJ, et al. *Pediatrics.* 2018;141:e20173716.
4. Cusick SE, et al. *J Pediatr.* 2016;175:16-21.

Risks From Maternal Iron Deficiency

- Potential results of maternal iron deficiency
  - Higher risk of low birth weight and preterm birth
  - Smaller placental size
  - Slowed organogenesis in first trimester
- Impact on fetal growth
  - Risk of chronic fetal hypoxia
  - Low iron stores in newborn
  - Poor cognitive development
  - Cardiometabolic disease later in life

1. Beluska-Turkan K, et al. *Nutrients.* 2019;11:2891. Image: nasharaga/Bigstock

Impact on Early Developmental Motor Control

- Lozoff et al show motor control at 9 months significantly lower in iron-deficient anemic infants [1]
- Assumed iron is acquired postnatal
- Measuring status of newborn [2]
  - Clark et al 2017 highlights prenatal deficiency
  - Reviews maternal iron status to child's iron status

1. Lozoff B, et al. *Nutr Rev.* 2006; 64:S34–S43.
2. Clark KM, et al. *J Pediatr.* 2017;181:56-61.

Assessing Feeding Patterns and Iron Status at 9 Mos

- *Objective* (Clark et al 2017): Association between breastfeeding and iron status at 9 months of age in 2 Chinese provinces
- Highlights pre-natal deficiency
- Odds of ID/IDA at 9 months were increased in BF and MF infants; ID/IDA was common
- Breastfeeding in later infancy identifies infants at risk for ID/IDA in many settings
- Protocols for detecting and preventing ID/IDA in BF infants are needed

Table. **Breastfeeding associated with iron status**

	Zhejiang (n= 142)	**Hebei (n= 183)**
BF infants	27.5% IDA	44.0% IDA
FF infants	0%	2.8%
Odds of ID/IDA increased in BF and MF infants compared with FF:		
BF vs FF OR	28.8, 95% CI: 3.7–226.4	78.8, 95% CI: 27.2–228.1
MF vs FF OR	11.0, 95% CI: 1.2–103.2	21.0, 95% CI: 7.3–60.9

P-values < .001

BF, breastfed; FF, formula-fed; MF, mixed-fed; ID, iron deficiency; IDA, iron deficiency anemia, defined as ID + hemoglobin <110 g/L; OR, odds ratio.

Clark KM, et al. *J Pediatr.* 2017;181:56-61.

Altered Social and Emotional Development

- Increased hesitation and wariness
- Less engagement
- Less soothability
- Mother-child interactions altered by iron deficiency
- Certain neurobehavioral effects of early-life iron deficiency may be irreversible
- Reduced iron is associated with neonate cognitive impairment

Beard JL. *Curr Pediatr Rep.* 2013;1:247-256; Beard JL, et al. *J Nutr.* 2005;135:267–72; Beard JL. *J Nutr.* 2008;138:2534-6. 3; Perez EM, et al. *J Nutr.* 2005;135:850–5; Georgieff MK, et al. *Annu Rev Nutr.* 2019;39:121-146.

Prenatal Iron Deficiency and Motor Outcomes

- Studies show optimization of long-term outcomes for intellectual, executive, and motor function
- Santos & Lozoff et al 2018; n=1194
- *Objective:* Assess relations between ID timing, duration, and severity, and gross motor scores, neurological integrity, and motor behavior quality at 9 months.
- Iron status determined at birth and 9 months in healthy term Chinese infants
  - **More severe ID in late pregnancy:** lower INFANIB Vestibular function (p=0.01), and total score (p=0.03)
  - **More severe ID in infancy:** lower scores for locomotion (p=0.03), overall gross motor (p=0.05)
- Results underscore **importance of preventing iron deficiency in fetus**

ID, iron deficiency; INFANIB, Infant Neurological International Battery.

Santos DCC, et al. *Eur J Clin Nutr.* 2018;72:332-341.

Prenatal Iron Deficiency and Motor Outcomes *(continued)*

- Longitudinal follow-up study (Zhang et al 2019)
  - 9 months (n=107); 18 months (n=109); 5 years (n=114)
  - Children with **prenatal ID** had **significantly lower scores** of motor development compared with non-ID children (52.04 vs 54.05 scores, β=-2.01, *P*=0.007)
  - Children with **postnatal ID** had **similar scores** of motor development compared with non-ID children, showing no significant difference (53.07 vs 54.05 scores, β=-0.98, *P*=0.180)
- Motor development of **children with prenatal ID did not catch up** with counterparts without ID by 5 years of age

This study shows the importance of preventing ID in the fetus

ID, iron deficiency.

Zhang YL, et al. *Zhonghua Er Ke Za Zhi.* 2019;2;57:194-199.

Managing Iron Deficiency

Start with a full tank!

Prevention vs Treatment of Iron Deficiency

“Start with a Full Tank”

- Prevention starts prenatally
- Be smart—**loading fetus prenatally** protects against postnatal iron deficiency
- Note: fetal iron loading does NOT diminish the need for postnatal iron. A combination of both is necessary to maintain iron sufficiency.

Iron Deficiency Rates Vary

ID rate varies based on

- Where you live in the world
- How you assess iron status
- Testing using hemoglobin [most often used in West]
  - India or Sub Africa >80%
  - US ~45%
- ID highest among multiparous women

- ID prevalence among toddlers varies according to
  - Sex
  - Age
  - Race/ethnicity
  - Family income
- Non-Hispanic Blacks and Mexican Americans have highest prevalence of ID

ID, iron deficiency.

1. Fisher AL, et al. *Am J Clin Nutr.* 2017;106:1567S-1574S.
2. Gupta PM, et al. *Am J Clin Nutr.* 2017;106:1640S-1646S.
3. Auerbach M, et al. *Am J Med.* 2017;130:1402-1407.

Importance of Iron in Last Trimester

- Iron requirements increase in each trimester
  - Maternal hepcidin concentrations are suppressed in second and third trimesters, facilitating an increased supply of iron in healthy pregnancies
- Iron supports fetoplacental development
- **Definitively, Mom has a negative iron balance**
  - Due to Mom's expanding blood volume and iron needs
  - Avg net pregnancy-related loss of iron ~740 mg
  - ~1 g of iron must be acquired during pregnancy to preserve maternal iron balance and support fetoplacental development

Fisher AL, et al. *Am J Clin Nutr.* 2017;106:1567S-1574S.

Screening for Maternal Iron Deficiency

- 16–18% of pregnant women are iron deficient [1],[2]
  - This rate (16–18%) is high for pregnant women
- 50% of infants with IUGR have low iron stores at birth
- Increased rate of IUGR, results in babies born with lower iron storage
- Screening alone is not sufficient
- Guidelines for maternal and neonatal screening and treatment are inconsistent
- **NEONATE:** Screening should center on biomarkers that index brain health, not hematology [4]

IUGR, Intrauterine growth restriction.

1. Lozoff B, et al. *Nutr Rev.* 2006;64:S34-43
2. CDC. NCCDPHP. Poor Nutrition. Last reviewed August 24, 2020.
3. Beard JL. *J Nutr.* 2008;138:2534-6.
4. Combs GF Jr, et al. *Ann N Y Acad Sci.* 2013;1278:1-10.

Oral vs Intravenous Iron Fortification

- Oral iron intolerance
  - Up to 70% report significant gastrointestinal side effects
- Oral ingestion reported to increase serum hepcidin leading to decreased absorption (which is the appropriate response)
- IV may be appropriate
  - When oral iron is ineffective or if/when harmful
  - If anemia is severe (<8 g/dL) in second trimester
- Evidence (Auerbach et al 2017) reports IV iron safe and effective in second and third trimesters

IV, intravenous.

1. Auerbach M, et al. *Am J Med.* 2017;130:1402-1407.
2. Auerbach M. *Reprod Health.* 2018;15:96.

Maternal Dietary Source or Iron Supplements

- Dietary recommended nutrient intakes for women
  - Pregnant: 27 mg/day
  - Lactating: 9 mg/day

> Multivitamin/multimineral supplements with iron typically provide 18 mg iron.

- Common dietary sources:
  - Heme sources: Fish, meat, poultry, seafood
  - Non-heme sources: Fortified cereals, nuts, seeds, spinach
- Note: maternal iron status greatly impacts the fetus, however, maternal iron intake does not affect breastmilk.

1. Young BE, et al. *Curr Pediatr Rep.* 2013;1:247-256. .
2. Baker RD, et al. *Pediatrics. 2010;126:1040-50.*
3. Beluska-Turkan K, et al. *Nutrients.* 2019;11:2891.

Iron Supplements Reserved for Those at Risk: Pregnancy

- Universal supplementation vs targeted populations
- US Preventive Services Task Force stated there was insufficient evidence to advocate routine iron supplementation during pregnancy
- European Food Safety Authority concluded iron supplementation during pregnancy should be reserved for **those at risk for** or with documented iron deficiency
- Need:
  - Data indicate ~2–3% of pregnant women in US experience IDA
  - ID estimated prevalence 16%
  - The estimate of nonanemic ID is likely an underestimate; may be as high as 45%

ID, iron deficiency; IDA, iron deficiency anemia.

Taylor CL, et al. *Am J Clin Nutr.* 2017;106:1547S-1554S; Brannon PM, et al. *Nutrients.* 2017;9:1327; Gupta PM, et al. *Am J Clin Nutr.* 2017;106:1640S-1646S; Georgieff MK, et al. *Annu Rev Nutr.* 2019;39:121-146; US Prevent. Serv. Task Force. 2015 Iron deficiency anemia in pregnant women: screening and supplementation; Fisher AL, et al. *Am J Clin Nutr.* 2017;106:1567S-1574S; Juul SE, et al. *Neonatology.* 2019;115:269-274.

Human Milk vs Dietary Requirements

- After 6 mos, Mother's breastmilk is no longer sufficient as a source for iron or any divalent metal (zinc, copper)
- >6 mos, potential gap between human milk and dietary requirements—highest for iron and zinc
- Infant's iron requirements exceed intake starting at 6 months of life
  - 4–6 months of age, internal stores depleted
  - Iron requirements increase
- Additional iron support needed from infant formula, complementary foods, or iron supplements

1. Georgieff MK, et al. *Annu Rev Nutr.* 2019;39:121-146.
2. Young BE, et al. *Curr Pediatr Rep.* 2013;1:247-256.
3. Beluska-Turkan K, et al. *Nutrients*. 2019;11:2891.
4. Kleinman RE. *J Pediatr.* 2015;167:S1-2.

Recommended Daily Intake of Iron for Infant

Infant Age	RDA Recommended Intake
0–6 months	0.27 mg/day
7–12 months	11 mg/day
1–3 years old	7 mg/day

RDA, Recommended Dietary Allowance.

Beluska-Turkan K, et al. *Nutrients.* 2019;11:2891.
NIH Office of Dietary Supplements. Iron: Fact Sheet for Health Professionals. Updated: February 28, 2020.
Lessen R, et al. *J Acad Nutr Diet.* 2015;115:444-9.

AAP Recommendations for Breastfed Infants

- Breastfed infants ≥4 mos and infants not exclusively breastfed, **AAP recommends iron-fortified formula**
  - Iron content in human milk is low
  - Be aware of potential adverse consequences of supplementation
  - Note: Guidelines are not consistent
- **AAP Committee on Nutrition recommends**
  - **Formula-fed infants** iron-fortified formula: 10–12 mg/L first 12 months of life
  - **Exclusively breastfed**: iron supplements 1 mg/kg per day beginning at 4 months

AAP, American Academy of Pediatrics.

1. USDA. Scientific Report of the 2020 Dietary Guidelines Advisory Committee. First Print: July 2020.
2. Kleinman RE. *J Pediatr.* 2015;167:S1-2.

Recommendation for Iron-Content Formula or Iron Supplementation of Exclusively Breastfed Infants

Age	AAP Committee on Nutrition	ESPGHAN Committee on Nutrition
Formula-fed infants		
0 to 6 months	10–12 mg/L formula	4–8 mg/L
6 to 12 months	10–12 mg/L formula	No specific recommendation
Exclusively breastfed infants		
>4 months	1 mg/kg per d as a supplement	No recommendation

Iron content of infant formula differs in US and Europe

- US formula 1.8 mg Fe/100 kcal
- European <1.8 mg Fe/100 kcal, based on assumption iron-containing foods in child's diet

AAP, American Academy of Pediatrics; ESPGHAN, European Society for Pediatric Gastroenterology, Hepatology, and Nutrition.

Kleinman RE. *J Pediatr*. 2015;167:S1-2.

Timing of Fortification

- Prevention of IDA in infancy is important for brain development
- Timing of nutrient fortification emphasizes fetal loading [1]
  - Risks to supplementing iron-sufficient children
- Potential consequence of mistimed or excessive iron
  - Long-term outcomes studies in Chile [2],[3]
    - » At 10 years, n=473 assessed (56.6%) [ClinicalTrials.gov NCT01166451]
    - » Low-iron group (mean, 2.3 mg/L) compared with iron-fortified group (mean, 12.7 mg/L) scored lower on every 10-year outcome [2]

IDA, iron deficiency anemia.

1. Georgieff MK, et al. *Annu Rev Nutr.* 2019;39:121-146.
2. Lozoff B, et al. *Arch Pediatr Adolesc Med.* 2012; 166:208–15.
3. Gahagan S, et al. *J Pediatr.* 2019. 2019;212:124-130.e1.

Benefits of Iron Interventions: Infants

- Cai et al 2017 meta-analysis of four RCTs; n=511 infants
- Iron supplementation in exclusively breastfed infants
- Beneficial effects
  - Hematologic parameters
  - Cognitive development
- Significant increase in Bayley psychomotor developmental indices in later life (MD = 7.00; 95% CI; 0.99–13.01)

MD, mean difference; CI, confidence interval .

Cai C, et al. *Breastfeed Med.* 2017;12:597-603.

Potential Risks of Iron Supplements: Infants

- Altered microbiome
  - In iron-replete children (12–35 months), most iron supplements are not absorbed and could promote a more pathogenic microbiome with resulting diarrhea
- **Note:** US has not sanctioned routine iron supplementation with concern of supplementing kids who do not need it.
- Continued research needed for well-informed public policy to determine who will benefit from iron supplementation
- What amount will provide benefit or may case adverse outcomes?

1. Brannon PM, et al. *Nutrients.* 2017;9:1327.
2. Cusick SE, Georgieff MK. *Arch Pediatr Adolesc Med.* 2012;166:481-2.

NHANES Data on Iron Deficiency

- Nutrients are not consumed sufficiently by children in US.
- Iron intake adequate per NHANES data 2001–2016 children 1–3 yrs.
  - Individual nutrients (n=5579)
  - Serum ferritin (n=2498)
  - Hemoglobin (n=3919)
- NHANES iron nutritional gap data:

Rates of ID	1–2 yrs	1–3 yrs
non-Hispanic white females	8.5%	6.9%
Hispanic children	**11.6%**	8.9%
non-Hispanic Black children	6.0%	4.2%

ID, iron deficiency; NHANES, The National Health and Nutrition Examination Survey

1. USDA. Scientific Report of the 2020 Dietary Guidelines Advisory Committee. First Print: July 2020.
2. Bailey A, et al. *Current Developments in Nutrition.* 2020;4(Suppl 2):507.

Older (6 mos) Infants' Iron Needs

- Gap between potential intake from HM and dietary requirement is highest for iron and zinc
- Base on growth, size, and body composition
- Older breastfed infant's needs based on
  - Gestational age
  - Complications of pregnancy (maternal iron deficiency anemia, diabetes)
  - Timing of umbilical cord clamping
  - Postnatal growth rate
  - Duration of exclusive breastfeeding

HM, human milk.

Young BE, et al. *Curr Pediatr Rep.* 2013;1:247-256.

Iron Needs of Toddlers

- Prevalence **15.1%** ± 1.7% in toddlers (n=615; Gupta et al 2017 [a])
- Base supplements on growth, size, and body composition
- By 6 mos, BF infant needs iron-rich CF ***or*** iron supplements to support increasing erythropoiesis and normal brain development
- Infants 6–12 months → RDA 11 mg Fe/day
- 12–24 months → RDA 7 mg Fe/d

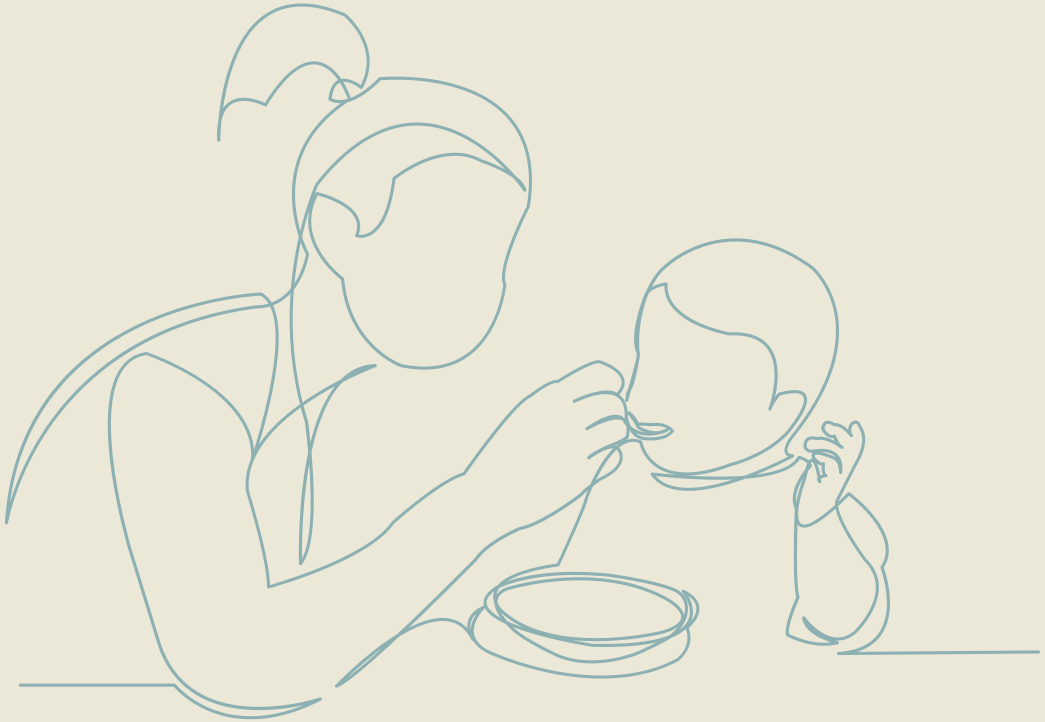
a. Analyzed data from NHANES; toddlers aged 12–23 mo (NHANES 2003–2010)

BF, breast fed; CF, complimentary feeding; NHANES, The National Health and Nutrition Examination Survey; RDA, recommended dietary allowance.

Young BE, et al. *Curr Pediatr Rep.* 2013;1:247-256.
Gupta PM, et al. *Am J Clin Nutr.* 2017;106:1640S-1646S.

Complementary Feeding & Supplements

- Iron-rich complementary feeding or iron supplements are needed to support increasing erythropoiesis and normal brain development
- Infant cereals
  - Iron fortified, as a first CF
  - Potential low iron absorption
- Red meats (late in CF progression)
  - Rich in heme iron, favorable bioavailability
  - 20–35% absorption rate



CF, complementary feeding.

1. Young BE, et al. *Curr Pediatr Rep.* 2013;1:247-256.
2. Gupta PM, et al. *Am J Clin Nutr.* 2017;106:1640S-1646S.

Image: nasharaga/Bigstock

Challenges Addressing Iron Imbalance

- Supplement use needs to be balanced, based on need by pregnant and lactating/breastfeeding women
- NHANES 2003–2006 study estimate iron intake
  - Women ≥19 y old at 25 and 14 mg Fe/d
- Challenges include no established cutoffs for iron repletion or iron excess based on TBI

NHANES, The National Health and Nutrition Examination Survey; TBI, total-body iron stores.

1. Kleinman RE. *J Pediatr.* 2015;167:S1-2.
2. Gupta PM, et al. *Am J Clin Nutr.* 2017;106:1640S-1646S.

Nutritional Counseling

- Importance of nutritional counseling
  - 14% of children aged 1 to 2 years are iron deficient
- All women and toddlers would benefit from programs and policies that support adequate nutrition
- Risk of ID is not equal throughout the pediatric lifespan
- Pediatricians need to be aware that the newborn, toddler, and adolescent are at highest risk and should be aware of factors that increase those risks

ID, iron deficiency.

1. CDC. NCCDPHP. Poor Nutrition. Last reviewed Aug 2020.
2. Schwarzenberg SJ, et al. *Pediatrics.* 2018;141:e20173716.
3. Baker RD, et al. *Pediatrics.* 2010;126:1040-50.

Key Takeaways

- Iron is critical in early neurodevelopment. Poor motor development reported in infants with iron deficiency.
- The brain is particularly susceptible to iron deficiency. Early detection for at-risk infants is crucial for brain health.
- AAP recommends iron-fortified formula for formula-fed infants (10–12 mg/L of iron) first 12 months of life, and iron supplements (1 mg/kg per day) in exclusively breastfed infants beginning at 4 months.