The Crucial Contributions of Early Life Nutrition

Robert D Murray MD FAAP

Early Life Nutrition

- Epigenetics
- Singular growth
- Nutrition
- Nurture
The 21st Century: Chronic Disease Management

Nutrient Insufficiency

The Epigenetics of Nutrition

Periconception/ Intrauterine/ Postnatal

Under nutrition/ Nutrient Imbalance/Over nutrition

Tissue Remodeling
Cell Metabolism
Mitochondrial Dysfunction
Neuroendocrine Signaling

CHANGES FETAL DEVELOPMENT

Structure / Function Permanently Altered

Body Physiology
Cardio-metabolic function
Appetite and energy regulation

underweight
overweight
Genetics: DNA Codes for Proteins

Epigenetics: Which, When, & How Much

What Happens to Mother Happens to Baby

- Poor diet & inactivity
- Under- or over-weight
- Blood pressure and flow
- Corticosteroids
- Smoking, alcohol
- Physical, mental stress
- Toxins, drugs
- Chronic diseases
- Blood sugar

Mother’s *experiences* affect the baby’s development
Fetal Experiences
“Program” Future Disease

- Growth
- Obesity
- Hypertension
- Dyslipidemia
- Cardiovascular Ds
- Diabetes
- Metabolic Syndrome
- Mental Health

Epigenetics Shapes Us

Social experience changes 
How our genes work, 
which changes 
How our body works, 
which changes 
How we behave, 
which changes 
who we become

Pregnancy Status

Pregnancy Risk = Assessment of Exposures

Risk

• Lack of contraception
• Lack of health counseling
• Tobacco, alcohol, drug use
• Physical abuse
• Poor quality nutrition
• Sedentary
• Prior low-birth weight or
• Prior premature baby

Health

• Over- or under-weight
• Diabetes
• Hypertension
• Anemia
• Asthma
• Dental disease
• Stress
• Depression

Weight gain guidelines

IOM 2009: Total and Rate of Weight Gain During Pregnancy

<table>
<thead>
<tr>
<th>Pre-pregnancy BMI</th>
<th>Total weight gain</th>
<th>* 2nd and 3rd trimester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight (≤18.5 kg/m²)</td>
<td>28-40 lbs</td>
<td>1 (1.1-1.3)</td>
</tr>
<tr>
<td>Normal weight (18.5-24.9 kg/m²)</td>
<td>25-35 lbs</td>
<td>1 (0.8-1)</td>
</tr>
<tr>
<td>Overweight (25-29.9 kg/m²)</td>
<td>15-25 lbs</td>
<td>0.6 (0.5-0.7)</td>
</tr>
<tr>
<td>Obese (≥30 kg/m²)</td>
<td>11-20 lbs</td>
<td>0.5 (0.4-0.6)</td>
</tr>
</tbody>
</table>

*Calculations assume a 0.5-2 kg (1.1-4.4 lbs) weight gain

### A Strong Fetal Environment

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baby</td>
<td>7-8 lbs</td>
</tr>
<tr>
<td>Placenta</td>
<td>1-2 lbs</td>
</tr>
<tr>
<td>Amniotic fluid</td>
<td>2 lbs</td>
</tr>
<tr>
<td>Uterus</td>
<td>2 lbs</td>
</tr>
<tr>
<td>Maternal breast tissue</td>
<td>2 lbs</td>
</tr>
<tr>
<td>Maternal blood</td>
<td>4 lbs</td>
</tr>
<tr>
<td>Fluids in maternal tissue</td>
<td>4 lbs</td>
</tr>
</tbody>
</table>

### A Quality Dietary Pattern = Health

- Heart Disease
- Stroke
- Diabetes
- Obesity
- Hypertension
- Metabolic syndrome
- Osteoporosis
- Cancers
- Alzheimer’s
- Depression
What is a Dietary Pattern?

“Over the course of any given day, week, or year, individuals consume foods and beverages in combination – an eating pattern. It is more than the sum of its parts; it represents the totality of what individuals habitually eat and drink, and these dietary components act synergistically in relation to health.”

Dietary Guidelines for Americans, 2015

A Healthful Diet Pattern

• Plant oils
• Fish & seafood
• Lean meats
• Legumes
• Nuts & seeds
• Vegetables
• Fruits and 100% juices
• Dairy & yogurt
• Whole grains
• Wine
• Dark chocolate

Dietary Patterns are personal: preferences, experiences, culture. Improvements are incremental
After the 1\textsuperscript{st} trimester the baby is 2 inches long and weighs $\frac{1}{2}$ ounce

How does a neonate survive birth?
Organ Development Continues after Birth

- Gastrointestinal Tract
- Immune system
- Brain and CNS
- Lungs
- Kidneys
- Reproductive systems
- Endocrine signaling

GI Tract:
- Swallowing
- Gastric acidity
- Pancreatic function
- Epithelial digestion & absorption
- Gut motility & nervous system
- Bacterial colonization of the microflora
- Gut & systemic immunity

70% of the immune system is in the gut

Bacteria
Viruses
Chemicals
Allergens

Immune
Vascular
Neurological
Breast Milk
Optimal Nutrition & Transition to Ex-vivo Life

Anti-microbial Factors
- Secretory IgA, IgM, IgG
- Lactoferrin
- Lysozyme
- Complement C3
- Leukocytes
- Bifidus factor
- Antiviral mucins, GAGs
- Oligosaccharides

Hormones
- Feedback inhibitor of lactation (FIL)
- Insulin
- Prolactin
- Thyroid hormones
- Corticosteroids, ACTH
- Oxytocin
- Calcitonin
- Parathyroid hormone
- Erythropoietin

Digestive Enzymes
- Amylase
- Bile acid-stimulating esterase
- Bile-stimulating lipases
- Lipoprotein lipase
- Ribonuclease

Others
- Casomorphins
- D-sleep peptides
- DNA, RNA
- Long chain polyunsaturated fatty acids (LCP)
- Carotenoids

Transporters
- Lactoferrin (Fe)
- Folate binder
- Cobalamin binder
- IgF binder
- Thyroxine binder
- Corticosteroid binder

Cytokines and Anti-Inflammatory Factors
- Tumor necrosis factor
- Interleukins
- Interferon
- Prostaglandins
- α1-anti-chymotrypsin
- α1-anti-trypsin
- Platelet-activating factor: acetyl hydrolase

Inflammatory Resolution Factors
- Human milk
- Inflammatory lipid mediators

Growth Factors
- Epidermal (EGF)
- Nerve (NGF)
- Insulin-like (IGF)
- Transforming (TGF)
- Polyamines

Others
- Amylase
- Bile acid-stimulating esterase
- Bile-stimulating lipases
- Lipoprotein lipase
- Ribonuclease

The Mystery of Human Milk Oligosaccharides

Breast milk Contains 200 different HMOs

Functions of HMOs

- Prebiotics: promote a protective gut bacteria
- Facilitate GI development
- Stimulate innate and adaptive immunity
- Block pathogen adhesion
- Establishes colonic milieu
- Systemic signaling

Triantis et al. Front Pediatrics, 2018; 6:190
Short-chain fatty acids (SCFA) Affect Metabolism

Tan et al, 204:121-91-119

Maternal microbiota
Bifidobacterium
Lactobacillus
Enterococcus
Enterobacteriaceae

Cesarean
Staphylococcus
Propionibacterium
Clostridium
Bifidobacterium
Bacteroides

Vaginal
Lactobacillus
Streptococcus
Prevotella
Enterobacter

Delivery mode
Gestation time

Preterm
Enterobacteriaceae
Clostridium difficile
Staphylococcus
Klebsiella pneumoniae

Term
Bifidobacterium
Lactobacillus
Streptococcus

Firmicutes
Bacteroidetes
Actinobacteria

Age 2 years
Early colonizers
Antibiotics

Diet

Weaning
Bifidobacterium
Enterobacteriaceae
Clostridium spp.
Bacteroides
Ruminococcus

Breastfeeding
Less complexity
Bifidobacterium
Bacteroides
Lactobacillus
Ruminococcus

Formula
More complexity
Bacteroides
Clostridium
Streptococcus
Enterobacteriaceae
Veillonella

Penders J et al. Pediatrics 2006;118;511-521
The First 1000 Days of Life

*Is the foundation of cognitive, motor, social, and emotional outcomes*

### Explosive Early Growth

**Velocity**

**Linear growth**
- 10 in (25 cm) in first yr
- 4-5 in (10-12 cm) second yr
- Doubled birth length by 5 yrs

**Weight**
- Doubled by 4 months
- Tripled by 12 months
- 5 lbs or 2.25 kg/ year to 5 yrs

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Son'kin and Tambovtseva. *Bioenergetics*, 2012; Chap 5:121-142
We are born with...

**Potential**

- **In utero:**
  Neurons, spine, sensory-motor nerves, vasculature, rudimentary synaptic connections form during pregnancy

- **The Big Bang: Birth**
  Information floods the brain from all 5 senses
  muscles
  movement, gravity, balance

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At birth 85 billion neurons --
Synaptic formation will
Double brain volume by 12 months
Triple brain volume by 36 months

The Brain accounts for
>50% of the
basal metabolic rate

- Birth
- 12 months
- 3 years
- Adult
Many Nutrients Contribute

- **Vit B1** – utilize glucose, modulate cognition, language development
- **Vit B1, B6, B12, and choline, tryptophan, tyrosine, histidine, threonine** – synthesis of neurotransmitters
- **Vit B12** – cognition, language
- **Vit C** – concentrated in nerve endings
- **Vit D** – prevents neurodegenerative disease
- **Vit E** – membrane protection
- **Flavonoids** – protect, enhance neuronal function
- **Iron** – oxygenation, synthesis of myelin & neurotransmitters, brain development, IQ
- **Magnesium** – energy and ion regulation
- **Zinc** – taste perception, attention
- **Iodine** – (via thyroid) cellular energy metabolism
- **Omega 3 PUFA** – cognition, visual development
- **Lutein** – macular protection

Gonzalez et al, Arch Argent Pediatr 2016. 114:570

Breast-feeding Stimulates *Optimal* Growth
**Goals for Complementary Feeding 6-12 months**

**A Major Shift**

*Past:* A few foods tightly sequenced

*Today:* Diverse foods repeatedly offered

- Augment energy and nutrients
- Introduce every taste, flavor, texture
- Ensure food acceptance
- Promote a *responsive feeding* style
- Establish an initial *dietary pattern*

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**How to Build a Dietary Pattern**

*Mix and Match the 5 Food Groups*

At every meal & snack

- Build up *Nutrient Dense Foods* in each Food Group

  - Fruits
  - Vegetables
  - Whole grains
  - Dairy
  - Quality proteins

*The Nutrient- per- Kcal Ratio*
Nutrient Rich Foods

- Peas
- Dates
- Carrots
- Sweet potato
- Pasta
- Mango
- spinach
- yogurt
- cheese
- avocado
- guacamole
- white & brown rice
- scrambled eggs
- hummus
- pureed beef
- infant cereals
- IRON

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Mealtime is Playtime, Too

- Sight
- Smell
- Taste
- Texture
- Sound
- Eating skills
- Explore new things

Relationship are Built in
“The magic of everyday moments”
Low Dietary Intake

Nutrients Fall

Nutrient Deficiencies

Weight Falters

Height Falters

What is the Risk of “Picky Eating”?

Parental Concern

Physician Concern

Serious Complications

Murray RD. Ped Annals, 2018; 47:e465-e469

Sensory & Motor Exploration
Cognitive Function is Built in Steps

The Child Responds

The Adult Responds
Stress Shapes the Brain

- **Positive Stress**
  - Is brief, infrequent, mild or moderate
  - Is normal in everyday life
  - Motivates, stimulates exploration and curiosity, and teaches the child how to adjust

  **Adult support**
  - Helps the child to manage stress and regain balance

Toxic Stress Damages the Brain

Adverse childhood events (ACEs)
- Long lasting, frequent, or intense
- Perceived by the child as overwhelming

- Results in
  - Anxiety
  - Anger
  - Emotional outbursts
  - Fear
  - Withdrawal

Permanent abnormal wiring of brain
Toxic Stress Impacts Life Long Health

Severe Stress can Harm a Child

- Hunger & Malnutrition
- Illness or Chronic disease
- Injury or trauma
- Neglect
- Violence & Abuse
- Family chaos
- Environmental stress

Tolerable?  Toxic?

http://www.cdc.gov/violenceprevention/acestudy/
Optimal Nutrition & Nurture are Crucial in Early Life

The Stakes are High