UNIVERSITY of MARYLAND
SCHOOL OF MEDICINE

Links Between Nutrition and Cognition in Children

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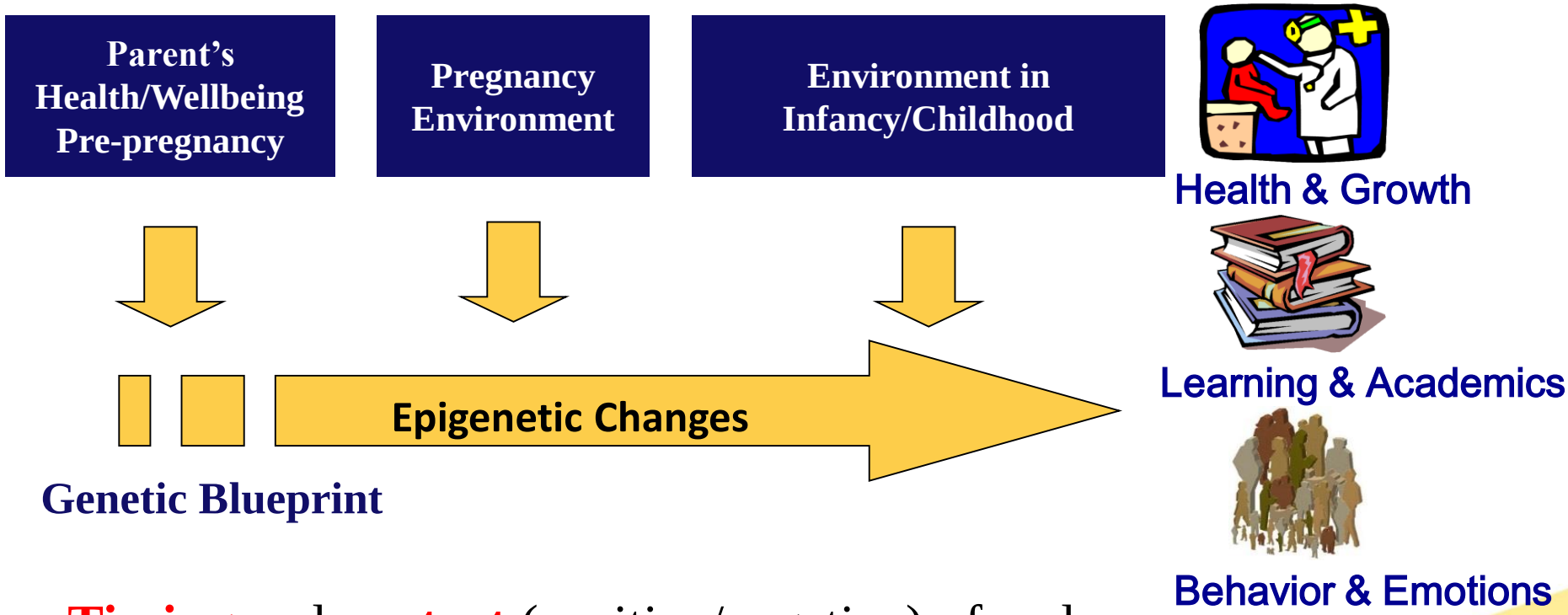
Learning Objectives

1. Describe how timing relates to associations between nutrition and cognition in children.

2. Describe why self-regulation is relevant to infant/toddler feeding practices.

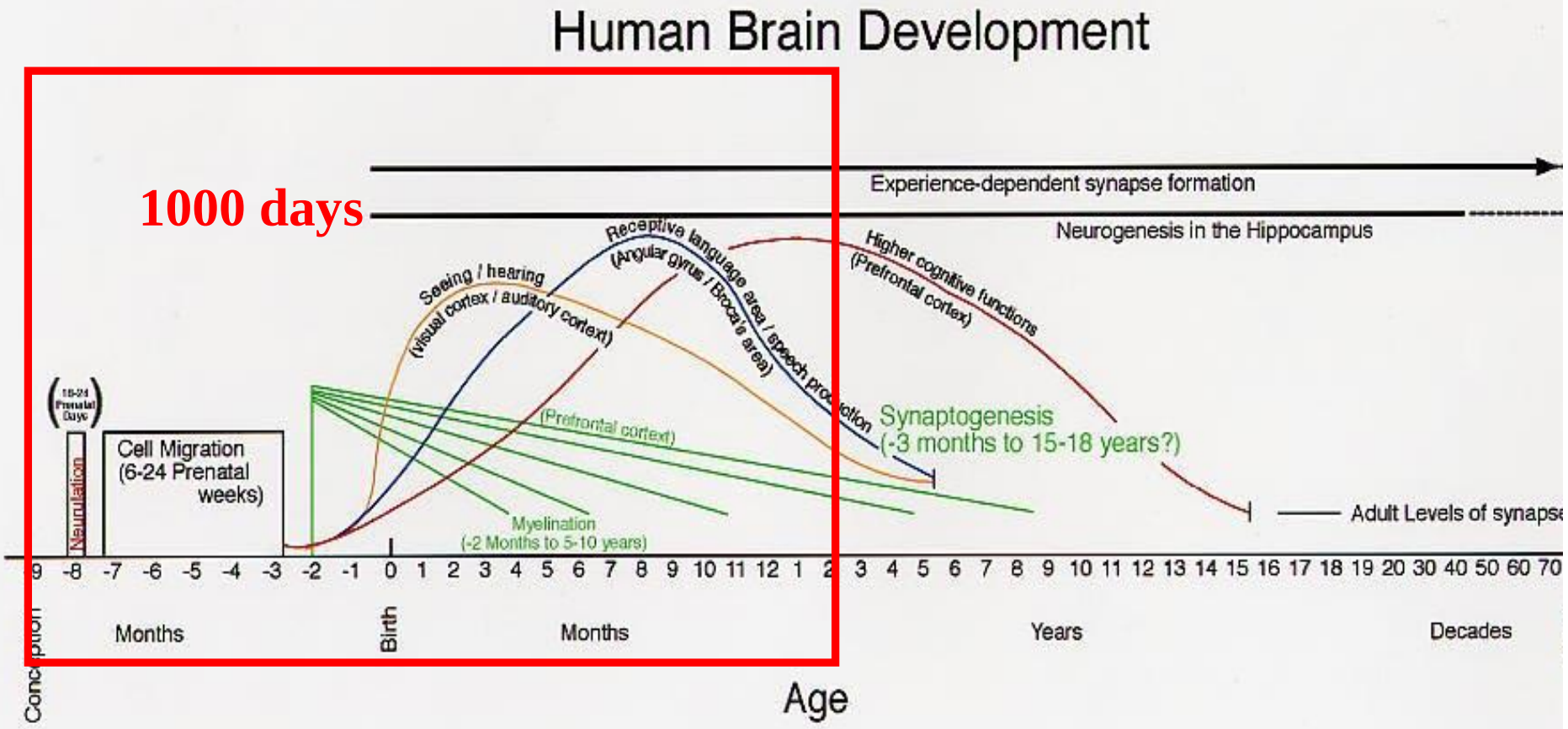
3. Describe recommendations for promoting infant/toddler nutrition.

Environments across the life-course



Timing and **context** (positive/negative) of early environments shape children's potential

Developmental Perspective



Fetus **Late Infancy/Toddler** **Pubertal**

Thompson & Nelson, 2000

Nutrient Deficiencies

- **Timing**
  - Sensitive Periods
- **Severity**
  - Deprivation vs. Toxicity
- **Duration**
  - Acute vs. Chronic
- **Recovery/Protection**

Macronutrients
necessary for growth

- Carbohydrates
  - Fuel, provide most calories
  - Fiber - carbohydrates that body cannot digest. Pass through the intestinal tract intact and remove waste.
- Proteins
  - Growth, immune functioning, tissue repair
- Fats and cholesterol
  - Concentrated calories
  - Taste

Micronutrients
specific functions

- Vitamins and minerals
- Not made by the body
- Poor diet quality (e.g., low fruits & vegetables, low animal source food)
- Not necessarily impact growth

IODINE: T3/T4 -essential to neurodevelopment

- Severe ID during pregnancy may lead to cretinism
- 2013 meta analysis - 24 studies[1]
  - IQ deficiencies of 6.9-10.2 points
- 2005 meta analysis - 37 studies in China[2]
  - IQs deficiencies of 12.5 points

- 2018 review
  - Associated with ADHD
  - Aggravated by pregnancy and maternal hypothyroxinemia
  - Can impact postnatal development and plasticity of neural tissues

■ Iodizing salt is a powerful prevention measure

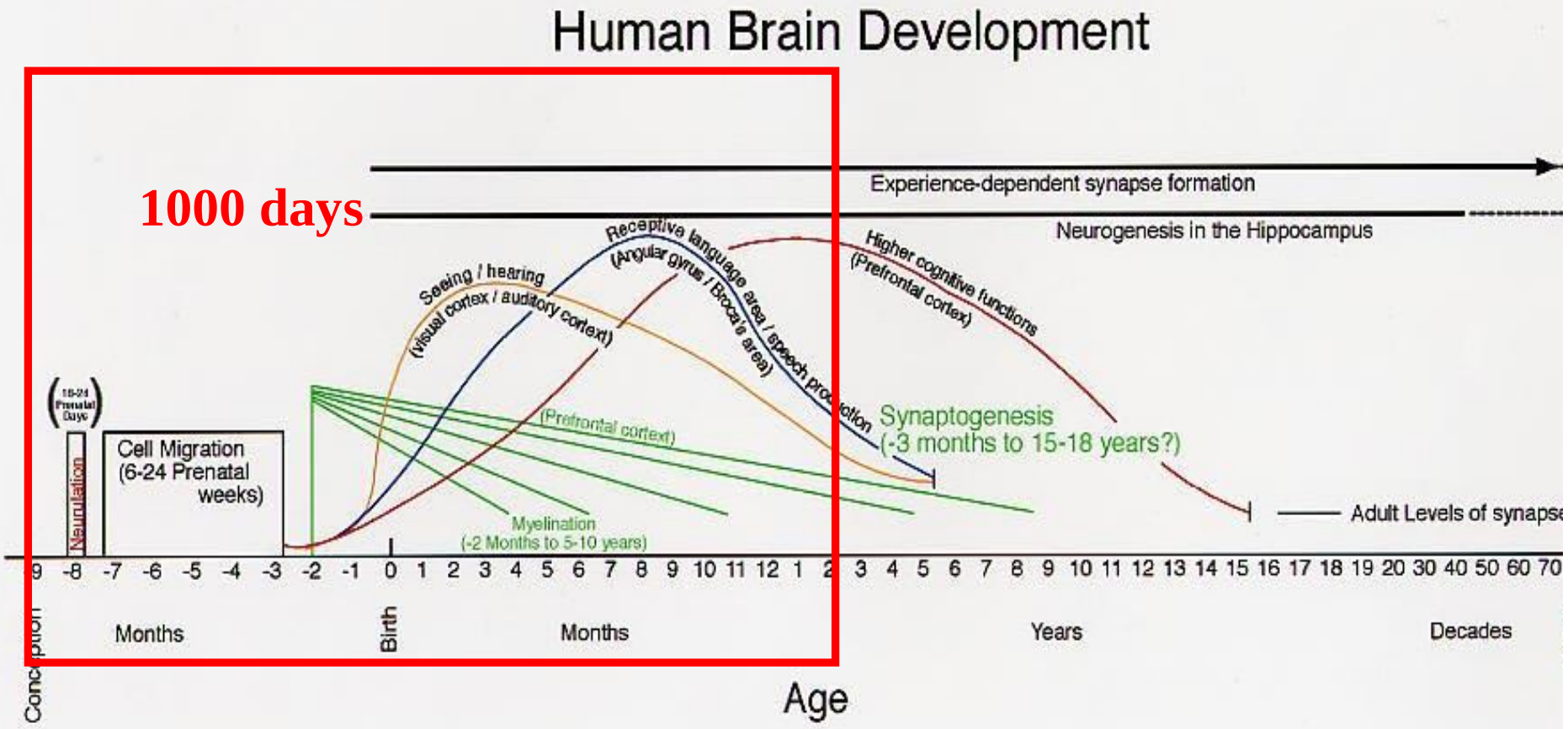
[1]Bougma et al, 2013; [2]Qian et al, 2005, [3]Velasco, 2018

IRON – aids transport of oxygen to brain

- IDA in infancy and < 2 y associated with poor development
- Long-term effects of infant IDA even after tx (observational studies)
- Prenatal iron supplementation trials show mixed findings
  - Mixed findings related to cognitive development[1-3]
- Mixed findings related to Infant iron supplementation on motor and cognition[4]
- Maternal iron supplementation, delayed clamping or “milking” umbilical cord, and early iron supplementation improve the iron status of at-risk infants [5]
- Concern about risk of morbidity and gut microbial composition and inflammation

- [1]Christian, JAMA, 2010; 2Li et al. Pediatrics. 2009; [3]Zhou et al, Am J Clin Nutr. 2006; [4]Baumgartner, 2015. 5 Cusiac, 2018

Developmental Perspective

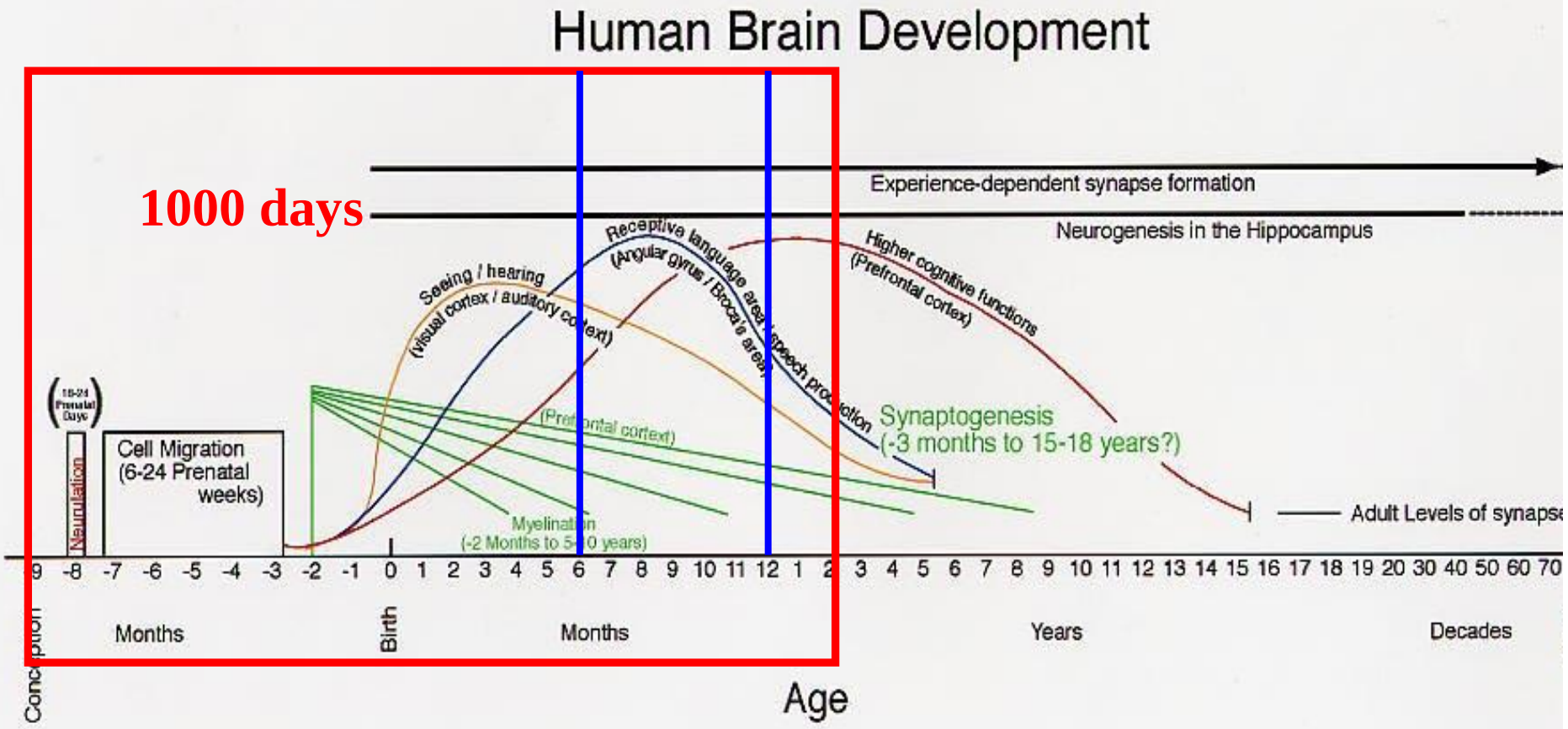


	Fetus	Late Infancy/Toddler	Pubertal
Iron:	**0.27 mg/day**	**11 mg/day**	**7 mg/day**
	0–6 months	**6-12 months**	**1-3 years**

Thompson & Nelson, 2000

Developmental Perspective

TIMING



Fetus **Late Infancy/Toddler** **Pubertal**

Iron: **0.27 mg/day** **11 mg/day** **7 mg/day**

0–6 months **6-12 months** **1-3 years**

Thompson & Nelson, 2000

ZINC – constituent of enzymes involved in many major metabolic pathways

- Benefits of preventing zinc deficiency in infancy and in combination with iron
- Cochrane review of zinc supplementation and mental and motor development – concluded no consistent effects

Gogia & Sachdev, *Cochrane Database*, 2012; Colombo, *J Nutr*, 2014; Black *Pediatrics*, 2004

Multiple Micronutrients

- Deficiencies often occur in combination[1-5]
  - Poverty, Poor quality diet
  - Limited access to diverse, nutrient rich foods
- Impact of improving one micronutrient in the context of multiple deficiencies
- Interaction/competition among micronutrients
- Timing – when to intervene
- Side effects
- Short term effects of infant supplementation inconsistent – limited evidence on long-term effects[6-7]

- [1]Christian et al. JAMA. 2010; [2]Tofail et al. Am J Clin Nutr. 2008; [3]Prado et al, Pediatrics. 2012; [4]Li et al. Pediatrics 2009. 5McGrath et al. Pediatrics. 2006; [6]Adu-Afarwuah et al. Am J Clin Nutr. 2007; [7]Faber et al. Am J Clin Nutr. 2005

Prenatal Maternal Nutrition

- **Few trials examined effects on child development**
  - Motor development at 7 months; no effects at 18 months or 5 years (Bangladesh)
  - Motor and cognitive scores at age 3.5 in children of undernourished & anemic mothers (Indonesia)
  - Beneficial effect of MMN vs. vit A at 7-9 years on one test of cognition (Nepal)

(1) Haider & Bhutta, Cochrane Database, 2015; Fall et al., Food & Nutr Bull, 2009; Kawai et al., Bull WHO, 2011; Ramakrishnan et al., Paediatr Perinat Epi, 2012
(2) Hamadani et al., Pediatrics, 2014; Prado et al., Pediatrics, 2012; Christian et al., JAMA, 2010 , Nguyen, 2017

Preconception Maternal Nutrition

- Strong rationale for ensuring nutritional adequacy prior to conception
- Several trials in the field
- Controversy regarding appropriate timing and measures of child development.
- Preconception supplementation with IFA (not MMN) improved linear growth and fine motor development at 2 y of age compared with FA (Vietnam).

Nguyen, 2017

Nutrition and Early Development

Stunting by age 2 associated with:

- **Childhood**: poor school performance
- **Adulthood**: low human capital
- **Subsequent generation**: similar growth pattern, offspring benefit from maternal intervention

- **Economic impact** of reducing stunting

Sudfeld, *Pediatrics*, 2015; Victora, *The Lancet*, 2008; Stein, *Pediatrcs*, 2004; Hoddinott, MCN, 2013.

Difference in School-Age Cognition Per Unit Increase in Length-for-age at 2 years[1]

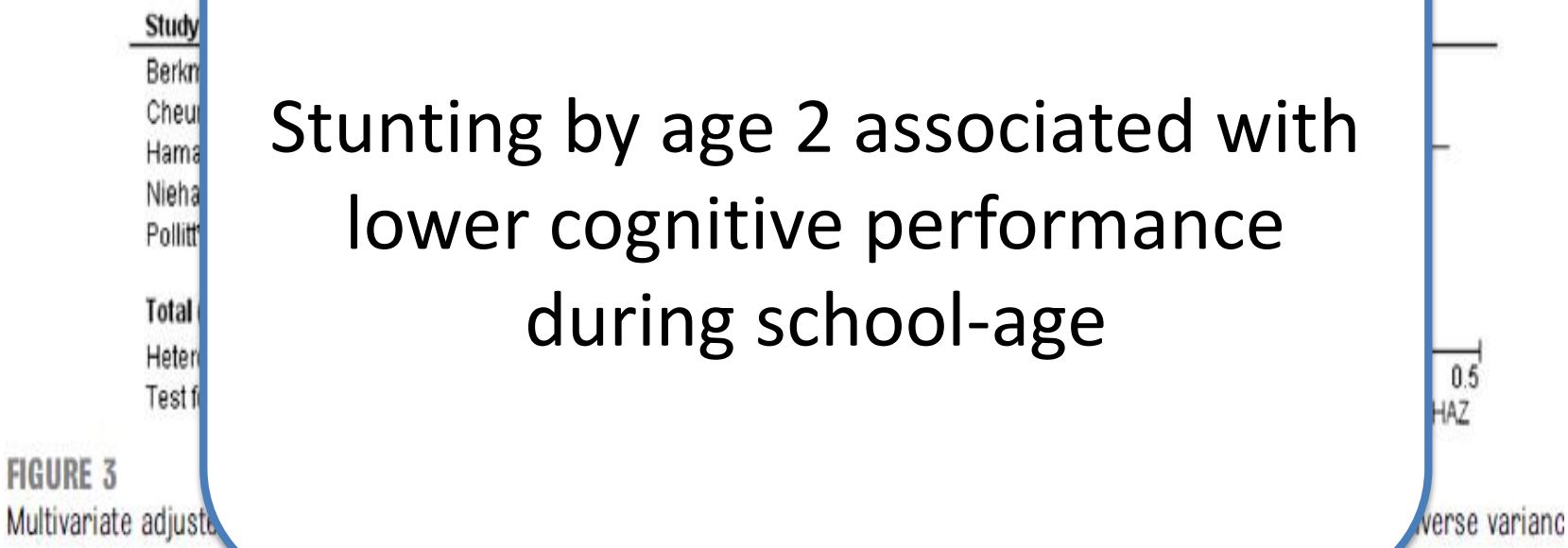


FIGURE 3
Multivariate adjust
verse varianc

Stunting by age 2 associated with lower cognitive performance during school-age

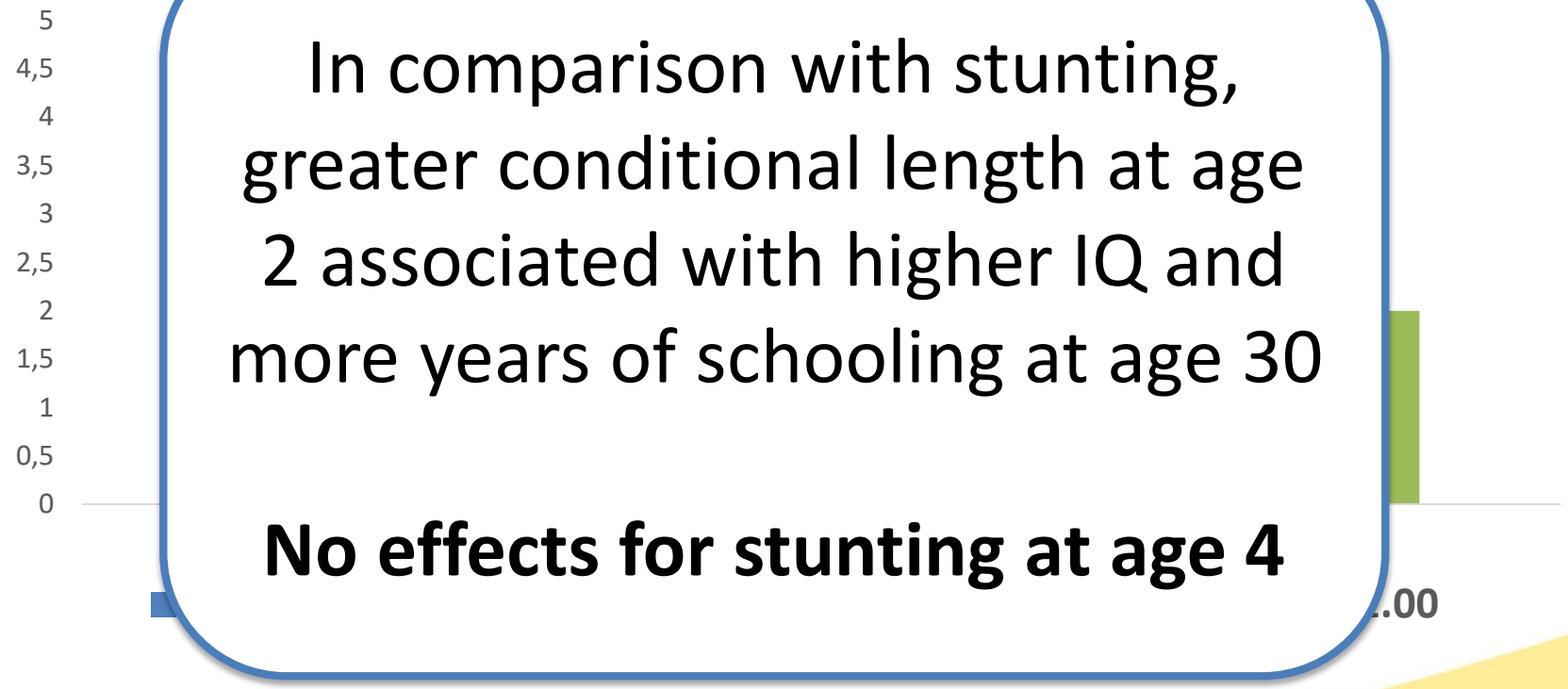
[1] Sudfeld, *Pediatrics*, 2015

Long-term effects of stunting on human capital

- Linear growth in first 2 years of life more strongly associated with years of schooling than weight gain. (Adair, Lancet, 2013)

- Conditional growth: how a child deviates from expected height or weight, based on previous measures and growth of the population

Regression coefficients for IQ & Years Schooling at Age 30 by Conditional Length at Age 2



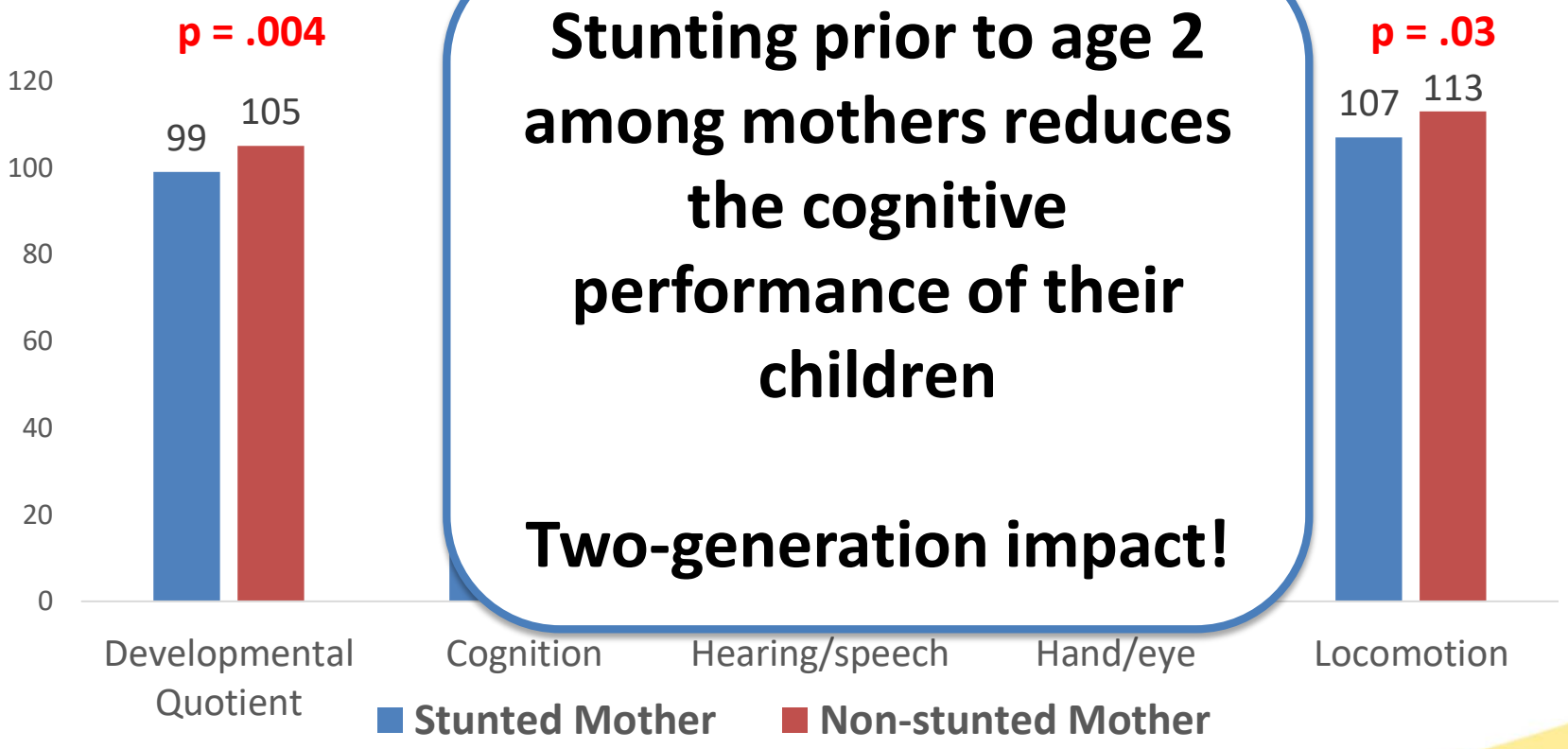
In comparison with stunting, greater conditional length at age 2 associated with higher IQ and more years of schooling at age 30

No effects for stunting at age 4

Adjusted for family income, parent ed, household index, skin color, mat smoking preg, birth wt, breastfeeding duration

Horta et al, J Peds, 2017

Developmental Skills of Children (12-72 months) of Mothers Stunted/Non-stunted as Infants (9-24 months)



Stunting prior to age 2 among mothers reduces the cognitive performance of their children

Two-generation impact!

Adjusted for child age, sex, birthwt, HAZ
mater ed, occup, father in home, SES, HOME

Walker et al., J Nutr, 2015

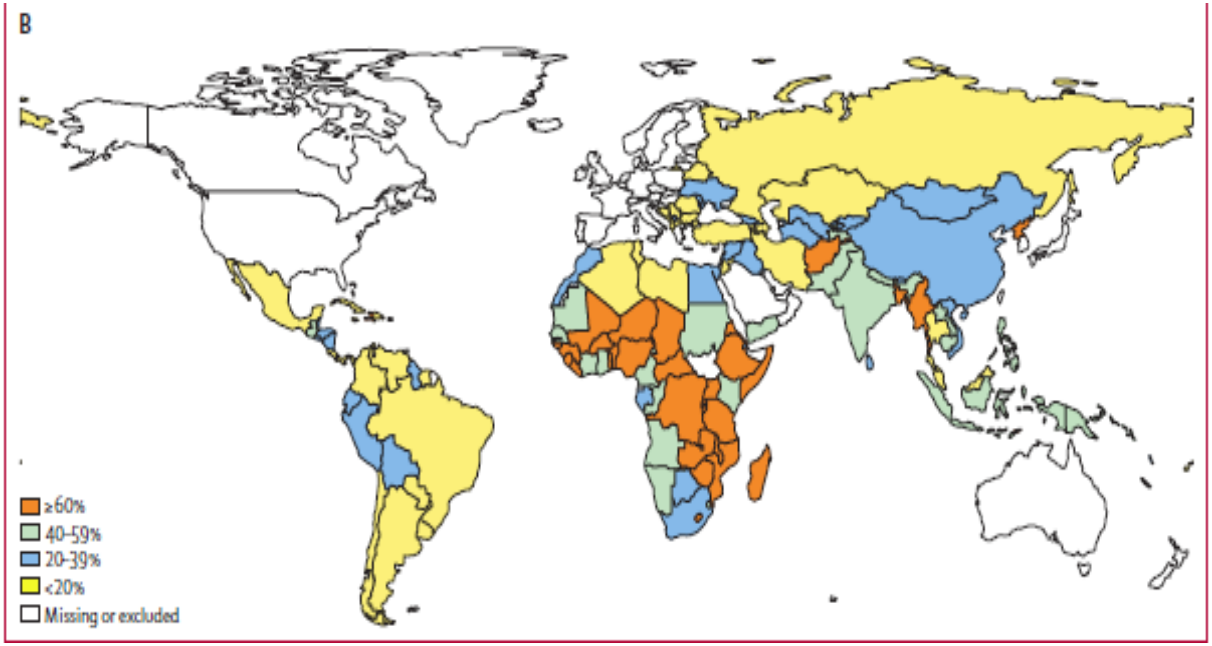
Poverty and Early Development

Stunting and severe poverty used to estimate prevalence of children at risk of **not reaching developmental potential**

249 million children < age 5 years
43% of world's children

Black, *The Lancet*, 2017; Lu, Black, Richter, *Lancet Global Health, 2016*

Children Not Reaching Their Developmental Potential



Risk of not reaching developmental potential 2010
249 million

Grantham-McGregor, *The Lancet*, 2007; Lu, Black, Richter, *Lancet Global Health, 2016*

Response to Food Insecurity

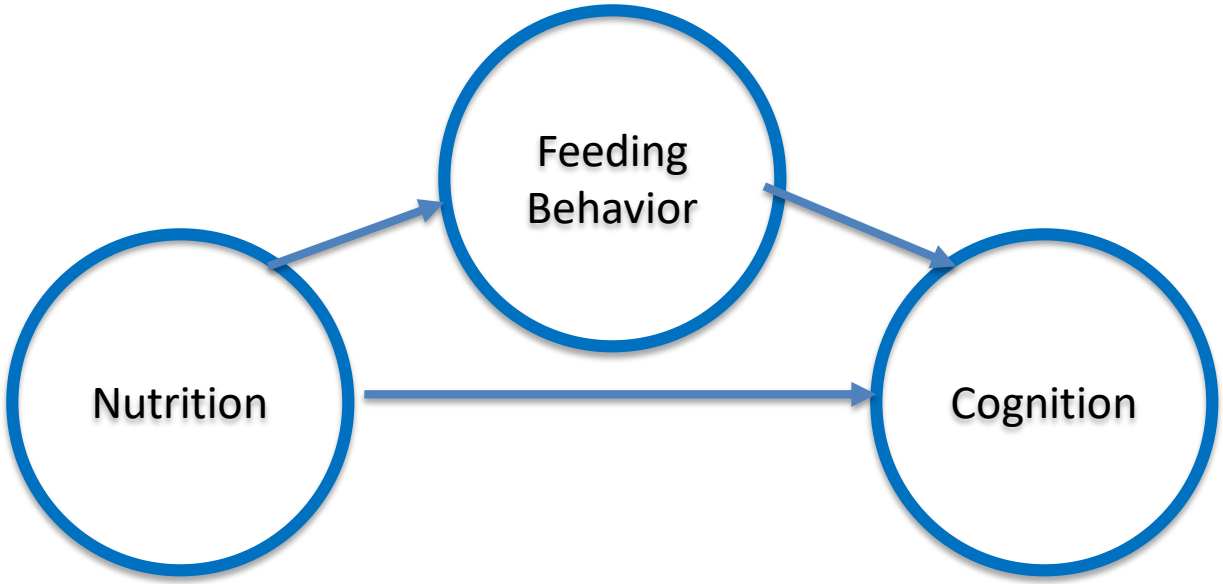
- **Quality**: Foods decreased
  - Proteins (eggs and meat)
  - Fruits and vegetables

- **Quality**: Foods increased
  - Starches
  - Noodles

- **Quantity**: Decrease food

Burke, *J Nutr Educ Behav*. 2017

Link between Nutrition and Cognition



Feeding Behavior

- Clara Davis (1928, 1939)
  - Infants in orphanage
  - Given choice of basic foods (not mixed foods)
  - Observed what they chose
  - Nurse fed
  - Regulated intake!
- Self-regulation thought to guide infant hunger and satiety

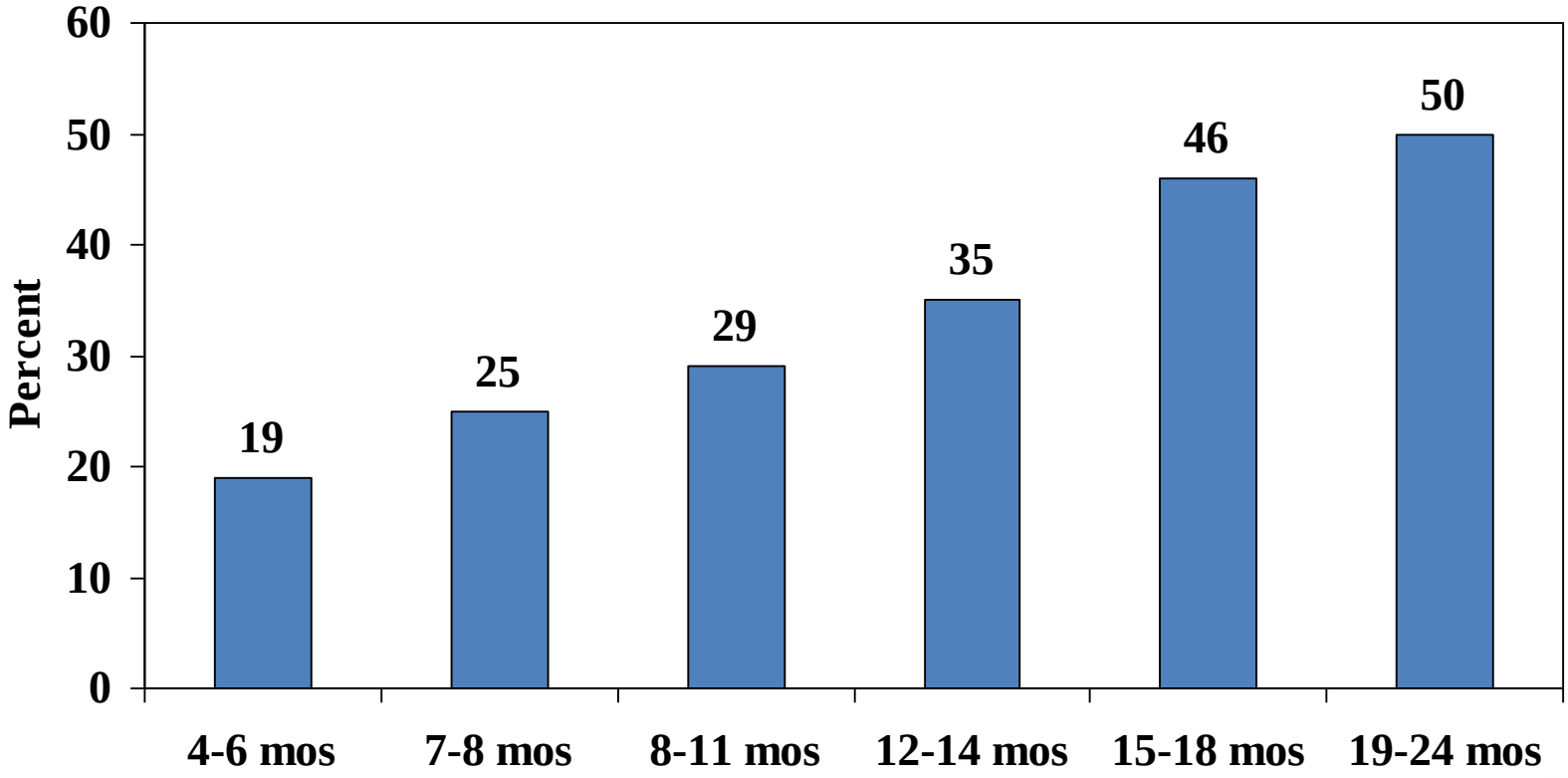
Developmental Milestones Related to Eating

- O-6 months
  - normal suck/swallow
  - breast milk or formula only
  - Regulate:
    - Demand – signal hunger
    - Turn away from breast/bottle when full

- ~6 months
  - Sit up, good head control
  - starts to touch food with fingers
  - Oral-motor (tongue laterality)
  - feed in high chair
  - Regulate
    - Lean toward food, mouth open when hungry
    - Turn head when full

Feeding Infants and Toddlers Study (FITS)

Percent of Parents Reporting Feeding Problems (n=3022)



Feeding problems often correspond with child's desire for autonomy.

Carruth, 2004

Challenges – Toddler Feeding Problems

- Feeding Problems Common (Picky)
  - 25-40%, Most resolve without major consequences
  - BUT
  - Can undermine family relations
  - Can signal GI problems (GERD, celiac, etc.)
  - Can lead to nutritional deficiencies
  - Can be a precursor to long lasting behavior problems

Infant/Young Child Feeding

Age	Developmental Skills	Food/Beverage	Feeding Behavior
0-6	Suck/swallow	Breast milk/ Formula	Breast/ Bottle
6-12	Tongue laterality, chew Sit Hand-mouth Emerging autonomy	Complementary food (texture & nutrients)	Self/ Caregiver

Infants (0-6)

- Bottle-fed infants gain more weight than breast-fed infants, even if the bottle contains breast milk.
  - Do m
  - Cross
- Observe

Bottle-feeding mothers: risk of not responding to infant and overfeeding

			ration
Opaque			15.5
Clear	8.2	22.0	15.0

* P < .05

Ventura, *Appetite*, 2015

Infants (prenatal-24 mos)

- Self-feed vs. caregiver feed
- BLISS (Baby-Led Introduction to Solids)
- Recruit 206 pregnant women (NZ)

CONTROL

BLISS
5 contacts (prenatal-5 mos)
3 contacts (6-9 mos)

Intervention addressed exclusive breastfeeding 6 mos, iron & energy-rich complementary foods, soft foods, avoid choking, respond to infant signals

Results: BLISS vs. Control 12 & 24 months

	Age	Control	BLISS	Significance
BM				os
n				

No difference:

BMI, Overweight, Choking, Energy Intake

Exclusive breastfeed: BLISS 4 weeks longer

Delay solids 6 months: BLISS 64.6%

Results: BLISS vs. Control 12 & 24 months

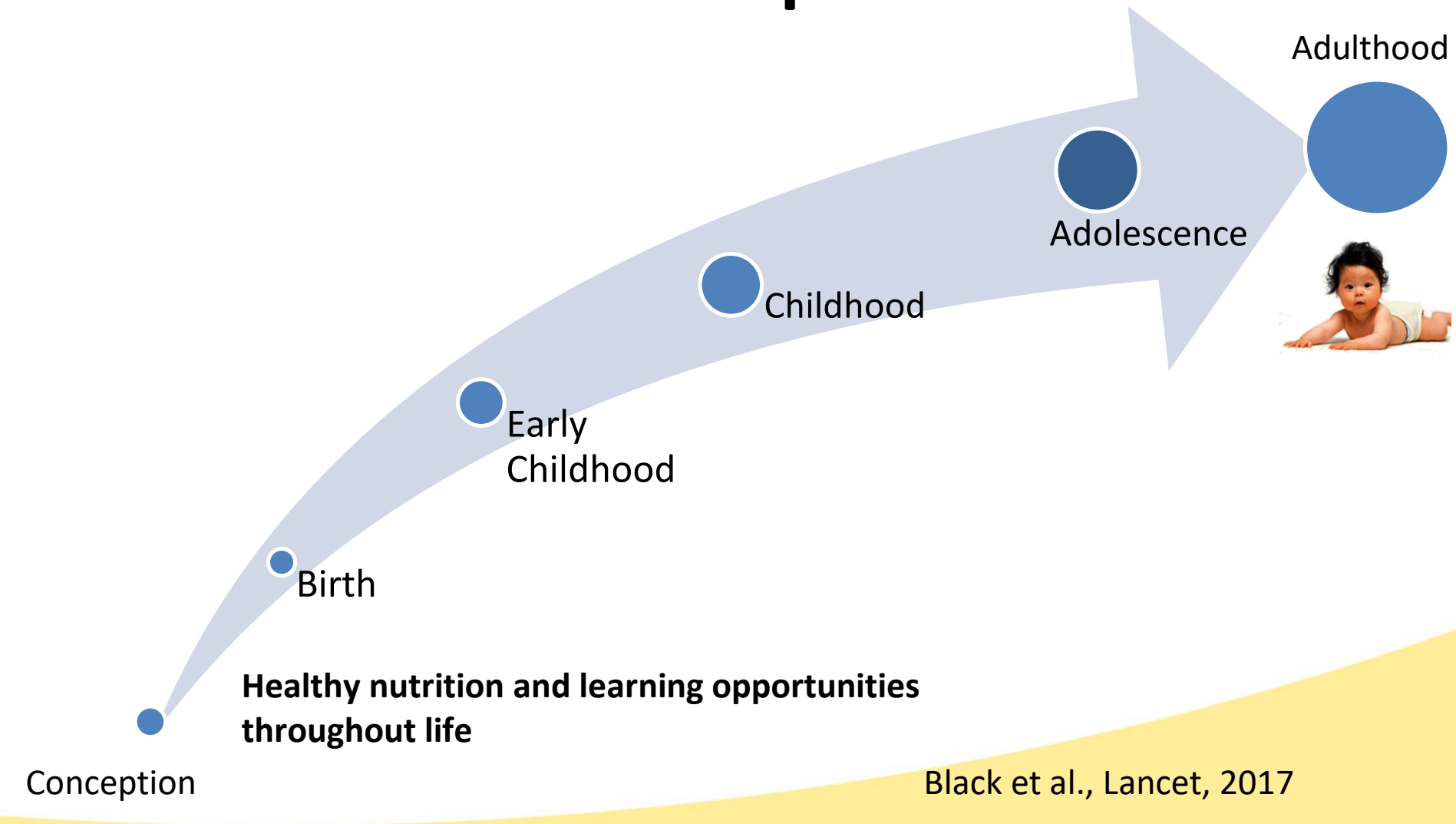
	Age	Control	BLISS	Significance
Fussy/picky (observe)				*
Enjoy Eatin (caregiver r				*
				*
Child mealtime decisions (caregiver report)	12	3.87	4.04	*

BLISS children less fussy/picky, greater eating enjoyment and mealtime decisions.

Concern: excess intake??

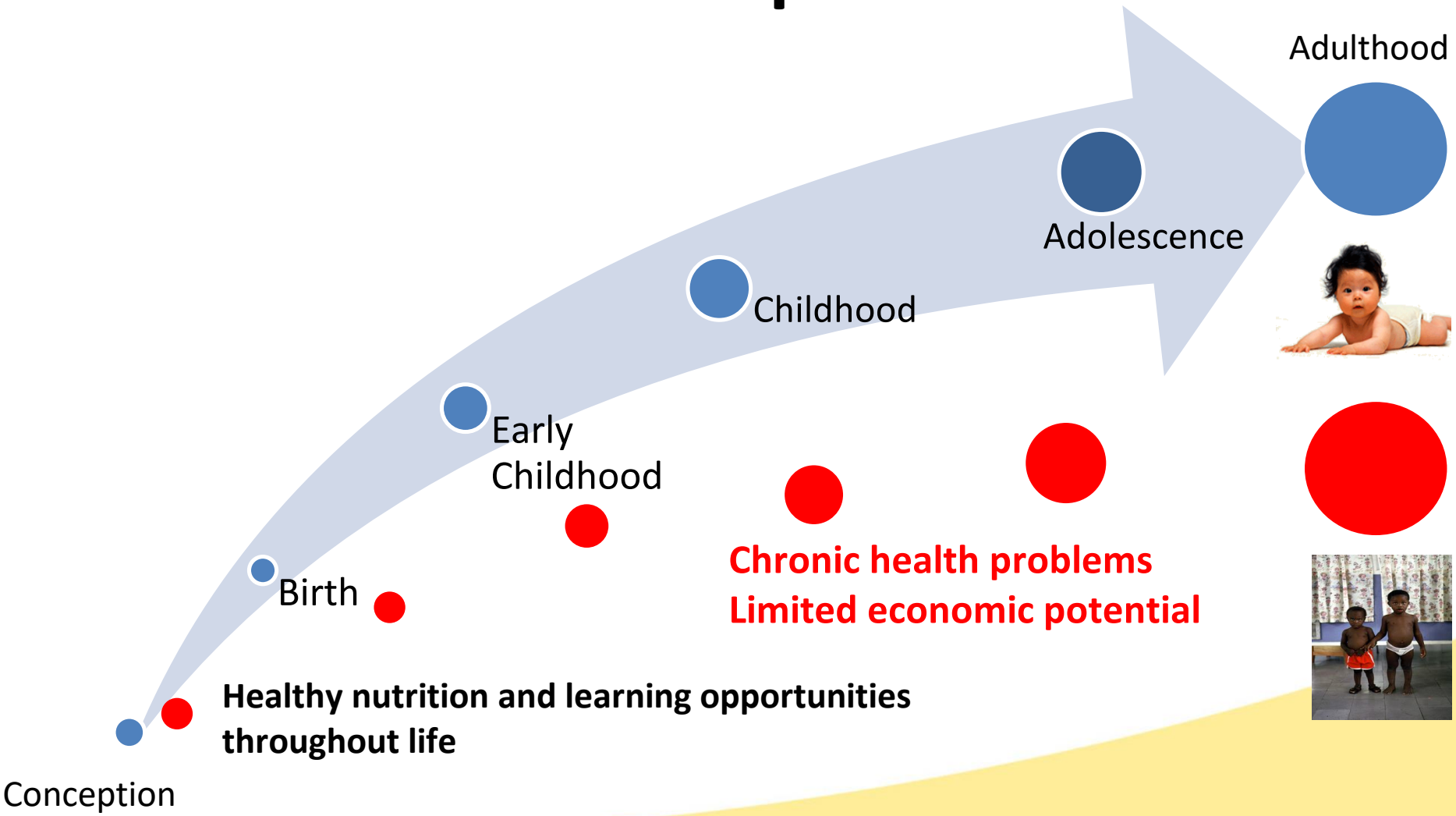
* P < .05

Life Course Perspective to Child Development



Black et al., Lancet, 2017

Life Course Perspective to Child Development



Cost of inaction in grades and earnings lost

	Grade Deficit	Income Loss	Children
Stunted only	4.67	42.3%	106.5m (18.5%)
Poor only	0.71	5.8%	75.6m (13.1%)
Stunted and poor	6.56	32.4%	67.2m (11.7%)

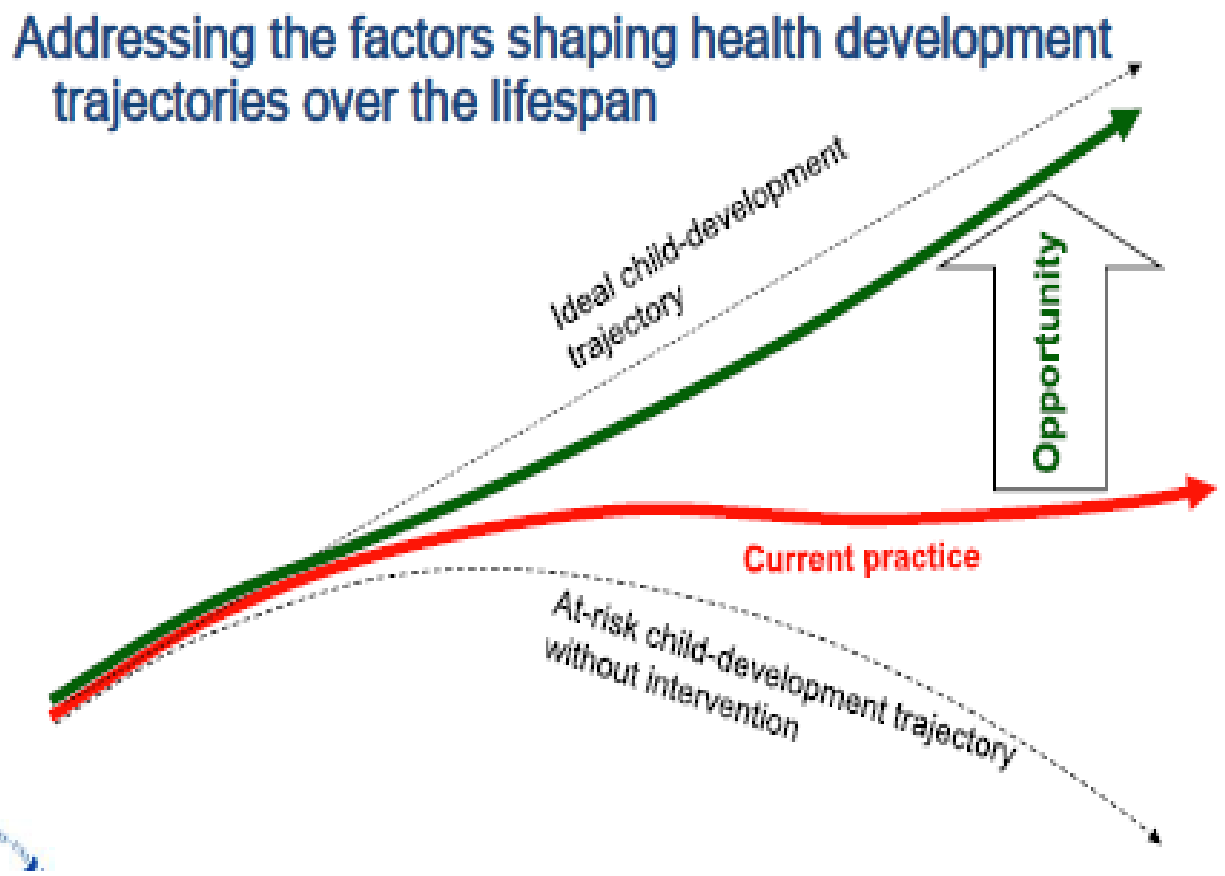
249.3m (43.3%)

Richter, *The Lancet*, 2017

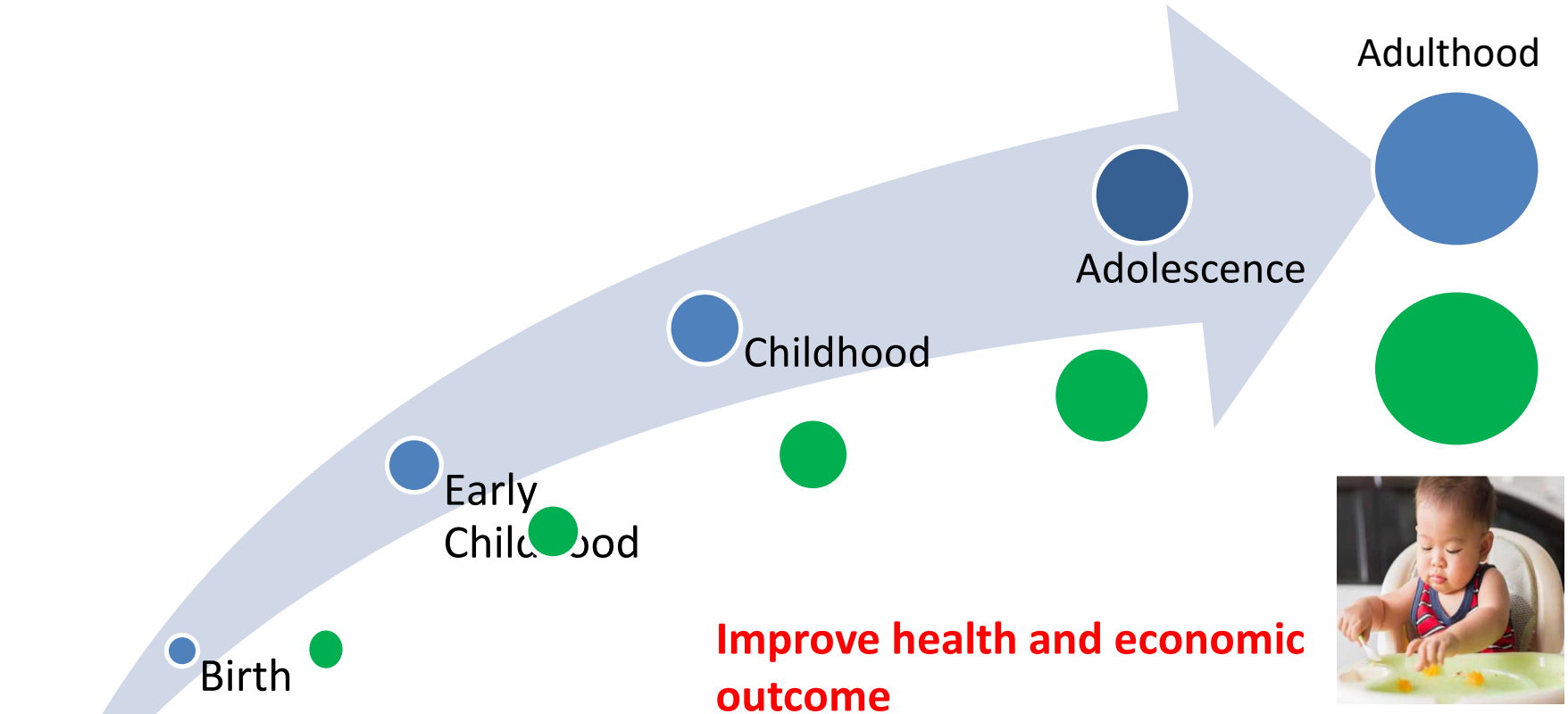
Cost of inaction in grades and earnings lost

43% of children in LMICs (249 million) lose **26.6%** of average adult income

Optimizing Healthy Development



Life Course Perspective to Child Development: Begins 1st 1000 Days



Nutrition and Early Development

Rapid infant weight gain by age 2 associated with risk of noncommunicable diseases (NCDs) in adulthood.

Grantham-McGregor, *Pulic Health Nutr,* 2005; Adair, *Nestle Nutr*, 2011

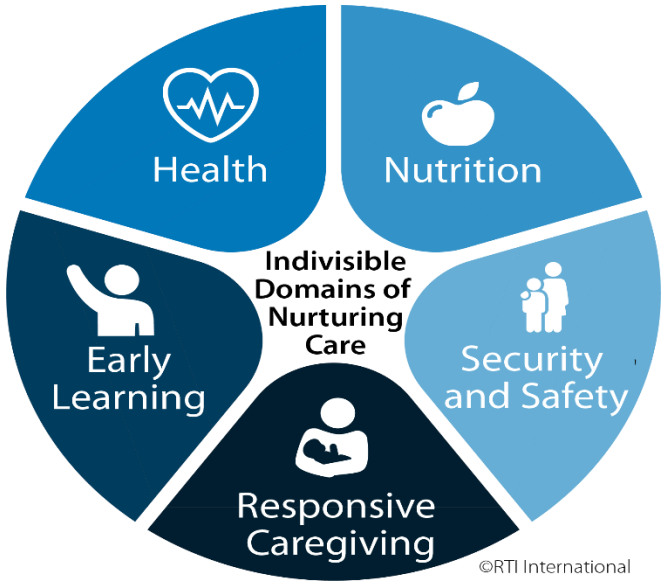
Nurturing Care

- Nurturing care promotes early child development
  - Nutrition

Each domain is necessary.

No single domain is sufficient.

learn and discover



Black, *The Lancet*, 2017; Black, Gove, Merseth, 2017

USA: Early Childcare (Abecedarian)

- Goal: Evaluate early enriched care on academic performance
- Randomized

Child Care Center

Nutrition, health care, learning curriculum

8 hours/day, 5 years

Care as Usual

- Followed through early adulthood – benefits on academic performance & economics
- Age 35…..

Campbell *Science* 2014

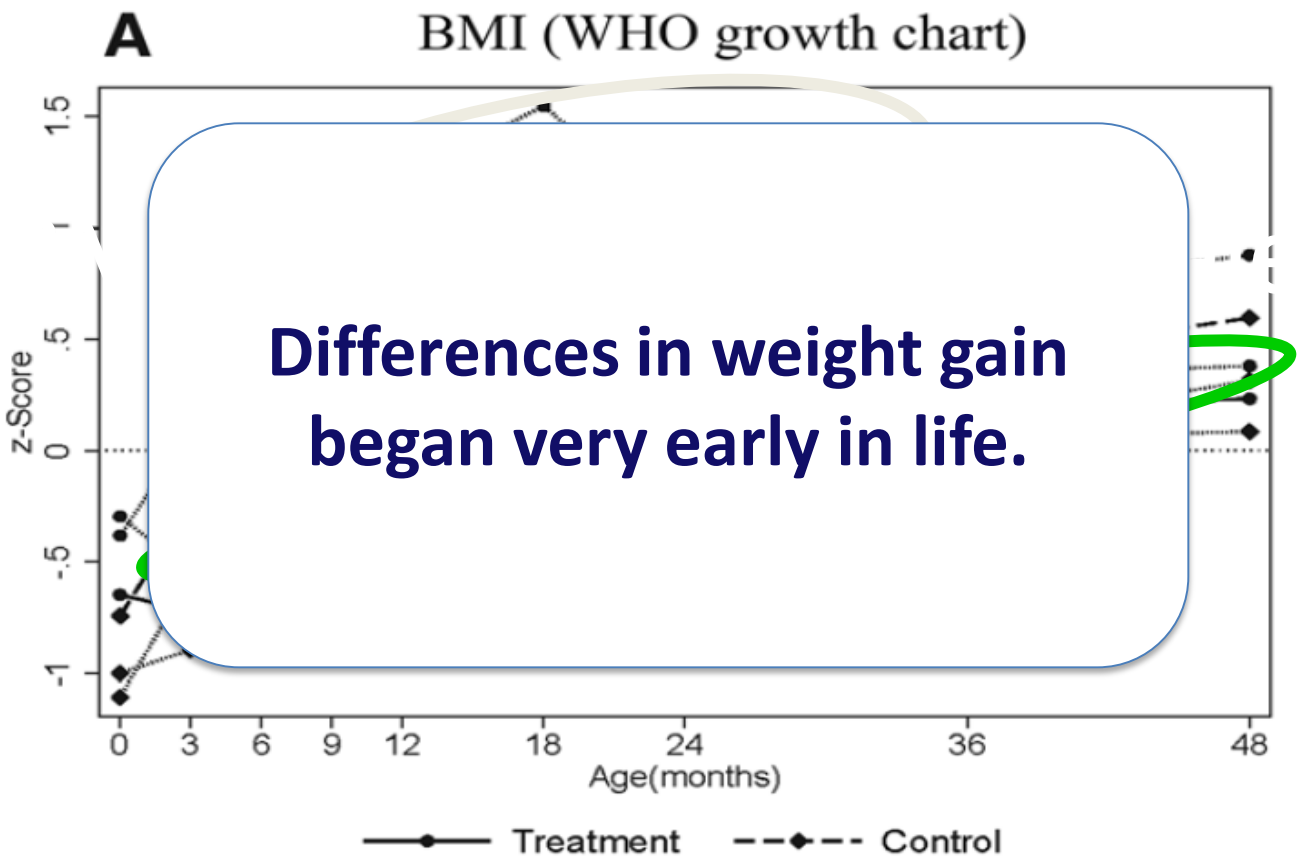
Biomedical Results Age 35: Males

	Control	Treatment	P-value Stepdown
Diastolic BP (mm Hg)			**0.02**
Systolic BP (mm Hg)			**0.03**
Hypertension (systo 140 and diastolic bp			**0.02**
Hypertension (systo 140 or diastolic bp ≥			**0.04**
Obese (BMI ≥ 30)			0.34
Obesity and hypertension			**0.02**
Metabolic syndrome (NCEP definition)	0.25	0.00	**0.01**

Age 35 years
Beneficial effects on blood pressure, metabolic syndrome

Campbell *Science* 2014

Early Weight Gain - Males



Differences in weight gain began very early in life.

Campbell *Science* 2014

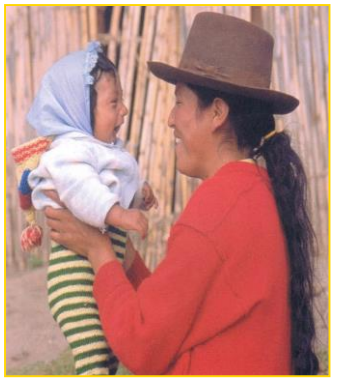
Maternal Feeding Evolution

- Cross-sectional studies
  - Unidirectional: Mother → Child
  - Bidirectional: Mother ↔ Child

- Supported by intervention trials (6)
  - Mothers taught to respond to infants' hunger and satiety cues.
  - Lower z-scores, less overweight & excess wt. gain

Responsive Caregiving

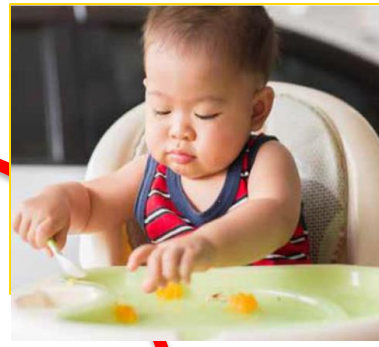
Caregiver “caring”

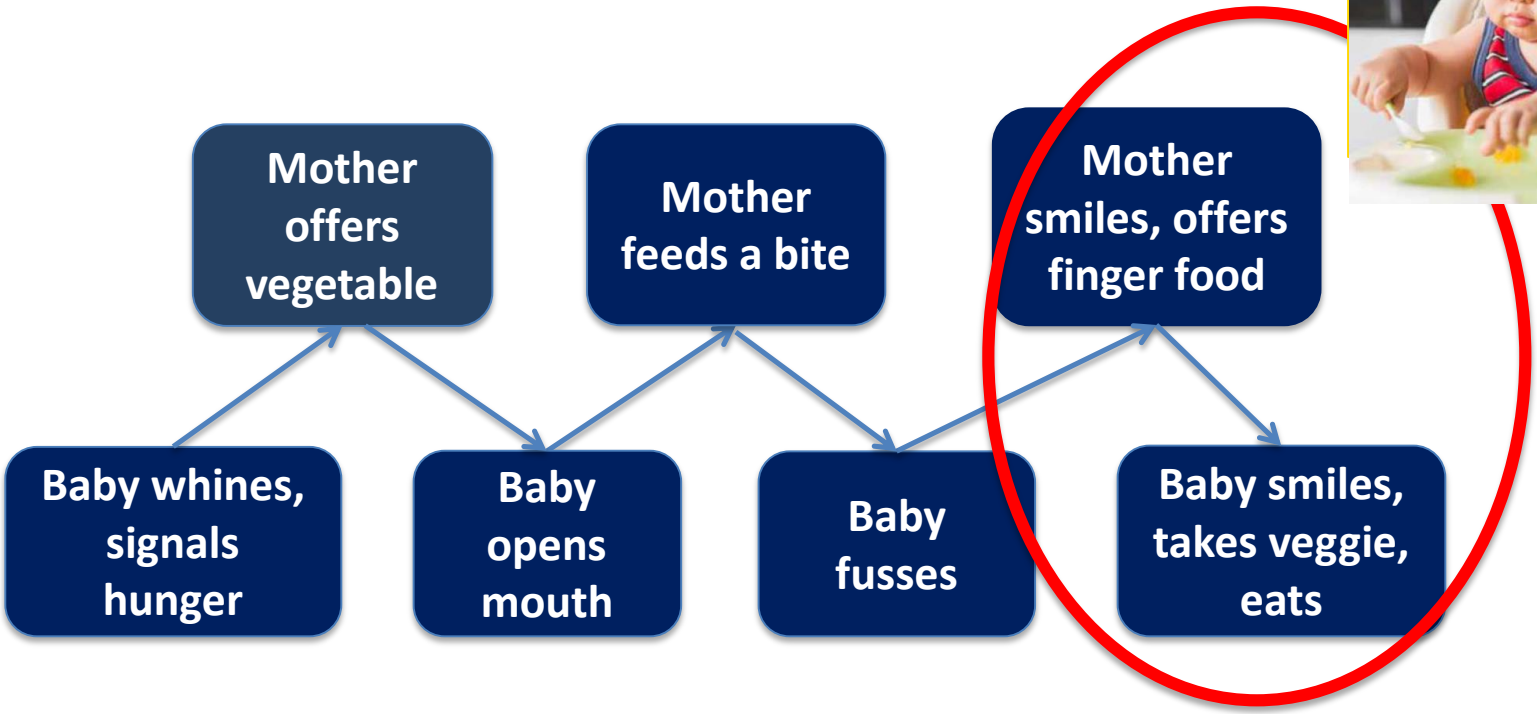


Consistent (predictable) routines

Provides feedback and guidance, not harsh

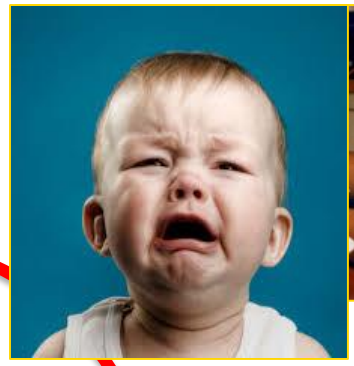
Responsive Feeding
Bidirectional concepts

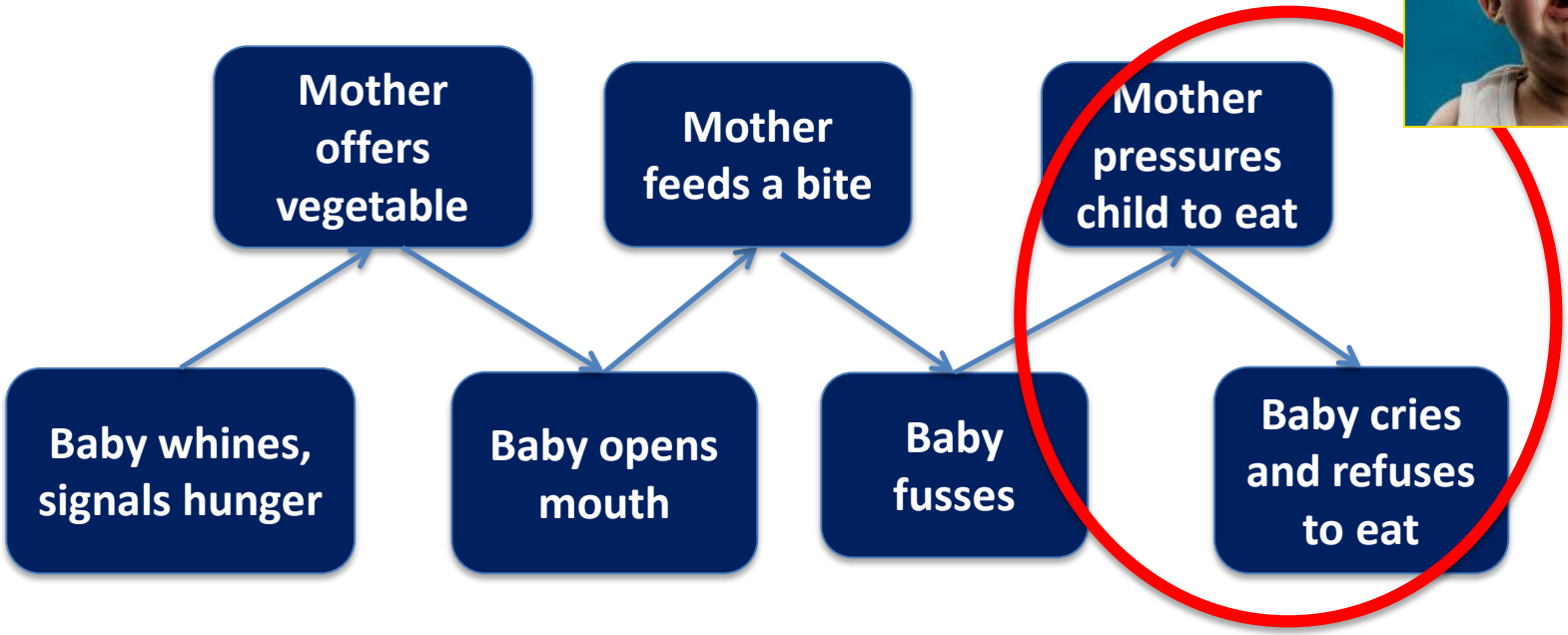




Black & Dewey, 2014

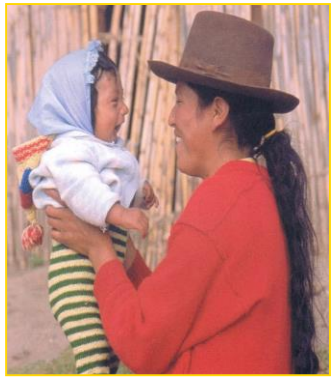
Responsive Feeding
Bidirectional concepts





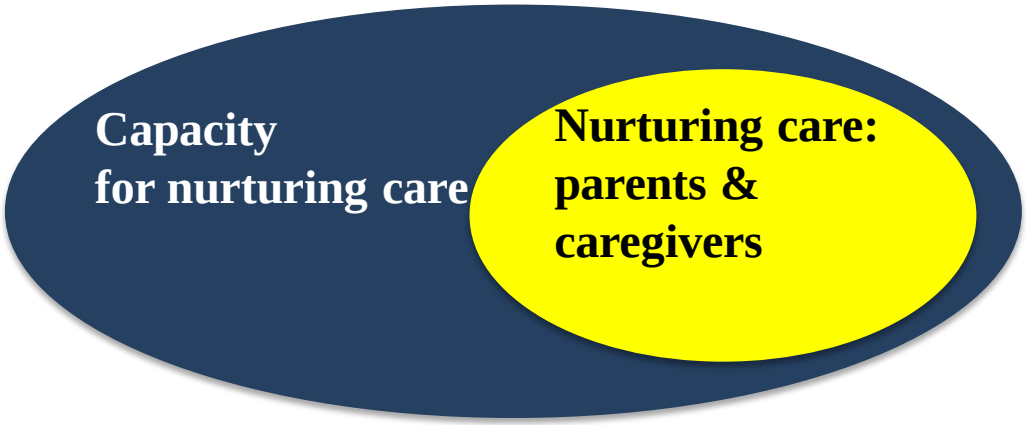
Black & Dewey, 2014

Nurturing care is fostered by a supportive environment

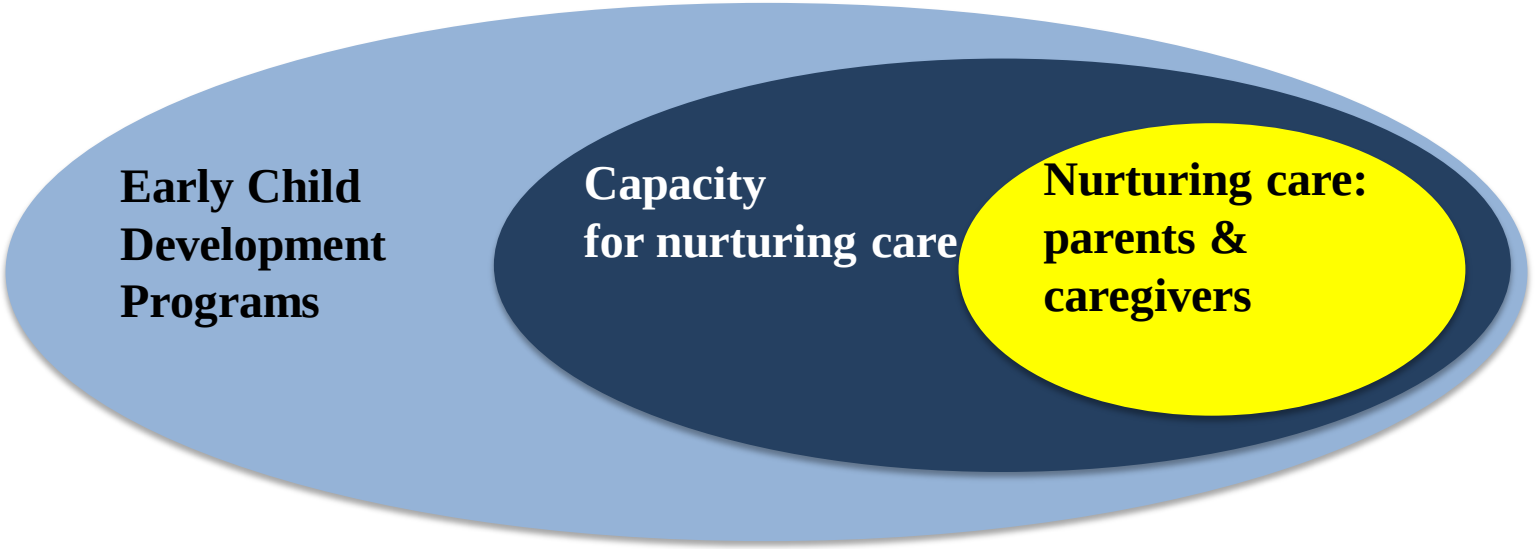


Nurturing care: parents & caregivers

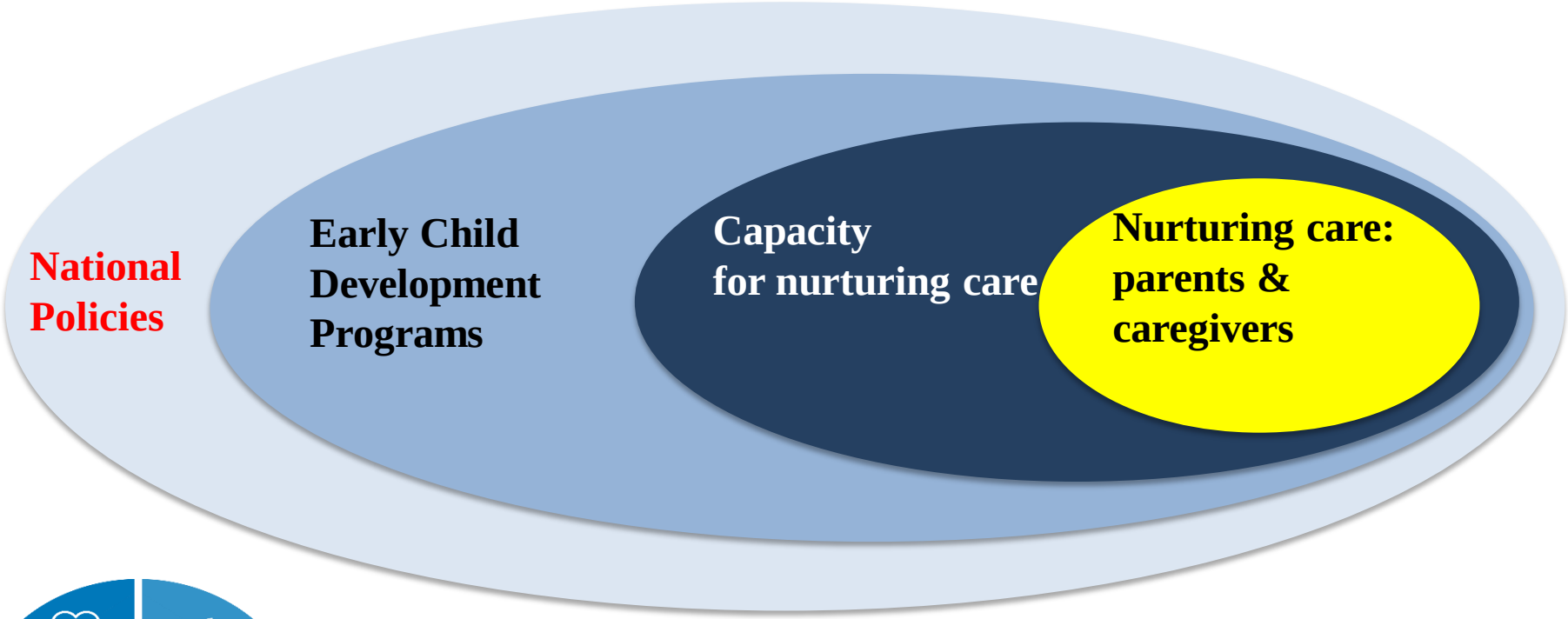
Nurturing care: fostered by a supportive environment –ecological model

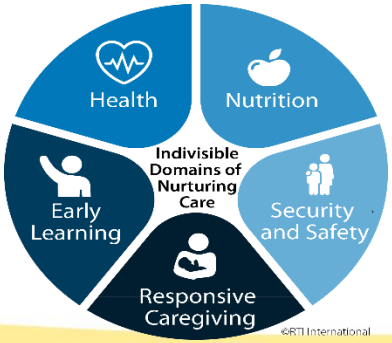


Nurturing care: fostered by a supportive environment –ecological model



Nurturing care: fostered by a supportive environment –ecological model





Early Child Development

- **Birth through age 8 years**
  - Pre-conception/prenatal
  - Antenatal
  - Infant/Toddler
  - Preschool
  - Early School-age

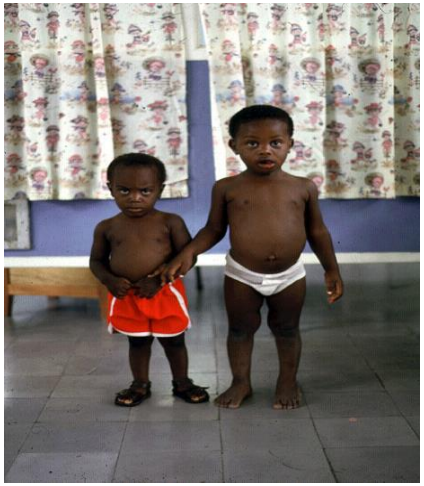
First 1000 days: conception-age 2 years

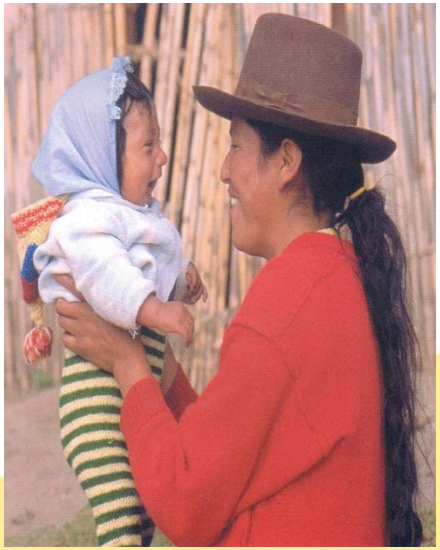
Second 1000 days: age 2-5

Improving Early Child Development:

Key to achieving the SDGs

Thank You!





Funding:
NICHD, Bill & Melinda Gates Foundation,
Hilton Foundation