Measuring Clean, Fed & Nurtured: Indicators for Child Growth and Development

October 6, 2015 Washington D.C.

Aligning indicators with expectations in assessing impact of interventions on children

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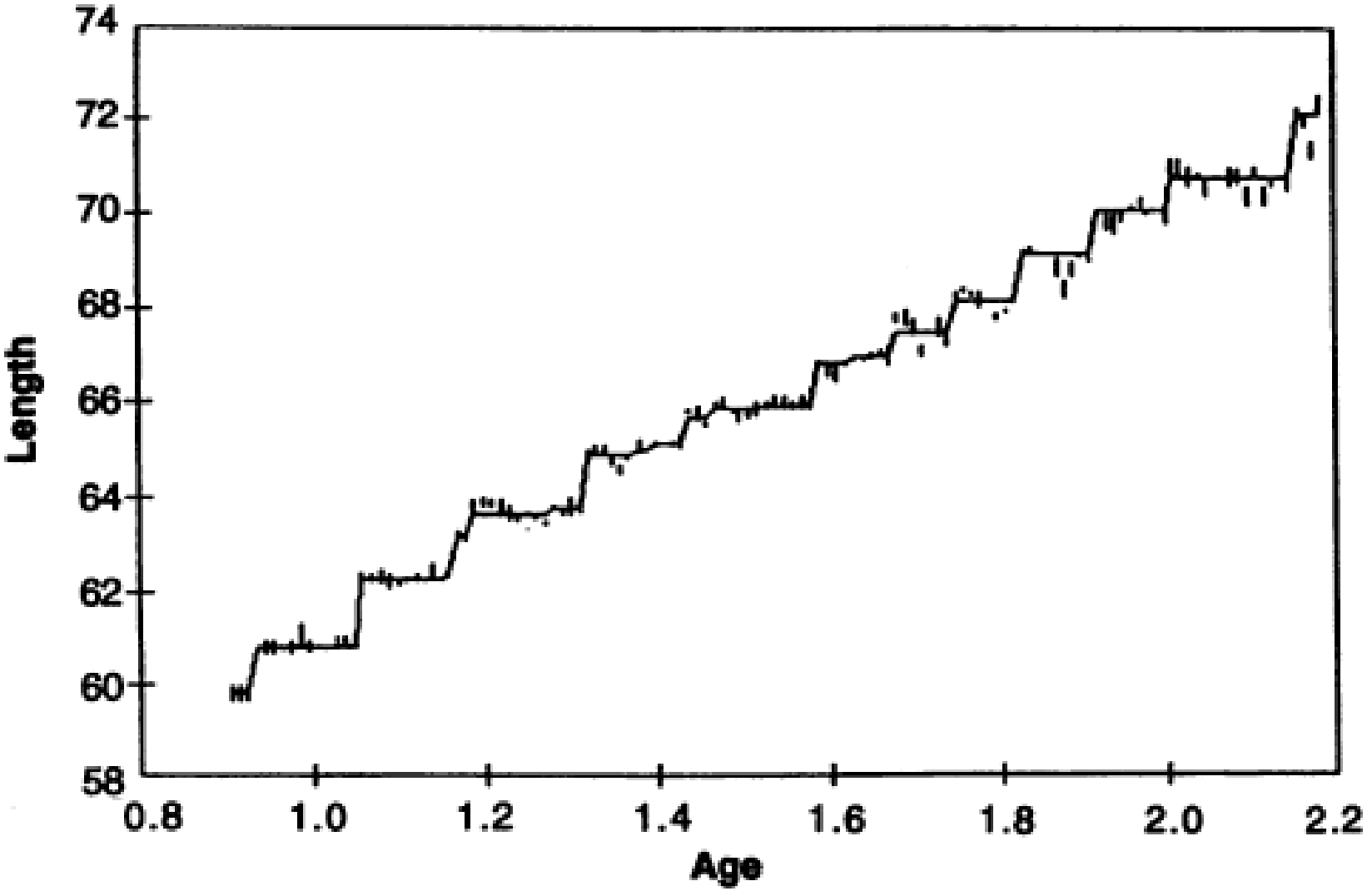
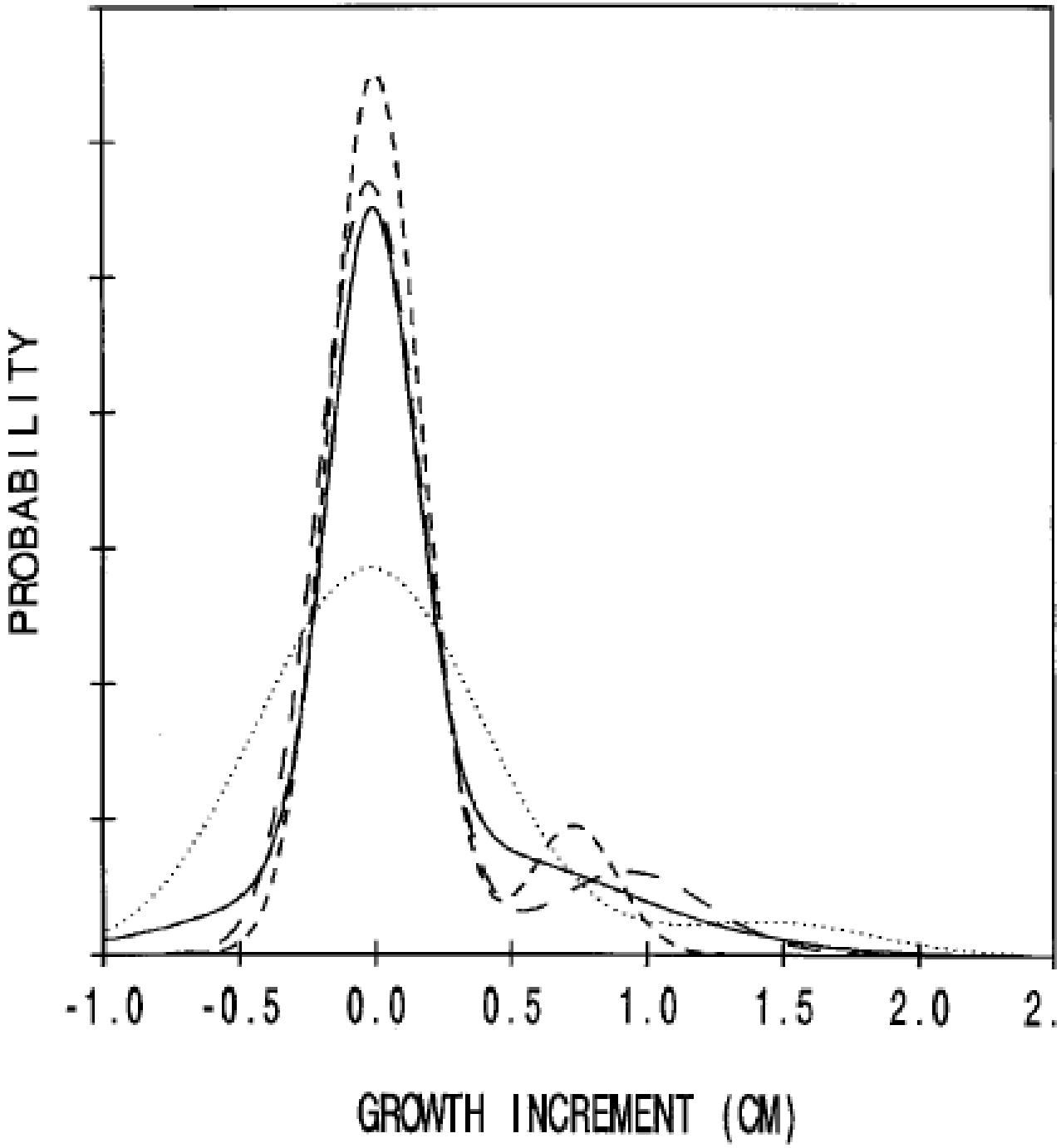
Current issues in nutrition planning and programming

- Claims that catch-up growth of children can occur after the 1000 days period (i.e., after 24 months of age)
- Lack of demonstrable intervention and program effects on reducing stunting
- Shifting emphasis from nutrition-specific to nutrition-sensitive interventions

Male infant measured daily from 90 to 218 days (~3 to 7 months) after birth (Lampl et al., 1992)





Distribution of daily increments in length for three infants

Lampl, Johnson, Frongillo (2001)

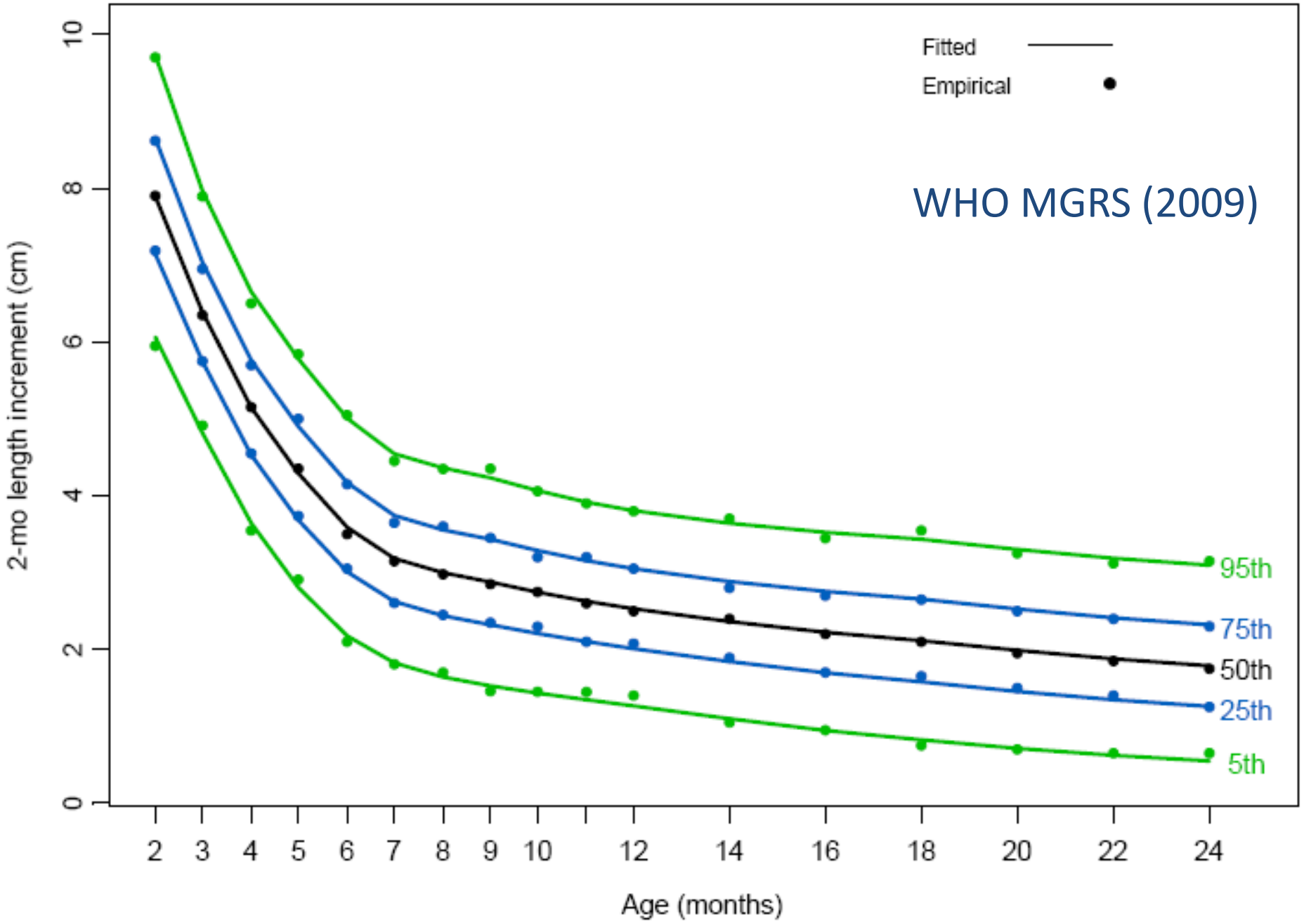


Figure A4.9 5th, 25th, 50th, 75th, 95th smoothed centile curves and empirical values: 2-month length velocity for girls

When, how, and why does length growth occur?

- Soft, pliable cartilage matrix takes up calcium and phosphate at end of long bones
- Regulation likely both local (i.e., at growth plate) and systemically
- 90% of bone elongation occurs during recumbence in lambs (Noonan et al., 2004)
- Infant growth in length follows prolonged sleep and increased naps (Lampl, Johnson, 2011)
- Weight gain coupled to length saltations in infants measured semi-weekly (21) or weekly (13) (Lampl, Thompson, Frongillo, 2011)

How could growth deficit and restoration theoretically occur?

Growth deficit

- Delayed saltation (i.e., extended stasis)
- Canceled saltation
- Reduced amplitude of saltation

Growth restoration

- Rescheduled saltation
- Replacement saltation
- Augmented amplitude of saltation

Restoring lost length growth

- Studied effect of fasting on tibia growth plates in 4-week-old rats
- 3-day fast caused immediate and profound decrease in growth rate in proximal plate to 30% of that of controls, while *stopping* growth in the more slowly growing distal plate
- Growth rate in both plates reached that of controls by 7 days post-fasting
- Proximal plate then maintained rates 10–15% higher than controls over rest of 4-week period
- Recovery of bone elongation rates is rapid, but restoration to expected length is prolonged process, even if insult of very short duration

Farnum et al. (2003)

Idea of restorative growth

- **Homeorhesis**: “tendency of growing organisms to return to their paths of growth after deviating from them” (Prader et al., 1963)
- **Catch-up growth**: “Height velocity above the statistical limits of normality for age or maturity during a defined period of time, following a transient period of growth inhibition; the effect of catch-up growth is to take the child towards his/her pre-retardation growth curve.” (Boersma & Wit, 1997; de Wit et al., 2013)

Note: full restoration of lost growth not required by this definition and unlikely to occur if prolonged inhibition

Evidence for human catch-up growth

- Adoption into better environment
- Alleviation of clinical disease (e.g., hypothyroidism, celiac disease, malnutrition, Cushing syndrome or chronic steroid treatment, and growth hormone deficiency)
- Growth of infants born small-for-gestational age

Note: several recent articles claim evidence of catch-up growth using methods that cannot provide such evidence

Uses of anthropometry

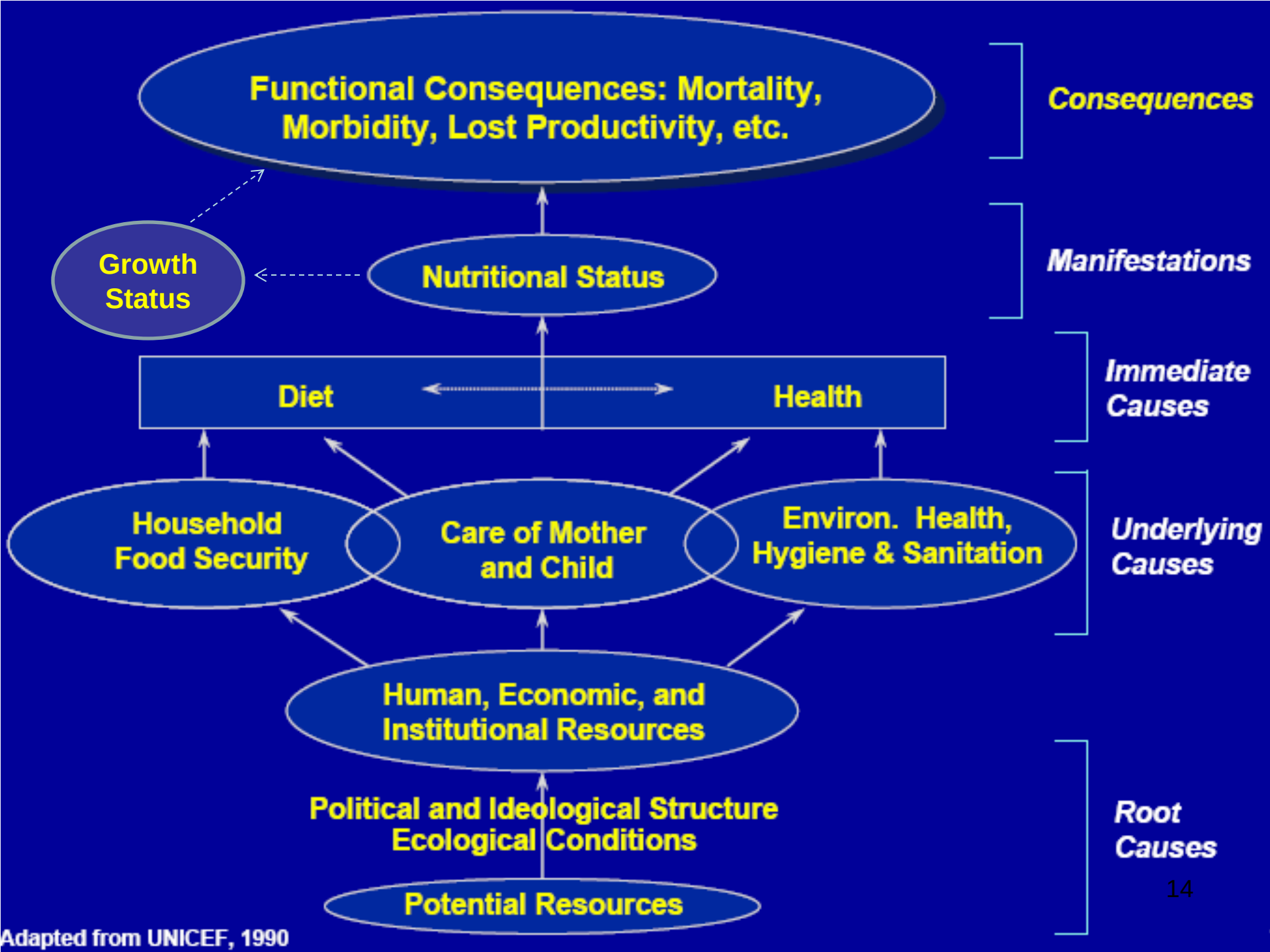
Growth similar across well-nourished populations	1974
International reference from US national data	1979-1983
SCN first report of world nutrition situation (weight)	1987
WHO review uses and interpretations of anthropometry	1991-1995
WHO Evaluation of Infant Growth	1994
WHO Multicentre Growth Reference Study designed	1996
SCN third report of world nutrition situation (height)	1997
WHO Multicentre Growth Reference Study in field	1997-2003
International cross-sectional growth standards 0-5 y	2006
Field-testing of growth standards in four countries	2007
WHO growth reference for school-aged children 5-19 y	2007
International velocity growth standards released 0-2 y	2009

Assessment through measures and indicators

- Measure
  - Assign numbers to represent whether a person or thing is higher or lower on some characteristic of interest
  - Obtained through the application of tools or instruments
- Indicator
  - Demonstrate an aspect of the characteristic for person or thing (or identify those with the aspect)
  - Derived from one or more measures or directly from tool or instrument

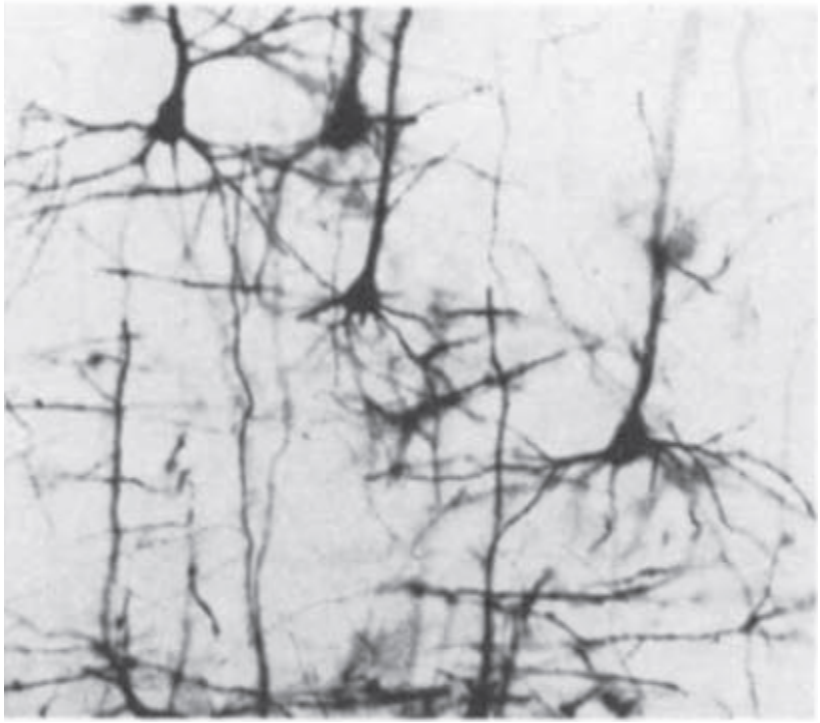
Assessing child physical growth

Method	**Measure**	**Indicator**
Physical assessment using: • weighing scales • length boards • stadiometers • tape measures	• Weight • Length • Height • Head circ. • Arm circ. • Z-scores	• < -2 SD relative to WHO growth standards • Others


Functional Consequences: Mortality, Morbidity, Lost Productivity, etc.
Consequences
Growth Status
Nutritional Status
Manifestations
Diet
Health
Immediate Causes
Household Food Security
Care of Mother and Child
Environ. Health, Hygiene & Sanitation
Underlying Causes
Human, Economic, and Institutional Resources
Political and Ideological Structure
Ecological Conditions
Potential Resources
Root Causes
Adapted from UNICEF, 1990

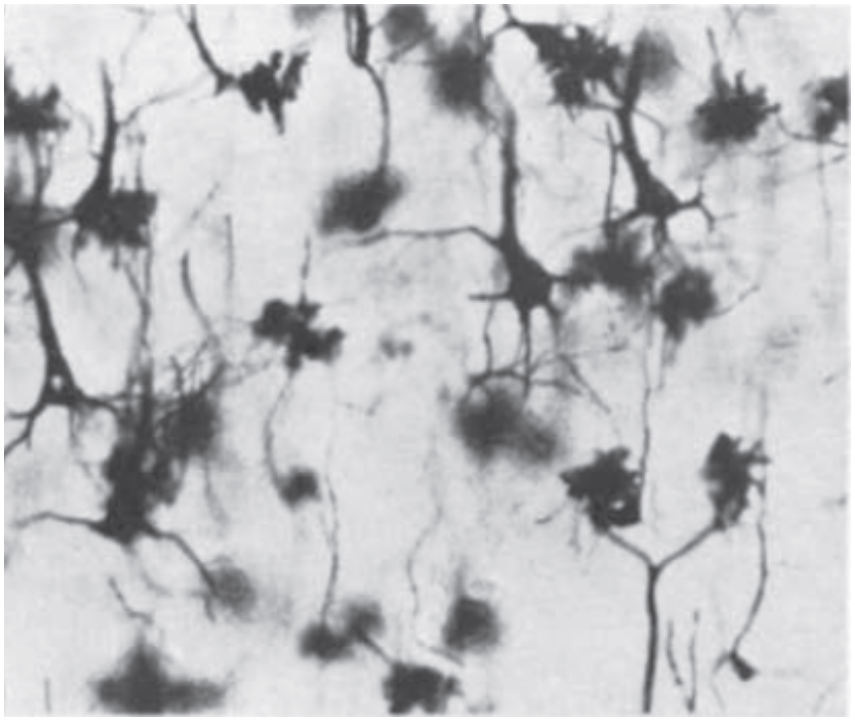
Stunting and brain development

Normal



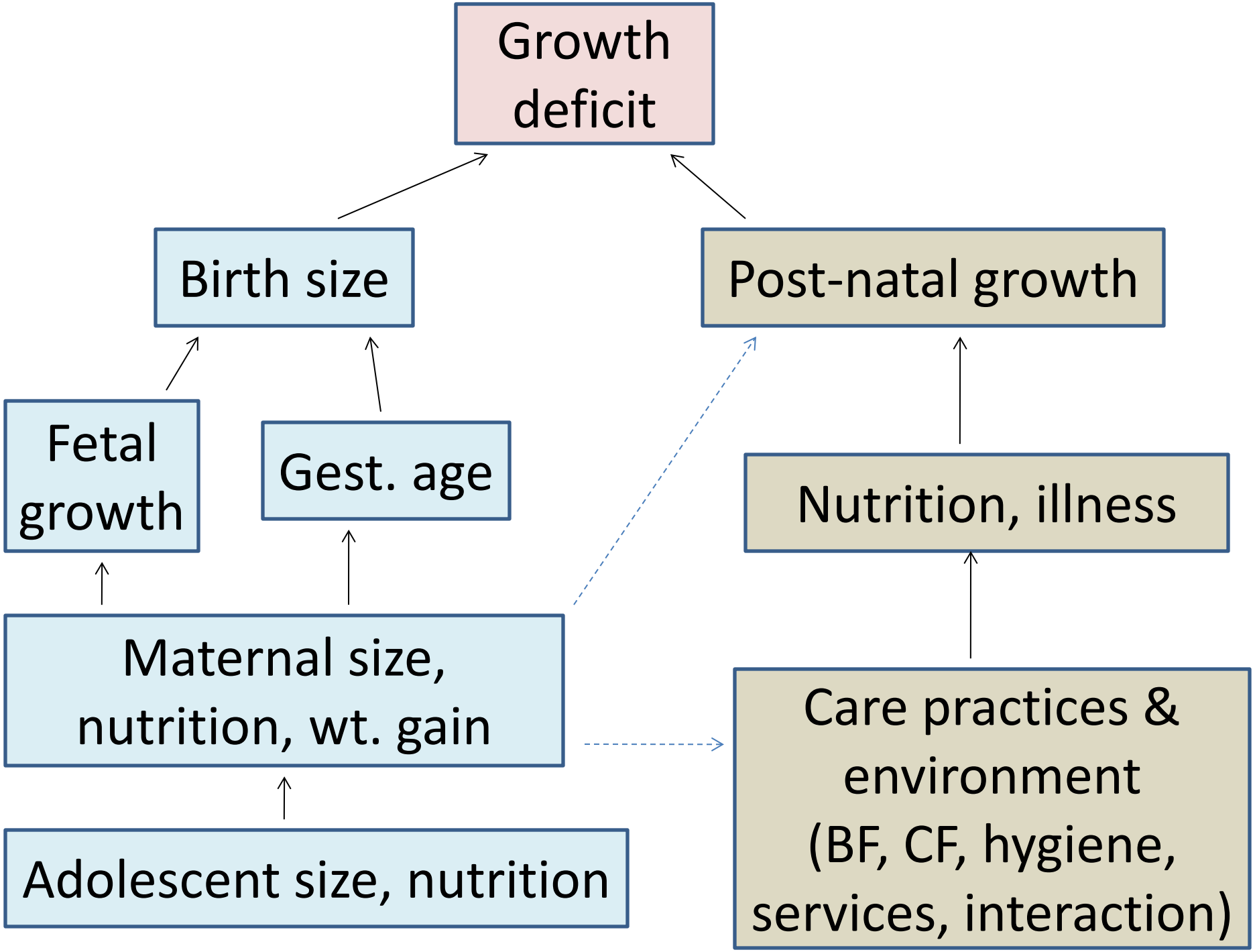
Typical brain cells
Extensive branching

Stunted



Impaired brain cells
Limited branching
Abnormal, shorter branches

Source: Cordero E et al, 1993


Growth deficit
Birth size
Post-natal growth
Fetal growth
Gest. age
Nutrition, illness
Maternal size, nutrition, wt. gain
Care practices & environment (BF, CF, hygiene, services, interaction)
Adolescent size, nutrition

Purposes for **groups** of households or individuals

Purpose	*Question*
Estimation of prevalence	How many are affected?
Determination of causes and consequences	Why are they affected and what are effects?
Early warning	When is action needed?
Targeting	Who will receive which action?
Monitoring	How is the situation changing?
Impact evaluation	Has the action made a difference?

WHO (1995), Frongillo (1999), Leroy et al. (2015)

Purposes for **groups** of households or individuals

Purpose	*Question*
Estimation of prevalence 1	How many are affected?
Determination of causes and consequences	Why are they affected and what are effects?
Early warning	When is action needed?
Targeting 2	Who will receive which action?
Monitoring 1	How is the situation changing?
Impact evaluation 3	Has the action made a difference?

WHO (1995), Frongillo (1999), Leroy et al. (2015)

Purposes for **separate** households or individuals

Purpose	*Question*
Screening	Is the household or individual at risk?
Diagnosis of problem	Does the household or individual have the problem, and what are the salient causes?
Diagnosis of solution	What is the most appropriate action?
Monitoring	How is the situation changing?

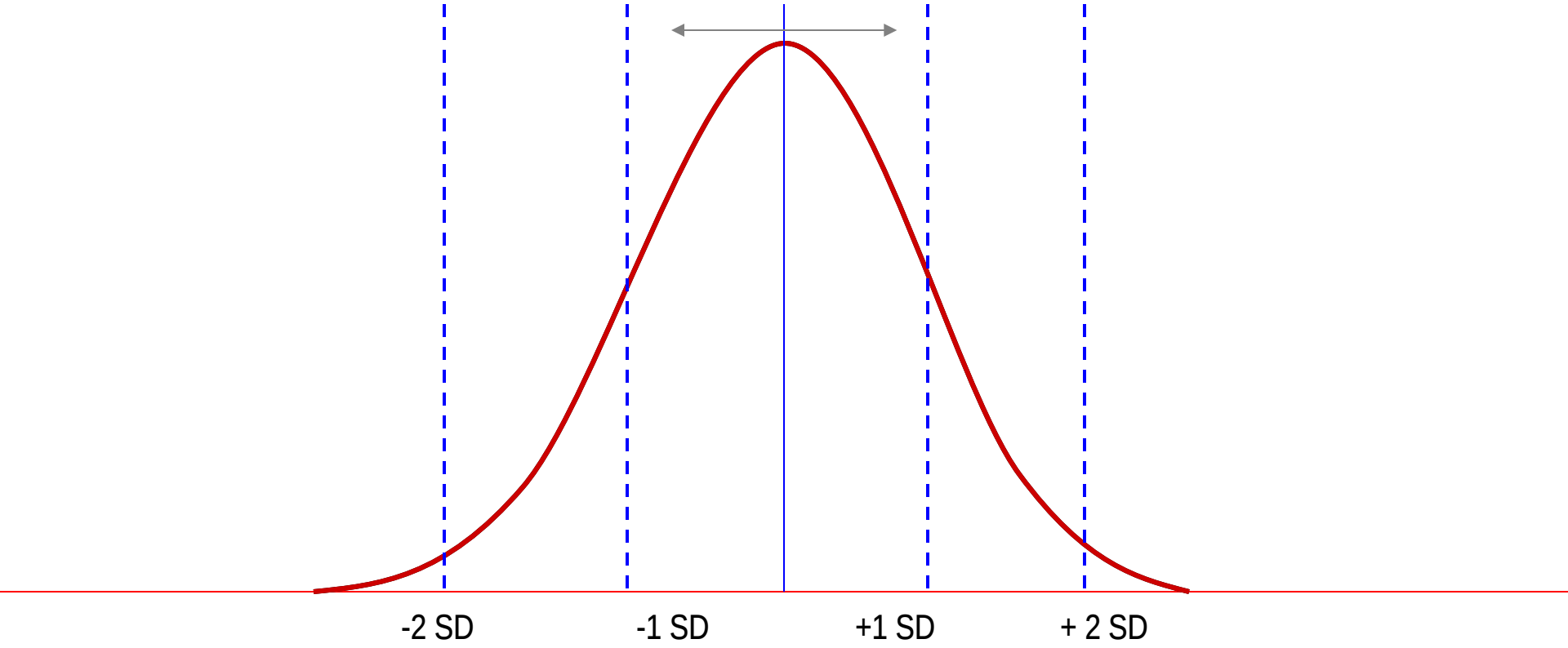
WHO (1995), Frongillo (1999), Leroy et al. (2015)

Considerations in selecting measures and indicators

- Valid for intended purpose and context
  - Well-constructed from in-depth understanding
  - Reliable (i.e., precise and dependable)
  - Accurate
- Equivalent across contexts with appropriate adaptation
  - Constructs and items
  - Interval and scale
- Contributes to advancing the field
  - Garners attention for issue and investment in solutions
  - Fosters understanding of issue and causes and consequences
  - Feasible in large effectiveness studies and monitoring
  - Reflects benefits of intervention inputs and activities

Frongillo (1999), Frongillo et al. (2014)

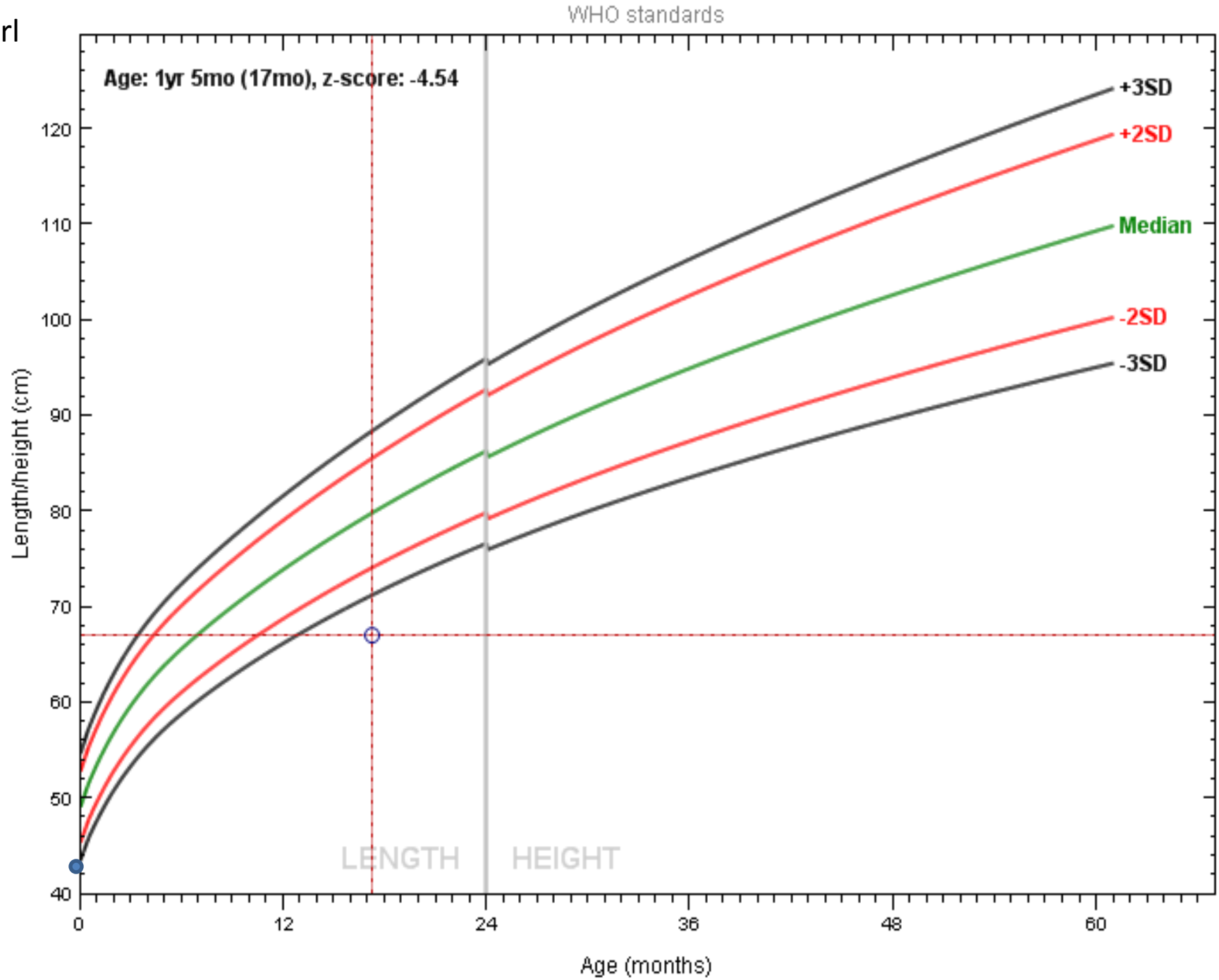
Z-scores

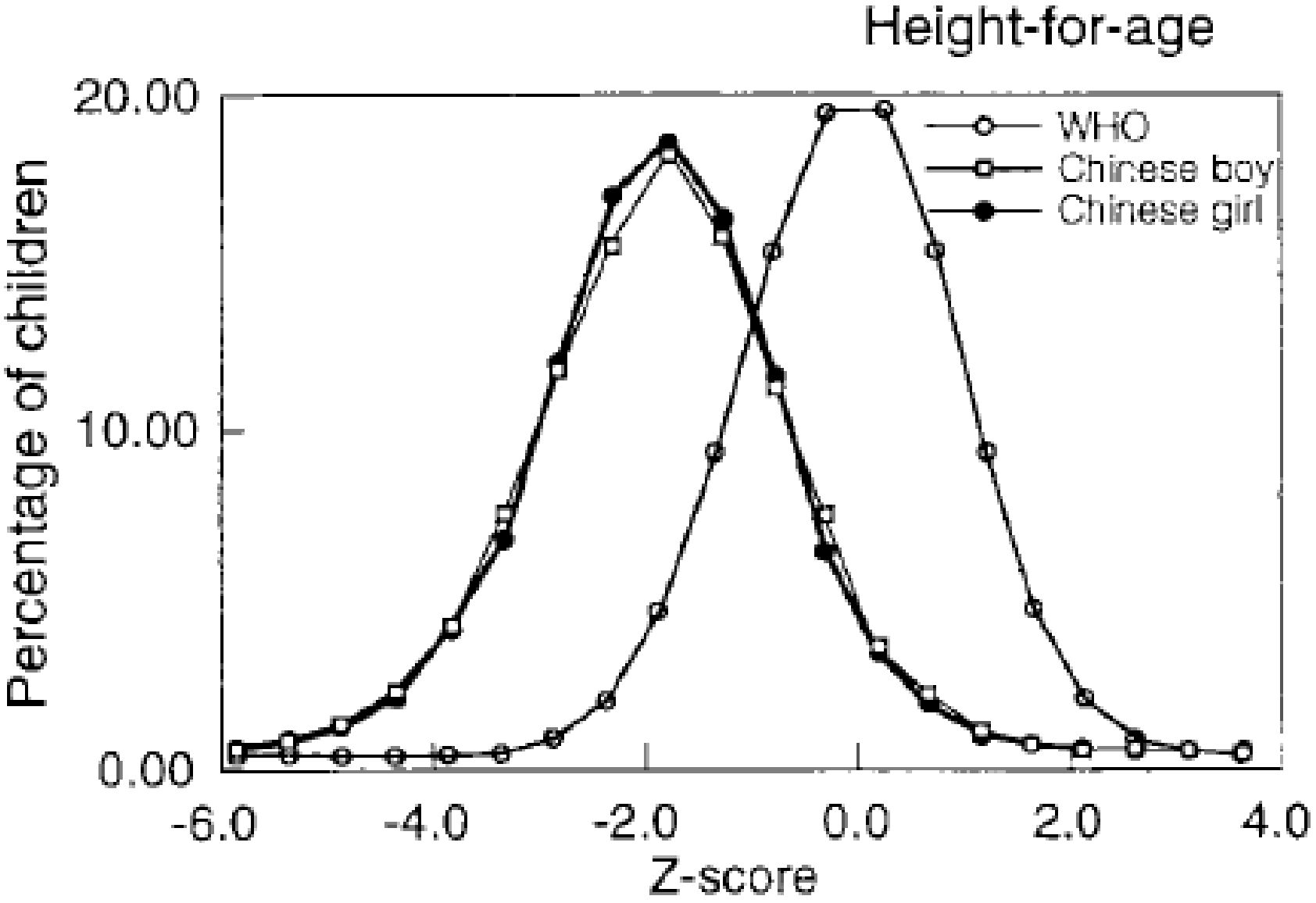


$$\text{Z-score} = (\text{measurement} - \text{median}_{\text{standard}}) / \text{SD}_{\text{standard}}$$

$$\text{centile} = 100\ \Phi(\text{Z-score})$$

Girl

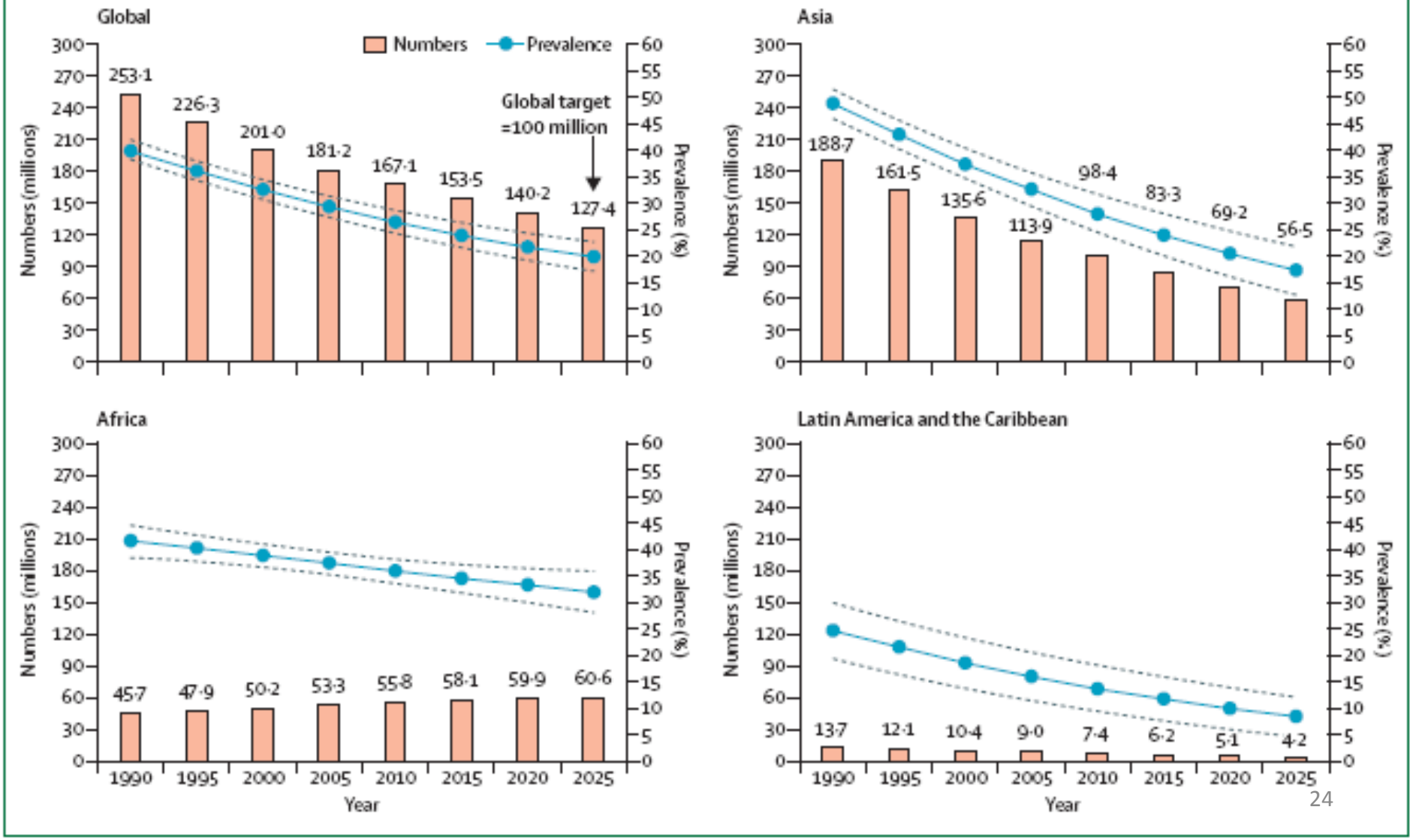

WHO standards
Age: 1yr 5mo (17mo), z-score: -4.54
+3SD
+2SD
Median
-2SD
-3SD
Length/height (cm)
120
110
100
90
80
70
60
50
40
LENGTH
HEIGHT
0
12
24
36
48
60
Age (months)


Height-for-age
20.00
10.00
0.00
Percentage of children
WHO
Chinese boy
Chinese girl
-6.0
-4.0
-2.0
0.0
2.0
4.0
Z-score

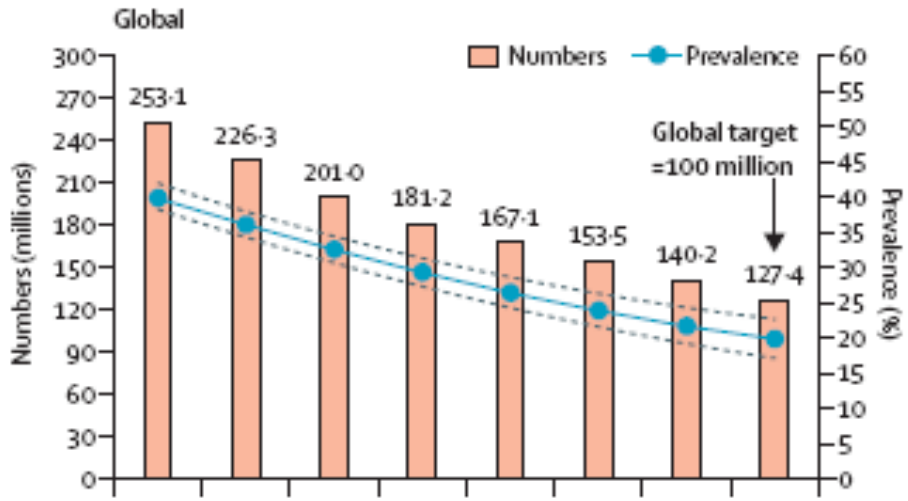
WHO (1995)

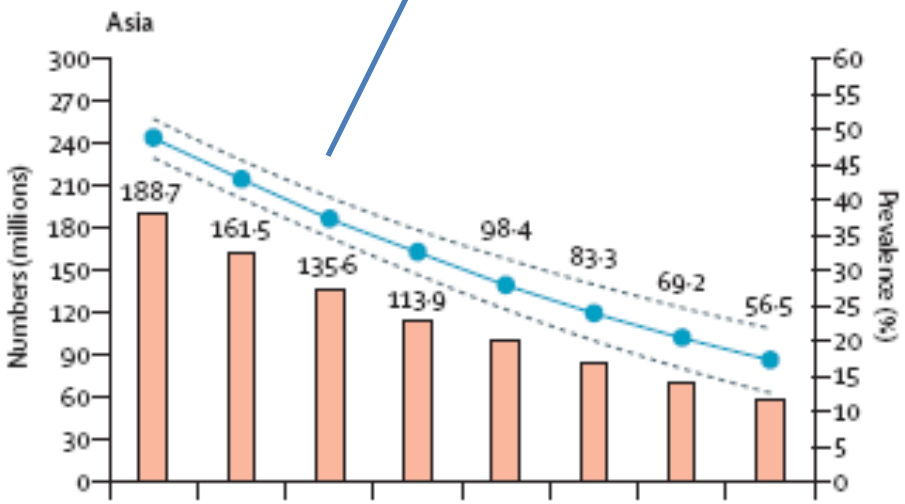
Child stunting

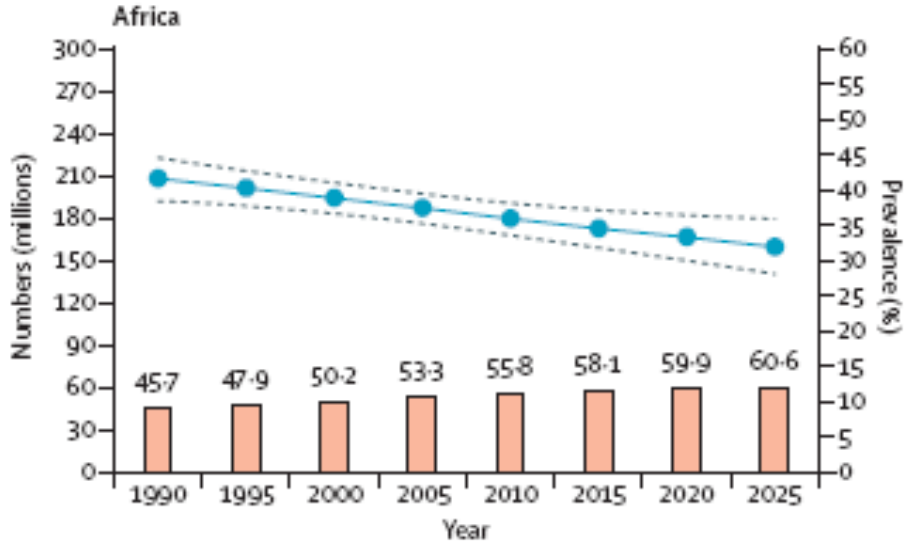
2013 Lancet Nutrition Series

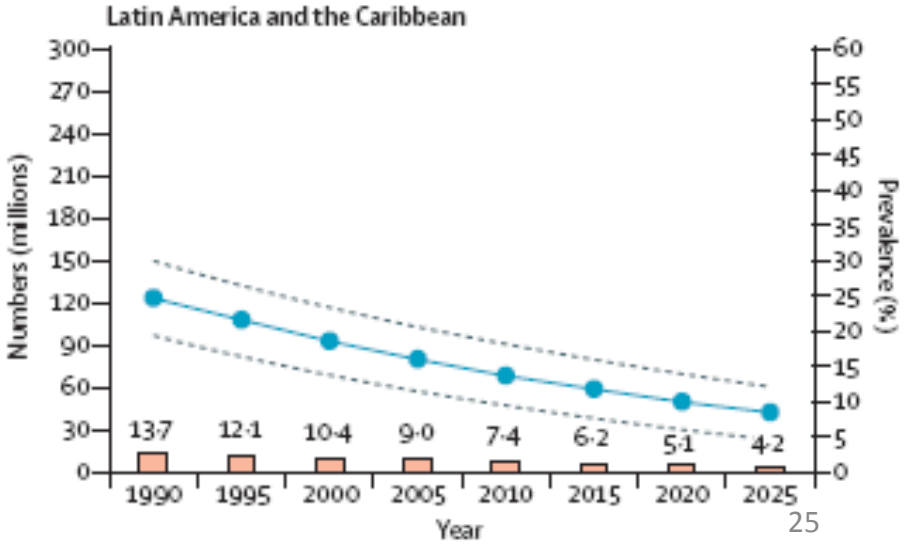


49% in 1990 to 28% in 2010 or 1 pp/y
Corresponding increase in HAZ: 0.6 or 0.03/y









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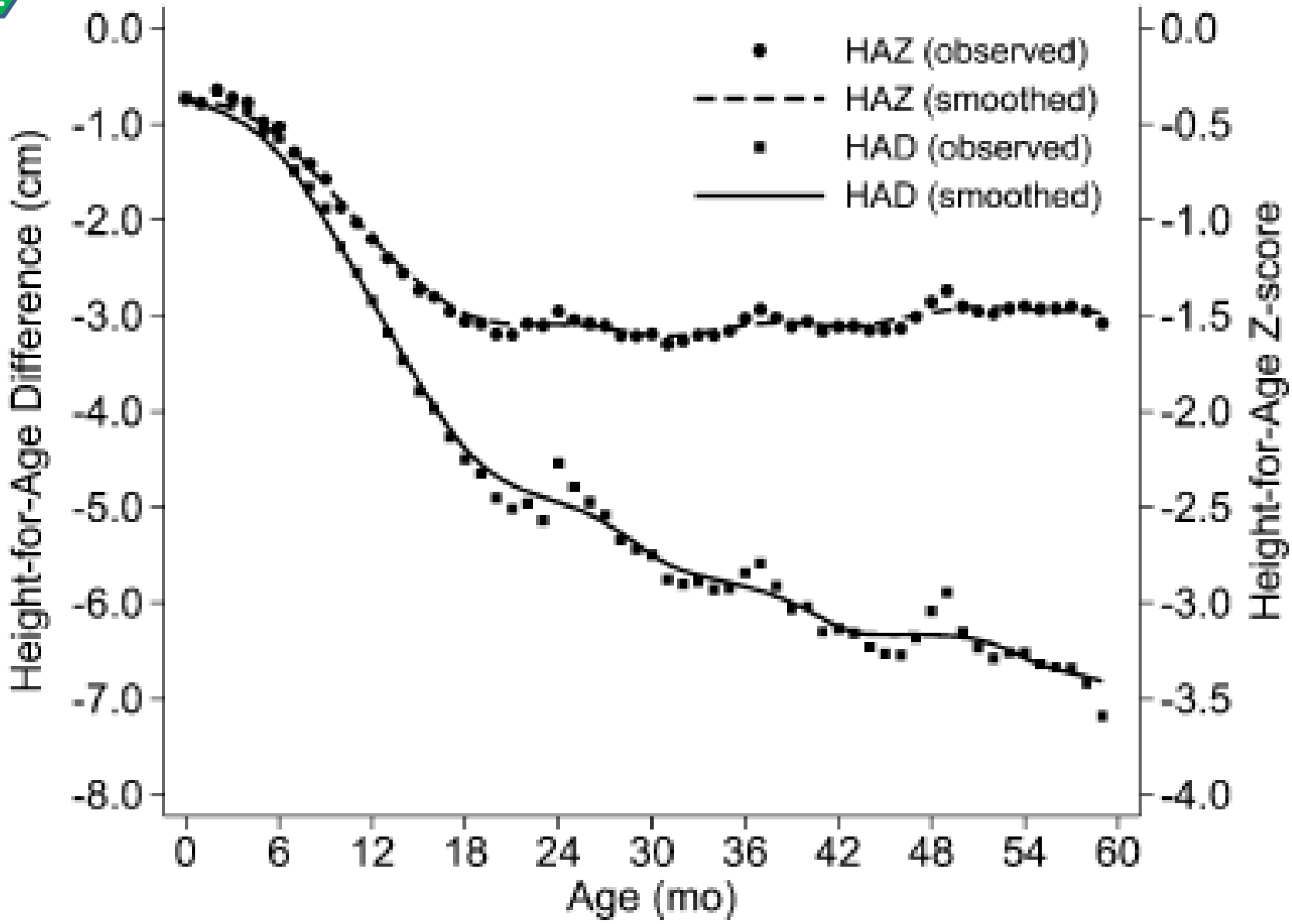

Leroy, Ruel, Habicht, Frongillo (2014, 2015)

3

MINIMat Study – Bangladesh

Differential effects of nutrition interventions

	Early invitation to food supplementation			Usual invitation to food supplementation		
	Fe30F	Fe60F	MMS	Fe30F	Fe60F	MMS
Birth weight	2689	2717	2696	2688	2665	2710
HAZ at 24 mo	-1.91	-1.92	-1.99	-1.99	-2.02	-2.06
Neonatal mortality*	28	33	12	25	38	42
Infant mortality*	43	43	17	31	44	47

*rate per 1000 live births

Khan et al. (2011); Persson et al. (2012)

MINIMat Study -- Bangladesh

Biggest group difference: 52 g
Increase throughout 2 y of study: 80 g

	Usual invitation to food supplementation			Usual invitation to food supplementation		
	Fe30F	Fe60F	MMS	Fe30F	Fe60F	MMS
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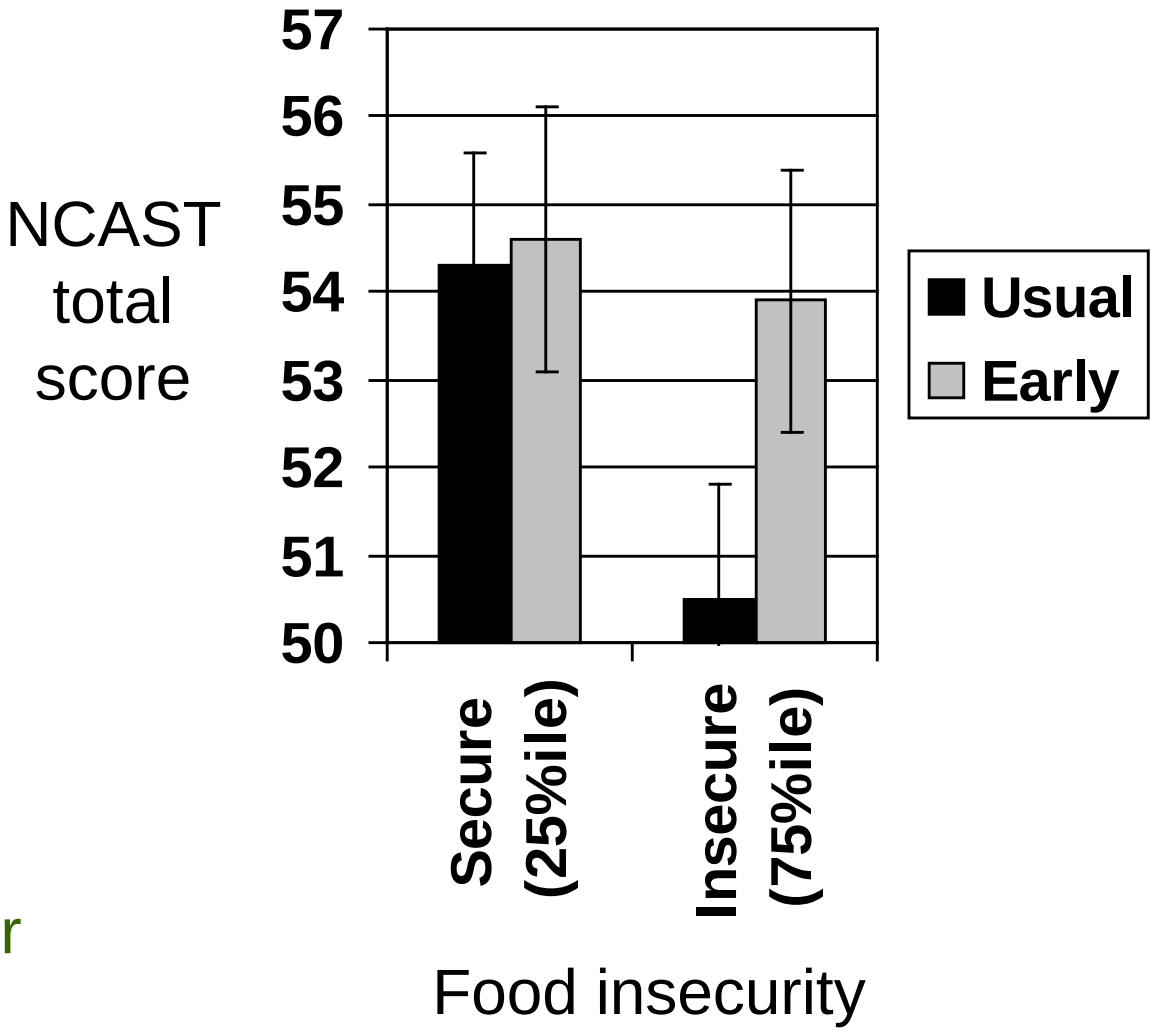
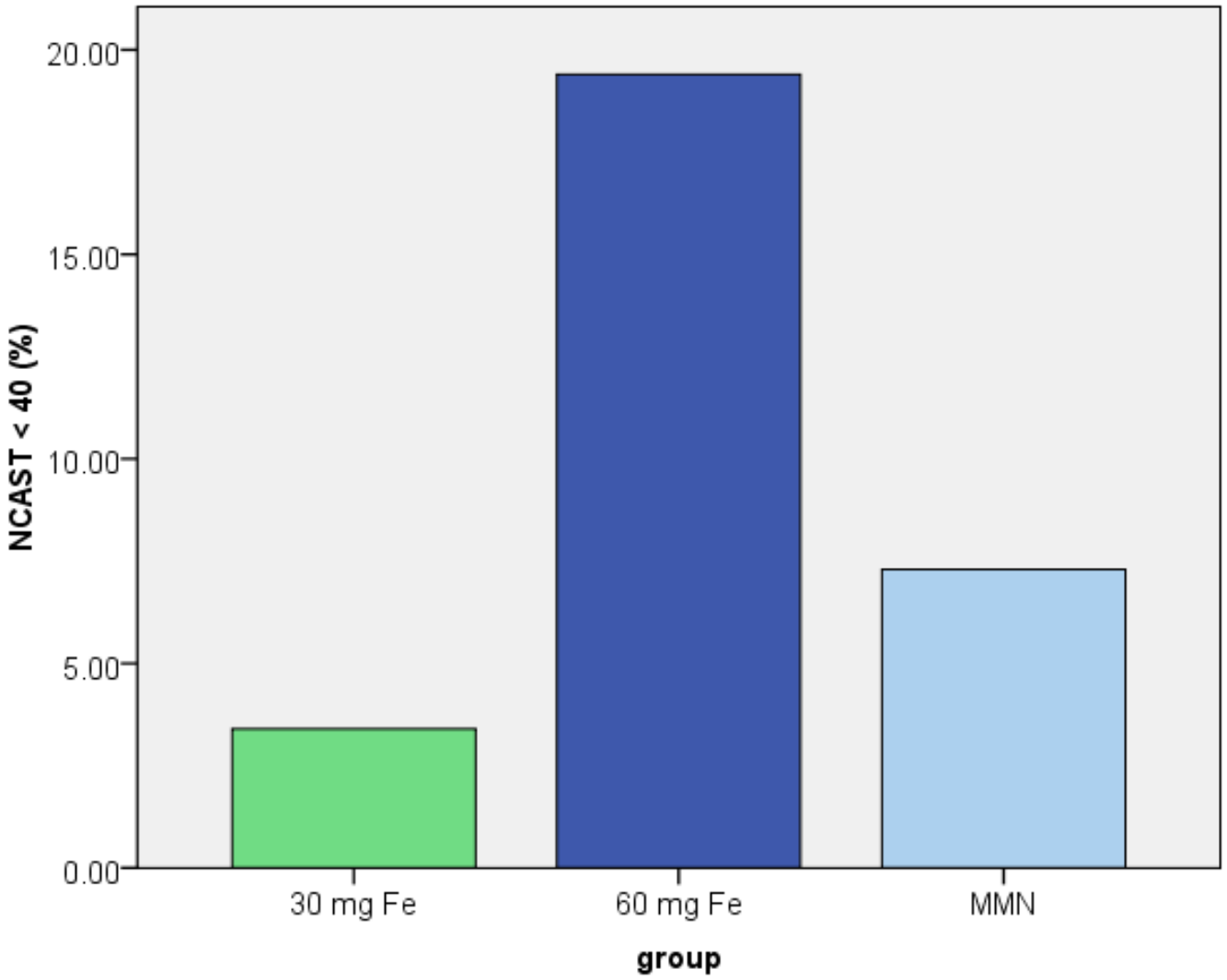
Early vs. usual supplementation



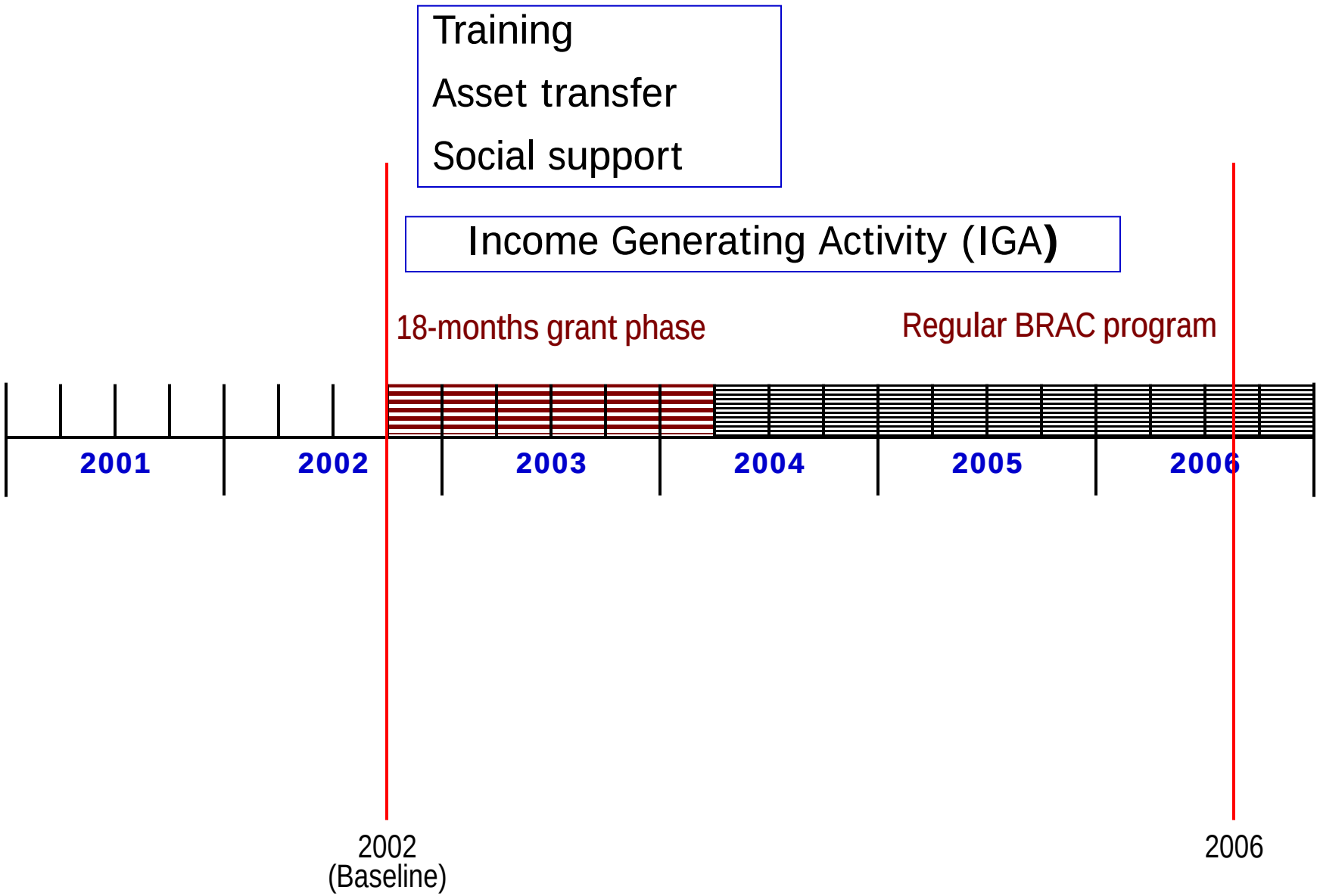
p=0.04

Similar pattern for physical abuse

Low maternal-infant interaction



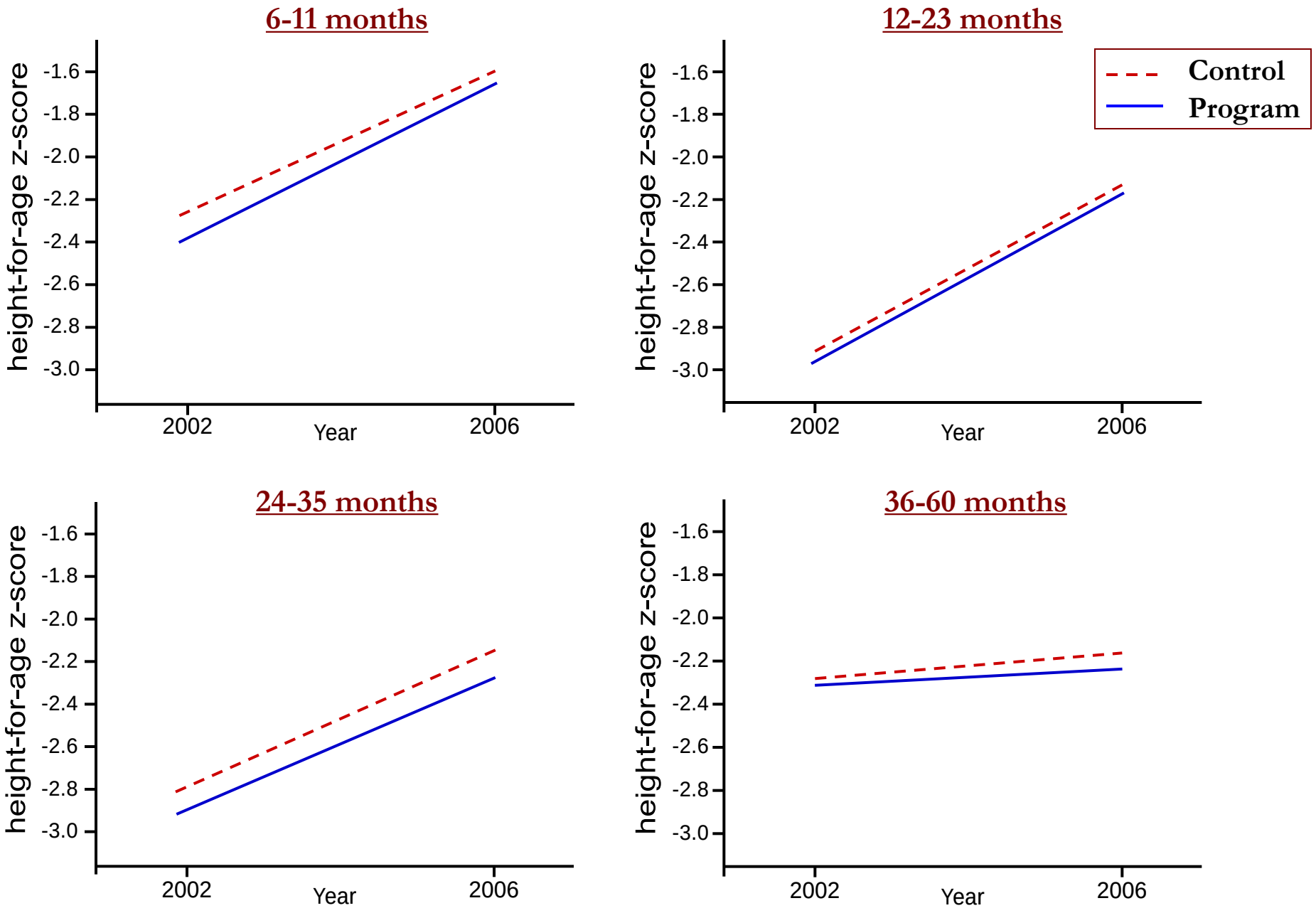
BRAC program for ultra poor



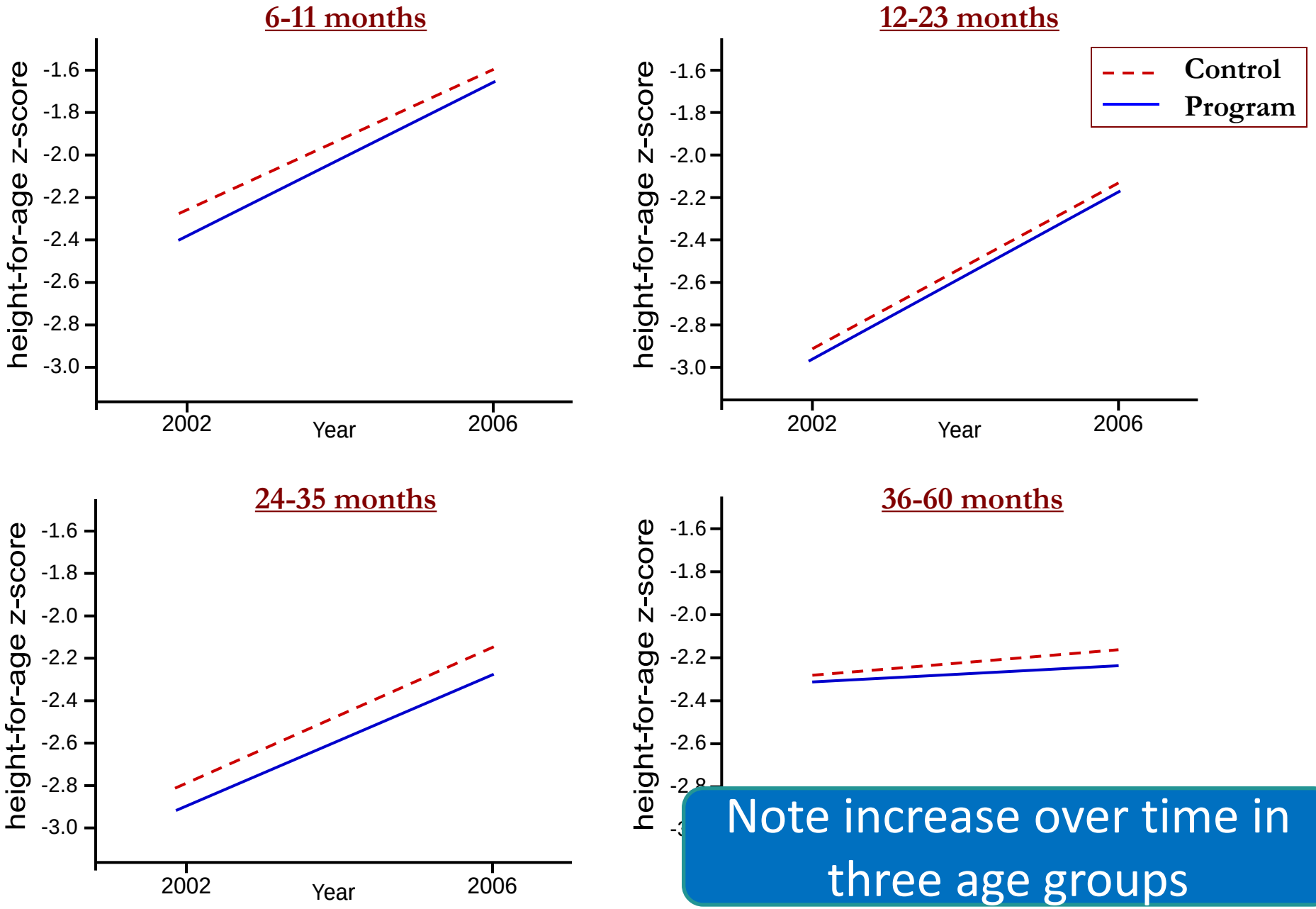
Magnitude of program's effect on outcomes

Outcome	Effect size	*p* value	*AR*
<u>Wellbeing</u>			
Positive Affect & Negative Affect Schedule	1.07	<0.01	
Satisfaction With Life Scales	1.31	<0.01	0.34-0.44
Single response	1.18	<0.01	
<u>Economic Status</u>			
Measured economy in 2005	0.60	<0.01	
Perceived economy in 2006	0.42	<0.01	
Food insecurity	0.53	<0.01	0.17
Domestic violence	0.29	<0.01	0.22

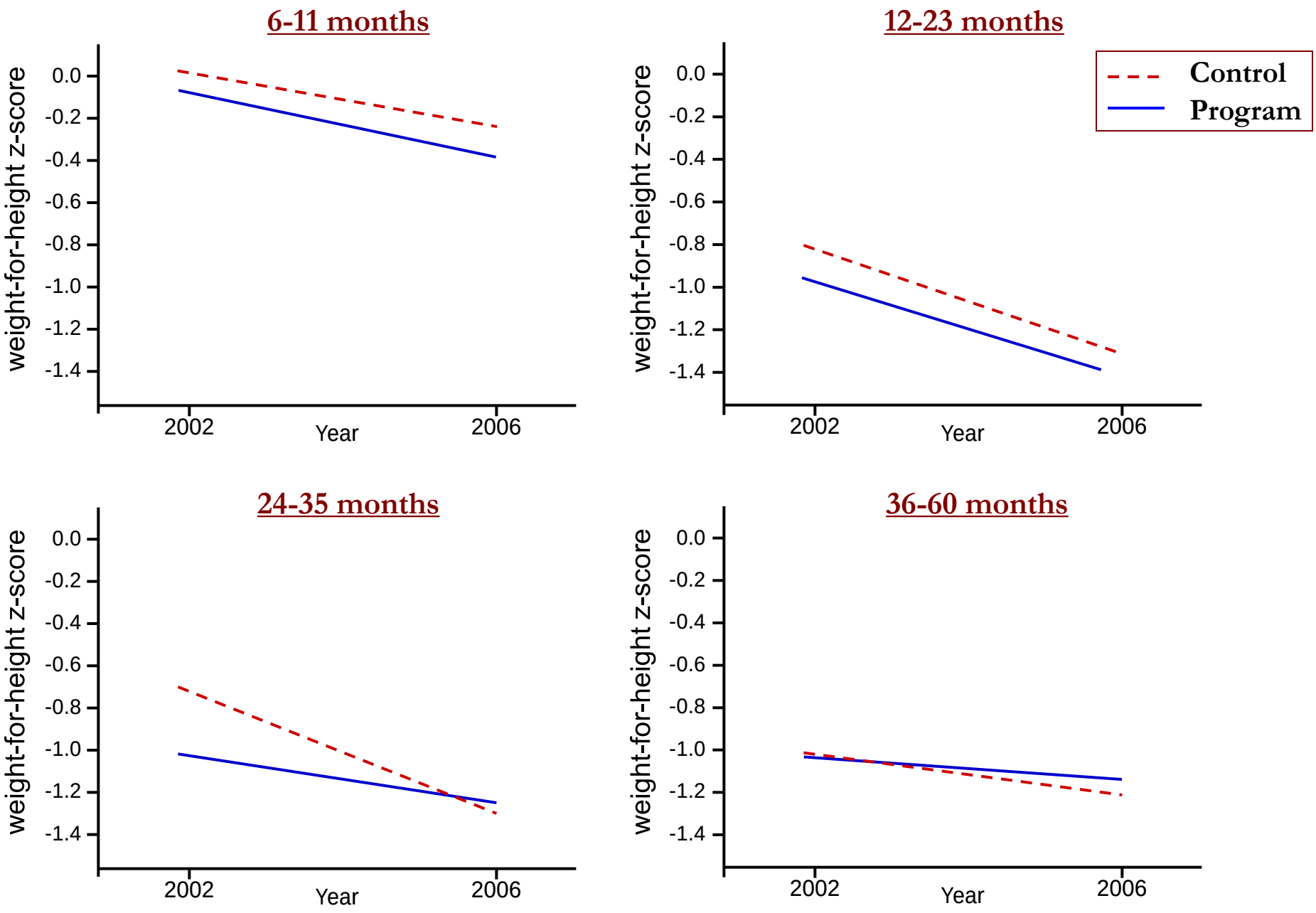
Comparison of adjusted mean height-for-age z-score



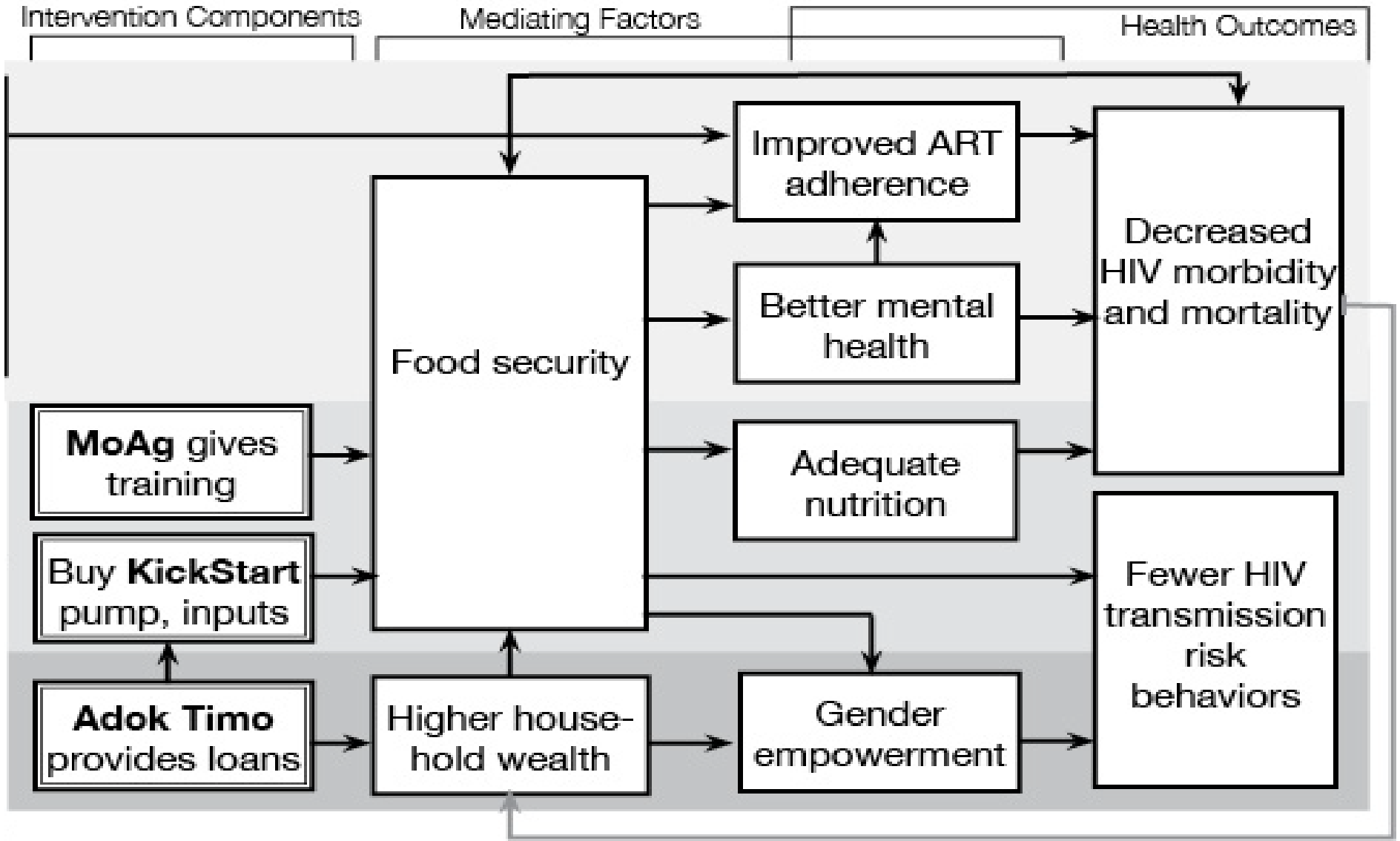
Comparison of adjusted mean height-for-age z-score



Comparison of adjusted mean weight-for-height z-score

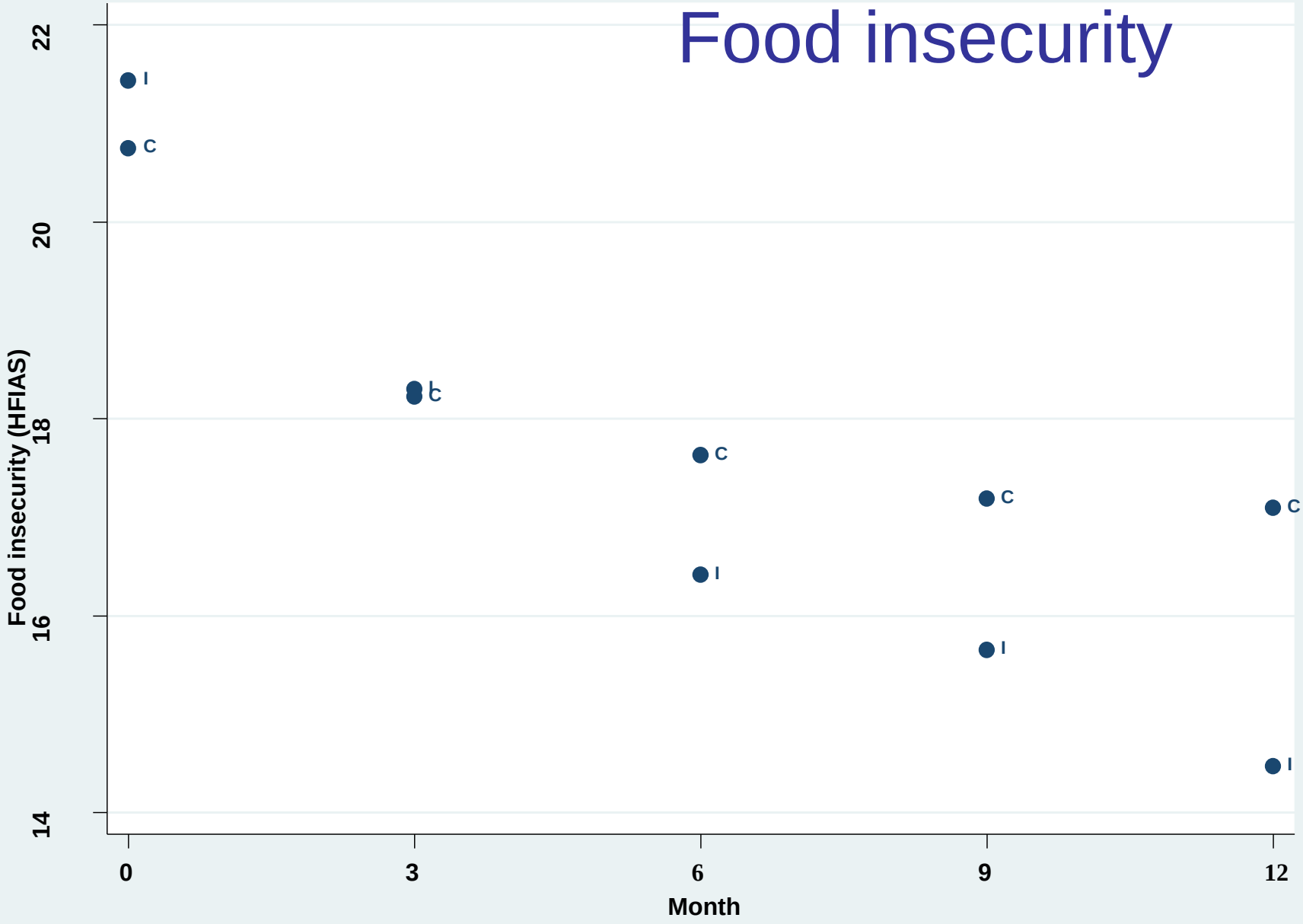


Shamba Maisha study -- rural Kenya



Weiser, Cohen, et al. (2015)

Food insecurity



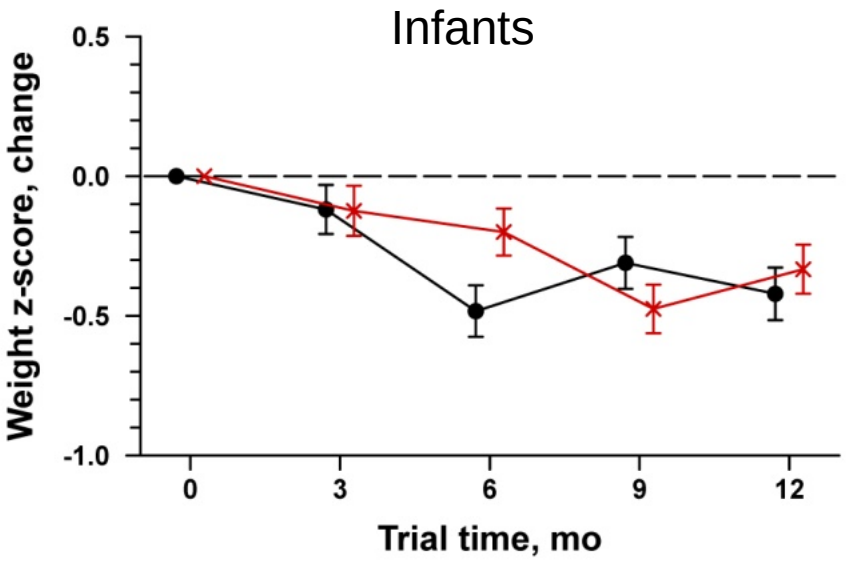
Greater increase with intervention

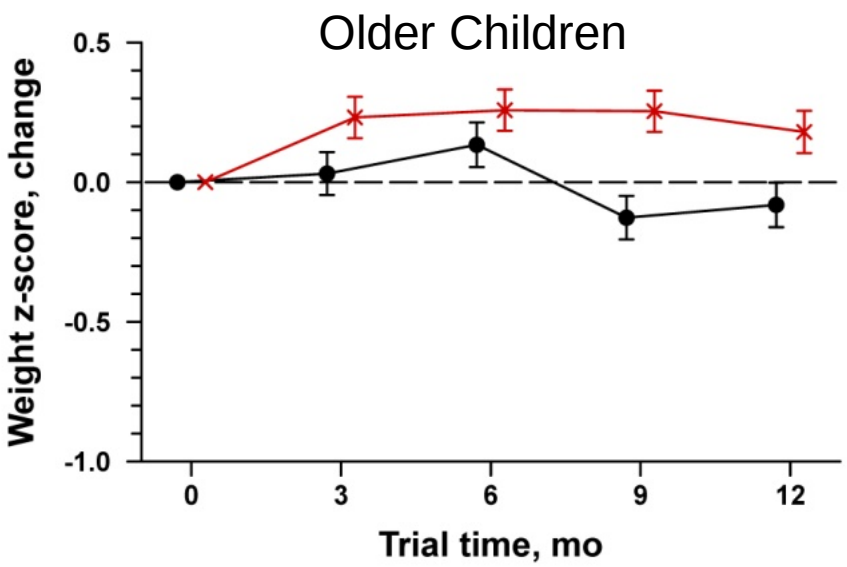
- food frequency
  - overall
  - cooking fat
  - dairy
  - sweets
  - vegetables
  - condiments
- food expenditures
  - sweets
  - fruit
  - condiments
- Self-confidence
- CD4
- Viral load suppression

Weiser, Cohen, et al. (2015)

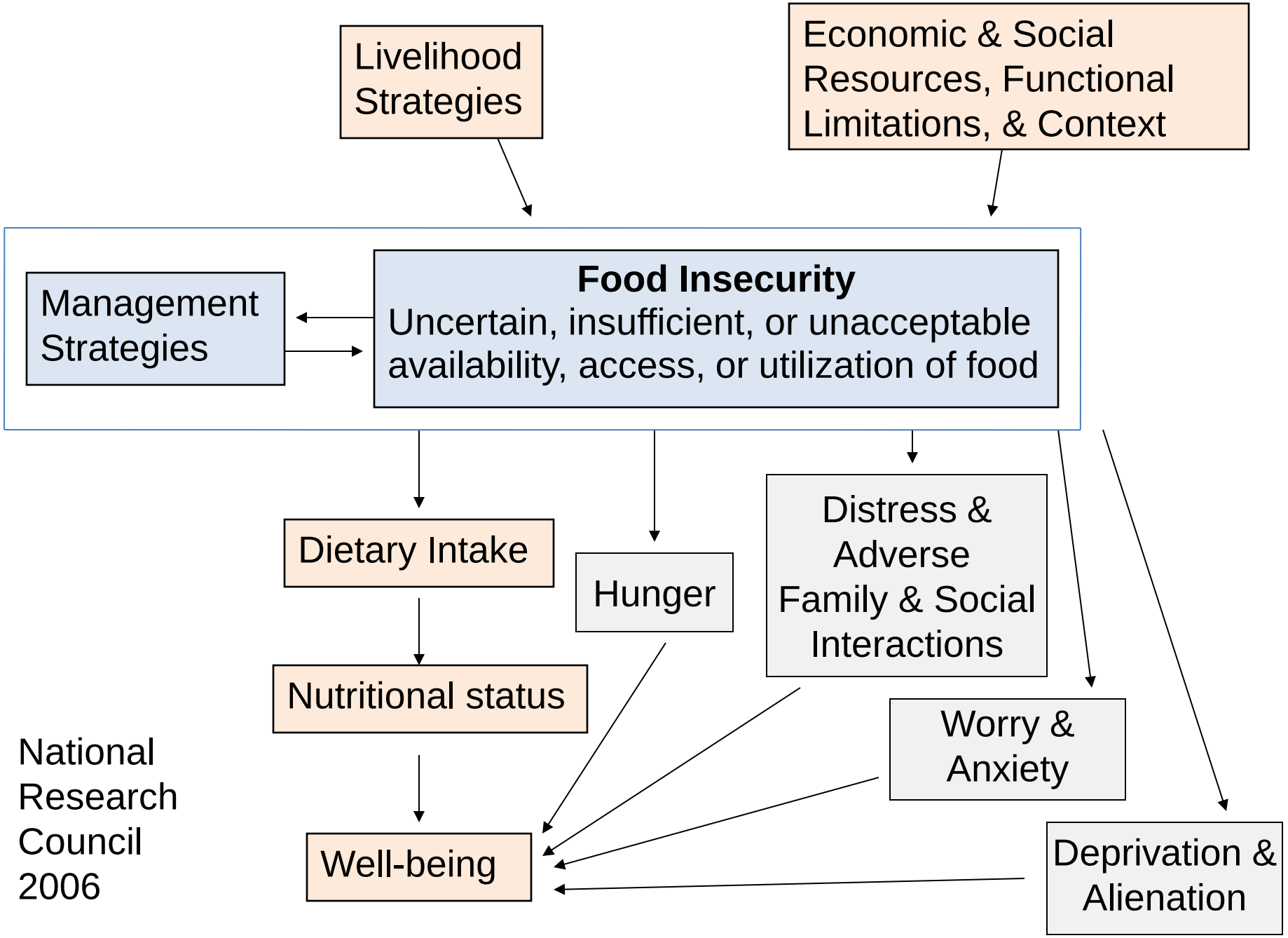
Weight Z-Score

Intervention
Control





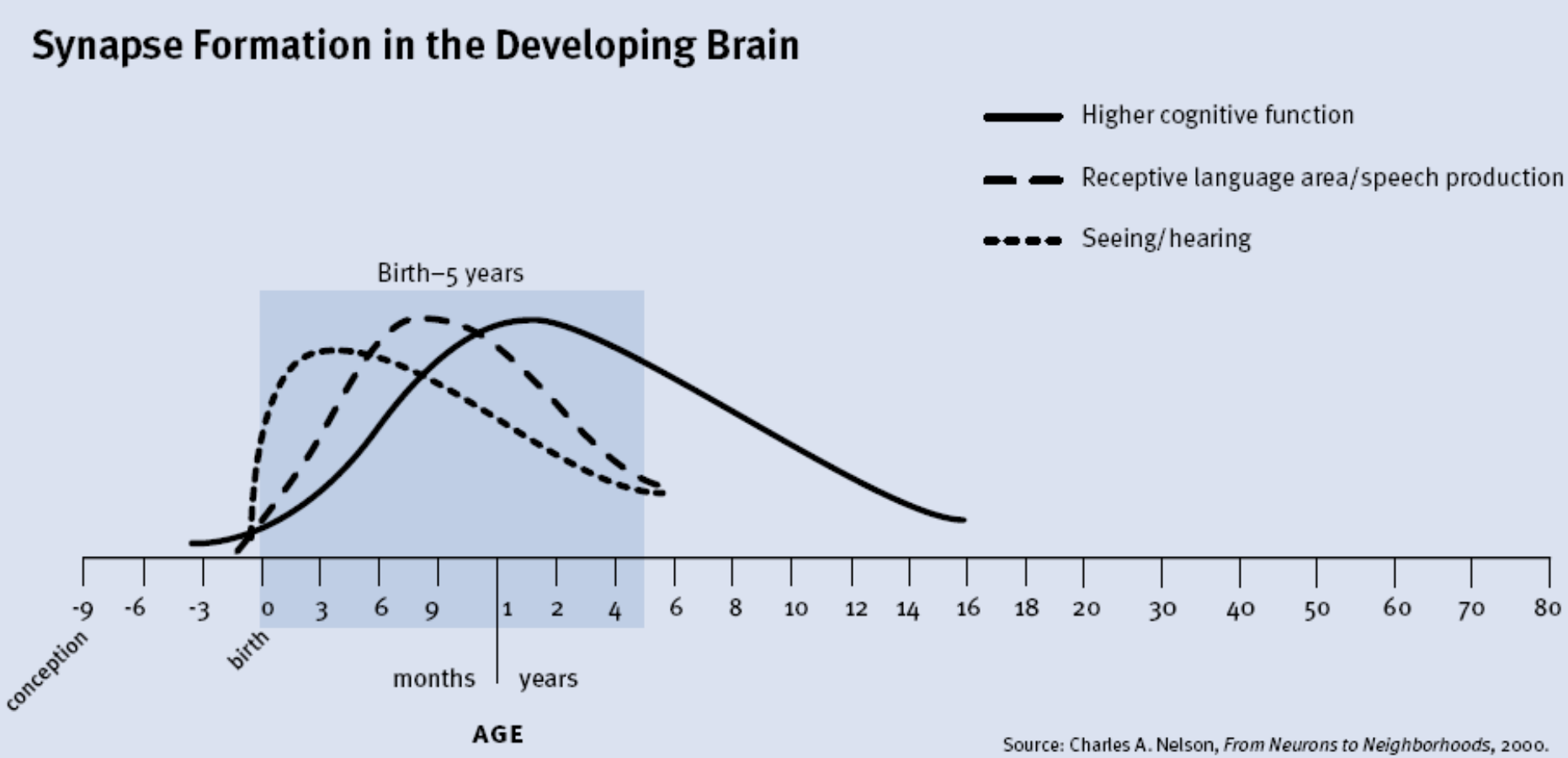
Butler et al. (in preparation)


Livelihood Strategies
Economic & Social Resources, Functional Limitations, & Context
Management Strategies
Food Insecurity
Uncertain, insufficient, or unacceptable availability, access, or utilization of food
Dietary Intake
Hunger
Distress & Adverse Family & Social Interactions
Nutritional status
Worry & Anxiety
Well-being
Deprivation & Alienation
National Research Council 2006

Children in (even marginally) food-insecure households do poorly

- Behavior
- Mental health
  - Depressive symptoms
  - Attempting suicide
  - Seeing psychologist
- Social
- Academic performance
- Absenteeism
- Repeating grade
- Developmental trajectories
- Hospitalizations
- Diet
- Physical activity
- Obesity
- Altered daily activities (e.g., cooking, care, labor)

National Research Council 2006; Alaimo, Olson & Frongillo 2001, 2002; Slack & Yoo 2005; Jyoti, Frongillo & Jones 2005; Cook et al. 2006; Cook et al. 2013; To et al. 2014; Bernal et al. 2014; Fram et al. 2015

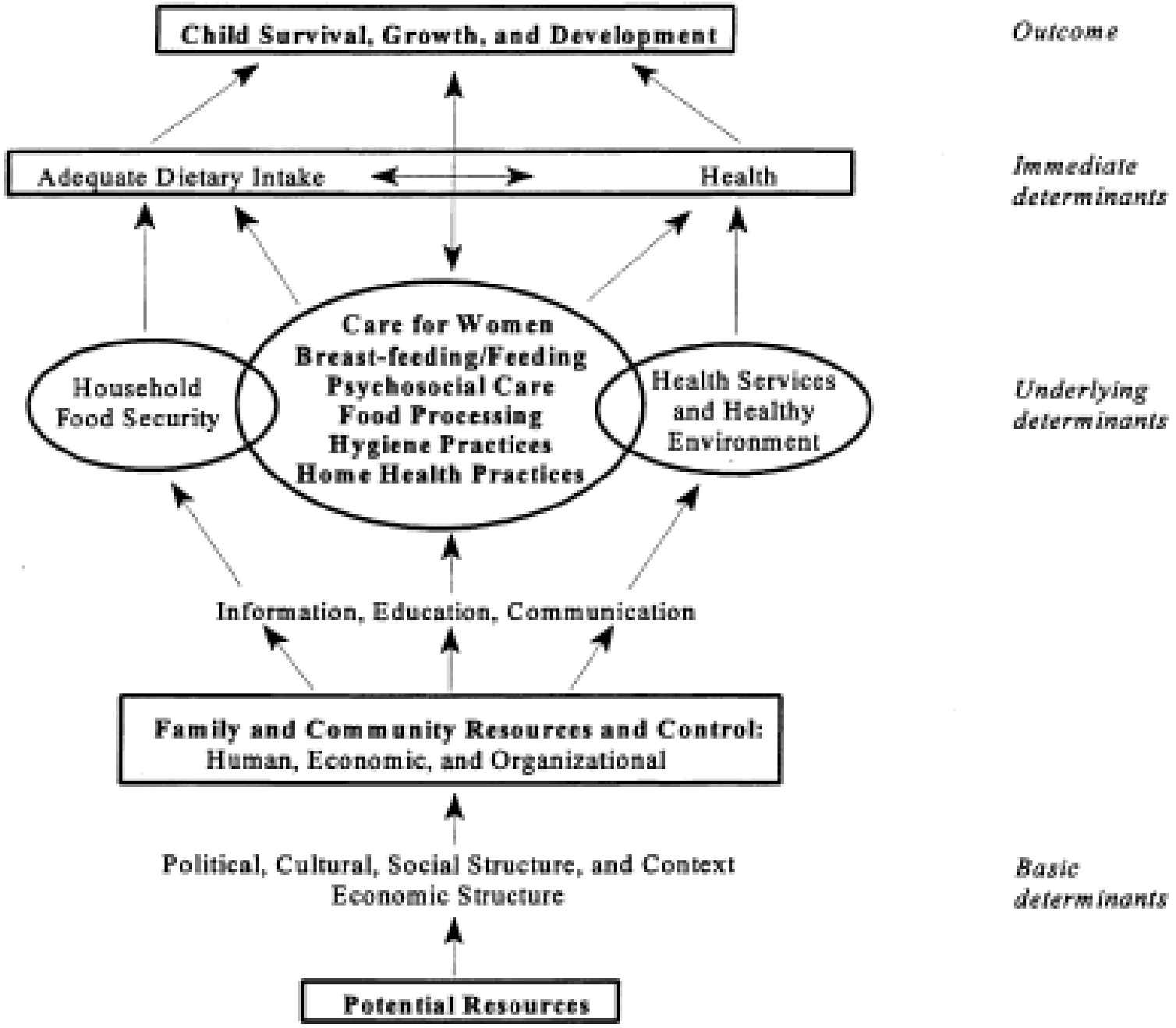


Social policy should be redirected toward the malleable early years, if we want to successfully reduce inequality and promote productivity in society by producing effective people (Heckman, 2013)

Early childhood development (ECD)

- Physical health, nutrition, growth, and motor development
- Cognitive and language skills
- Social and emotional functioning
- Ethical and spiritual development
- Sense of national or group identity

Britto, Engle, Super (2013)



Engle et al. (1999)

ECD domains and constructs (sub-constructs)

1. Food and nutrition
   - Food security
   - Dietary intake (quality and quantity)
   - Child nutritional status (anthropometry, micronutrients)
   - Breastfeeding and complementary feeding
2. Family (i.e., psychosocial) care
   - Support for learning and stimulating environment
   - Setting limits and punishment
   - Alternative caregivers
   - Father involvement
   - Responsiveness
   - Maternal depressive symptoms
   - Parent-child interaction

Frongillo et al. (2014)

Domains and constructs (sub-constructs)

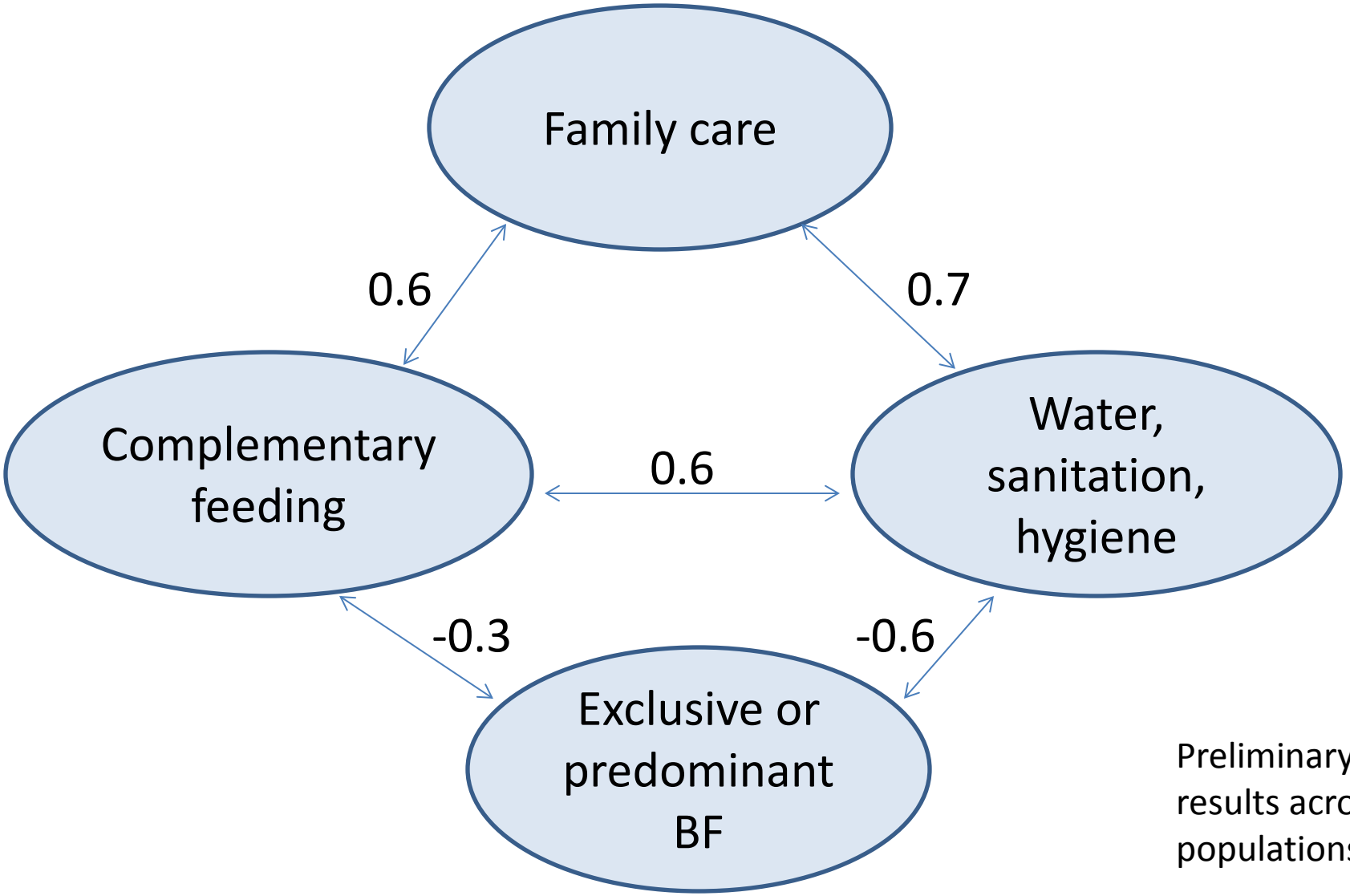
3. Health
   - Morbidity (morbidity symptoms and any hospitalization)
   - Care to prevent or treat illness (immunizations and care during illness)
   - Water, sanitation, and hygiene
4. Child development
   - Motor
   - Cognitive
   - Language
   - Socio-emotional

Frongillo et al. (2014)

Need to:

- validate child-development measures in LMIC
- develop innovative markers of child development

Association among populations in care behaviors (MICS4)



Preliminary results across 17 populations

Summary

1. Children grow through complex biological mechanisms that unfold daily and are not well understood
2. Partial restoration of lost growth is sometimes possible when constraints are removed, but not clear if this is important
3. Length growth is a marker of nutrition useful for some purposes, but is not nutrition
4. Nutrition interventions may reach and impact children, but may not discernably impact length growth deficits in short period
5. Interventions intended to have impact on one domain may have impact (positive or negative) on others

Summary

6. Use broad set of health, nutrition, and development measures and indicators to assess impact of interventions on children
7. Use measures and indicators for both outcomes and these care behaviors
   - Breastfeeding, complementary feeding, and food processing
   - Family care
   - Hygiene and home health
   - Care for women
8. Develop, refine, and validate measures and indicators for intended purpose, for example
   - Validate child-development measures in LMIC
   - Develop innovative markers of child development

Additional information

- Fulfilling Every Child's Potential through Integrated Nutrition and Early Childhood Development Interventions
  - Policy brief www.nyas.org/ChildNutrition-Policy
  - Articles in Annals of NY Academy of Sciences http://onlinelibrary.wiley.com/doi/10.1111/nyas.2014.1308.issue-1/issuetoc
- Post-2015 WASH Targets and Indicators
  - http://www.unicef.org/wash/files/4_WSSCC_JMP_Fact_Sheets_4_UK_LoRes.pdf