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

WHO MGRS (2009)
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

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

<table>
<thead>
<tr>
<th>Method</th>
<th>Measure</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical assessment using:</td>
<td>• Weight</td>
<td>• &lt; -2 SD</td>
</tr>
<tr>
<td>• weighing scales</td>
<td>• Length</td>
<td>relative to WHO</td>
</tr>
<tr>
<td>• length boards</td>
<td>• Height</td>
<td>growth standards</td>
</tr>
<tr>
<td>• stadiometers</td>
<td>• Head circ.</td>
<td></td>
</tr>
<tr>
<td>• tape measures</td>
<td>• Arm circ.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Z-scores</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Others</td>
</tr>
</tbody>
</table>
Functional Consequences: Mortality, Morbidity, Lost Productivity, etc.

Growth Status

Nutritional Status

Diet

Health

Household Food Security

Care of Mother and Child

Environ. Health, Hygiene & Sanitation

Human, Economic, and Institutional Resources

Political and Ideological Structure

Ecological Conditions

Potential Resources

Consequences

Manifestations

Immediate Causes

Underlying Causes

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
- Fetal growth
- Gest. age
- Maternal size, nutrition, wt. gain
- Adolescent size, nutrition

Post-natal growth
- Nutrition, illness
- Care practices & environment (BF, CF, hygiene, services, interaction)
### Purposes for groups of households or individuals

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Question</th>
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<tbody>
<tr>
<td>Estimation of prevalence</td>
<td>How many are affected?</td>
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<tr>
<td>Determination of causes and consequences</td>
<td>Why are they affected and what are effects?</td>
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<tr>
<td>Early warning</td>
<td>When is action needed?</td>
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<tr>
<td>Targeting</td>
<td>Who will receive which action?</td>
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<tr>
<td>Monitoring</td>
<td>How is the situation changing?</td>
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<tr>
<td>Impact evaluation</td>
<td>Has the action made a difference?</td>
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## Purposes for groups of households or individuals

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<td>How is the situation changing?</td>
</tr>
<tr>
<td>Impact evaluation</td>
<td>Has the action made a difference?</td>
</tr>
</tbody>
</table>

## Purposes for separate households or individuals

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening</td>
<td>Is the household or individual at risk?</td>
</tr>
<tr>
<td>Diagnosis of problem</td>
<td>Does the household or individual have the problem, and what are the salient causes?</td>
</tr>
<tr>
<td>Diagnosis of solution</td>
<td>What is the most appropriate action?</td>
</tr>
<tr>
<td>Monitoring</td>
<td>How is the situation changing?</td>
</tr>
</tbody>
</table>

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-score = (measurement – median_{standard}) / SD_{standard}

centile = 100 \Phi(Z\text{-score})
Age: 1yr 5mo (17mo), z-score: -4.54
Height-for-age

Percentage of children

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
### MINIMat Study – Bangladesh

**Differential effects of nutrition interventions**

<table>
<thead>
<tr>
<th></th>
<th>Early invitation to food supplementation</th>
<th>Usual invitation to food supplementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fe30F</td>
<td>Fe60F</td>
</tr>
<tr>
<td>Birth weight</td>
<td>2689</td>
<td>2717</td>
</tr>
<tr>
<td>HAZ at 24 mo</td>
<td>-1.91</td>
<td>-1.92</td>
</tr>
<tr>
<td>Neonatal mortality*</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>Infant mortality*</td>
<td>43</td>
<td>43</td>
</tr>
</tbody>
</table>

*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

<p>| | | | | | | | | | |</p>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fe30F</td>
<td>Fe60F</td>
<td>MMS</td>
<td>Fe30F</td>
<td>Fe60F</td>
<td>MMS</td>
<td>Fe30F</td>
<td>Fe60F</td>
<td>MMS</td>
</tr>
<tr>
<td>Birth weight</td>
<td>2689</td>
<td>2717</td>
<td>2696</td>
<td>2688</td>
<td>2665</td>
<td>2710</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAZ at 24 mo</td>
<td>-1.91</td>
<td>-1.92</td>
<td>-1.99</td>
<td>-1.99</td>
<td>-2.02</td>
<td>-2.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neonatal mortality*</td>
<td>28</td>
<td>33</td>
<td>12</td>
<td>25</td>
<td>38</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant mortality*</td>
<td>43</td>
<td>43</td>
<td>17</td>
<td>31</td>
<td>44</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*rate per 1000 live births

Khan et al. (2011); Persson et al. (2012)
Early vs. usual supplementation

p=0.04

Similar pattern for physical abuse
Low maternal-infant interaction

![Bar chart showing NCAST < 40 (%) for different groups: 30 mg Fe, 60 mg Fe, and MMN. The 60 mg Fe group has the highest percentage, followed by MMN and 30 mg Fe.]
BRAC program for ultra poor

Income Generating Activity (IGA)

- Training
- Asset transfer
- Social support

18-months grant phase

Regular BRAC program

2001 2002 2003 2004 2005 2006

2002 (Baseline)
## Magnitude of program’s effect on outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effect size</th>
<th>( p ) value</th>
<th>( AR )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wellbeing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive Affect &amp; Negative Affect Schedule</td>
<td>1.07</td>
<td>&lt;0.01</td>
<td>0.34-0.44</td>
</tr>
<tr>
<td>Satisfaction With Life Scales</td>
<td>1.31</td>
<td>&lt;0.01</td>
<td></td>
</tr>
<tr>
<td>Single response</td>
<td>1.18</td>
<td>&lt;0.01</td>
<td></td>
</tr>
<tr>
<td><strong>Economic Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured economy in 2005</td>
<td>0.60</td>
<td>&lt;0.01</td>
<td></td>
</tr>
<tr>
<td>Perceived economy in 2006</td>
<td>0.42</td>
<td>&lt;0.01</td>
<td></td>
</tr>
<tr>
<td><strong>Food insecurity</strong></td>
<td>0.53</td>
<td>&lt;0.01</td>
<td>0.17</td>
</tr>
<tr>
<td><strong>Domestic violence</strong></td>
<td>0.29</td>
<td>&lt;0.01</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Comparison of adjusted mean height-for-age z-score

6-11 months

12-23 months

24-35 months

36-60 months

- Height-for-age z-score
- Year
- Control
- Program
Comparison of adjusted mean height-for-age z-score

Note increase over time in three age groups
Comparison of adjusted mean weight-for-height z-score

6-11 months

12-23 months

24-35 months

36-60 months

Control
Program
Shamba Maisha study -- rural Kenya

Food insecurity (HFIAS)

Month

Food insecurity (HFIAS)

0 3 6 9 12 15 18 21 24

Month

Food insecurity (HFIAS)
Greater increase with intervention

- food frequency
  - overall
  - cooking fat
  - dairy
  - sweets
  - vegetables
  - condiments

- food expenditures
  - sweets
  - fruit
  - condiments

- Self-confidence
- CD4
- Viral load suppression

Weight Z-Score

Infants

Older Children

Butler et al. (in preparation)
Food Insecurity
Uncertain, insufficient, or unacceptable availability, access, or utilization of food

Management Strategies

Dietary Intake
Nutritional status
Well-being

Hunger

Distress & Adverse Family & Social Interactions

Worry & Anxiety
Deprivation & Alienation

Livelihood Strategies

Economic & Social Resources, Functional Limitations, & Context

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)

- Family care
- Complementary feeding
- Water, sanitation, hygiene
- Exclusive or predominant BF

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

• Post-2015 WASH Targets and Indicators