EE: Going Beyond Nutrition to Understand Child Growth and Development

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Stunting and EE: What We Know and....

What we are trying to figure out
The “Window of Opportunity” for Improving Nutrition is very small... Pre-pregnancy until 18-24 months of age

(Victora et al. 2010)
What is causing all this stunting?
Cause #1: Malnourished Mother

- Malnourished mothers give birth to babies that are smaller and shorter than normal
- 50% of Guatemalan babies are born stunted (Ruel 2001)
  - Prevalence of stunting at birth not well documented
  - Good length data on newborns is very hard to get!

Estimates of 20-50% of stunting is due to intra-uterine factors. Effective macronutrient interventions for pregnant women are not well established.
Cause #2: Poor Diet

- Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries
  - Dewey & Adu-Afarwuah, 2008
  - 42 studies/programs, most published 1996-2006
- Children who received interventions gained:
  - 0.0 – 0.76 Z scores weight-for-age
  - 0.0 – 0.64 Z scores length-for-age

The best studies caused a 0.7 Z score improvement. BUT: the average growth deficit of African and Asian children is -2.0 Z. At best, diet solved 1/3 of the problem.
Cause #3: Diarrhea

- Between 6-18 months of age, children in developing countries have around 9 episodes of diarrhea.
- Many authors reported that diarrhea accounts for 10-80% of growth faltering.
- But others contend that children grow at “catch-up rates” between episodes, and thus recover these deficits.

The Lancet Nutrition Series (2008) concluded that by implementing sanitation and hygiene interventions with 99% coverage, child malnutrition would be reduced by only 2.4%.
However:

Evidence exists that the effect of WASH interventions on linear growth is independent of its effect on diarrhea.

In several studies, WASH had a bigger effect on growth than it did on diarrhea.
Peru:  
(Checkley, et al)

- Children assessed for diarrhea and growth from birth to 2 years
- Household sanitation and water assessed
- What predicted height deficit at 2 years?
  - 16% explained by how much diarrhea the child had experienced
  - 40% explained by the level of sanitation and water in child’s household
Rural Ethiopia: HH Hygiene Index was the variable most strongly associated with stunting

Alive and Thrive baseline data; F Ngure (2013, in prep)

$y = -0.0537x - 1.9865$

$p$ value = 0.032
Cause #4: The Environmental Enteropathy Hypothesis

• A subclinical condition of the small intestine, called environmental enteropathy (EE)

• Characterized by:
  – Flattening of the villi of the gut, reducing its surface area
  – Thickening of the surface through which nutrients must be absorbed
  – Increased permeability to large molecules and cells (microbes)

• Likely causes:
  – Too many microbes in the gut
  – Effects of toxins on the gut

Decreased nutrient absorption + Infiltration of microbes
Microbial translocation

Microbial products cross into blood stream

Chronic immune activation
Diverts nutrients from growth to infection-fighting
Environmental Enteropathy and Stunting Hypothesis:

EE is a major cause of post-natal stunting, anemia and immune competence

EE can be prevented or reduced by preventing infants and young children from ingesting human and animal feces through a package of interventions that improve sanitation and hygiene.
Chronic immune activation

↑ pro-inflammatory cytokines

↑ Hepcidin

Anemia

↓ Growth Factor (IGF-1)

Stunting

Immunosenescence (premature aging) of adaptive cell-mediated immune system

↓ Growth Factor (IGF-1)

Impaired response to vaccines and infections
HAZ changes over first 18 months in stunted and non-stunted infants
IGF-1 and IGFBP3 were lower in stunted infants, beginning at 6 wk

P values for all time points 6 w to 12 mo, p<0.001

Values for healthy European children range from 54-170 ng/mL

P values for all time points 6 w to 18 mo, p<0.001
Development of the WASH Intervention (Efficacy = “Proof of concept”)

WASH Goal:
All infants never ingest any faeces between birth to 18 months
Conventional WASH formative research (2008-2009)

Sanitation HIGHLY valued don’t have a latrine because lack money; a Blair VIP is a source of status

- Infant stools less offensive than adults’
- Handwashing is seldom with soap
- Frequently feed cold leftover food
• 6 hour observation of 20 babies, recorded what and how often went in the mouth and if visibly dirty

• Returned and collected samples of most frequent and dirtiest things mouthed for micro analysis
Findings

Most frequent:
38 time in 6 hours
75% visibly dirty

Dirtiest
Soil (3 ate avg 11 bites)
chicken faeces, stones
If allowed, toddlers consume poultry feces

Peruvian shantytown families:
  – Households who owned free-range poultry:
    • **Average ingestion of poultry feces by toddlers per 12-hour observation period was 3.9 times**
      – Marquis GM et al., Am J Public Health 1990

Rural Zimbabwe:
  – Not selected for poultry ownership:
    • **3 of 7 toddlers directly ate chicken feces during a 6-hour observation period.**
      – Ngure F et al., submitted, 2012
The context: IO study

Laundry area

Bare soil and animal waste
Micro team
<table>
<thead>
<tr>
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<th>% HH with E coli + sample</th>
<th>E coli/Per gram</th>
<th>Average E Coli Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant Food</td>
<td>0%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Drinking Water</td>
<td>54%</td>
<td>2</td>
<td>800</td>
</tr>
<tr>
<td>Soil in laundry area</td>
<td>60-80%</td>
<td>70</td>
<td>1,400</td>
</tr>
<tr>
<td>Chicken feces</td>
<td>100%</td>
<td>10,000,000</td>
<td>10,000,000</td>
</tr>
</tbody>
</table>

Clearly, kids must stop eating dirt and chicken poop!
Babies are fed on
*Ground in the yard
(60-80% E coli+)
or
*Kitchen floor
(81% E coli+)
Routes of fecal disease transmission and protective barriers *for babies!*

- **Sanitation**
- **Clean water supply**
- **Hygiene**
  - Protective Play Space

- **Feces**
  - Fluids
  - Fingers
  - Flies
  - Fields/floors

- **Laundry Water**
- **Nappy Handling**
- **Geophagia, dirty hands**
- **Food**
A new way of thinking about WASH in the first 1000 days

• Protective play space, to protect developing child from contaminated soil and animal feces (especially chickens)
• Infant handwashing with soap, when outside of protective play space.
• Caregiver handwashing with soap after fecal contact and before preparing/serving food
• Safe disposal of feces—especially of children
• Water treatment
• Avoid feeding leftovers, or reheat
2x2 Factorial Design

<table>
<thead>
<tr>
<th>Control</th>
<th>WASH: Integrated Water, Hygiene &amp; Sanitation</th>
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</thead>
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<tr>
<td>Infant Feeding: Education + Nutributter</td>
<td>WASH + Infant Feeding</td>
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Objective

To measure the independent and combined effects of WASH and infant nutrition on stunting and anemia among children from birth to 18 months of age.

And, on a sample of 1600 infants, measure the hypothesized “causal pathway” of EE:
- 1000 HIV- mothers
- 600 HIV+ mothers
Programmatic approaches for nutrition, stimulation and social protection are well developed.

UNICEF 2006 Programming Experiences in Early Childhood Development
Lancet 2011 Child Development Series

Hygiene for babies (Baby WASH) needs to be further developed and tested

Environmental Protection?
Research Priorities

• Identifying the causal pathway by which WASH interventions may interrupt EE and child stunting

• Developing and implementing Baby WASH interventions that support nutrition, hygiene and child development
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