Animal sourced foods and child stunting

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Introduction

Why do we care about stunting?

• Globally, 160 million children under the age of 5 are stunted
• Stunting in early life – a marker of poor nutrition – is linked to adverse physical, cognitive & economic development
• Most stunting manifests in the first 1000 days of life (Victora, et al., 2009), especially over ages 6-24 months

Why do kids start to fall behind at ~6 months?

• Poor diets: Rapidly increasing nutrient requirements no longer met by breastmilk, poor feeding frequency, inadequately diversified diet
• Infection: Infant’s weak immune system is highly vulnerable to increased exposure to pathogens ... diarrhea, EED, etc
Introduction

Surprisingly, dietary determinants of stunting somewhat neglected

- Diets are elusive: Individual “usual” diets are hard to measure
- Diets hard to experiment on: Surprisingly little evidence in LDCs
- Household surveys used to link dietary diversity indicators to stunting, but associations tend not to be robust

For child growth, diversifying into ASFs may be especially crucial

- Since 1974, protein deficiency concerns largely sidelined
- Yet ASF proteins contains essential amino acids that can’t be synthesized within the body: seminal role in programming growth
- ASFs also dense in a wide range of micronutrients linked to growth
- Multiple ASFs preferable: e.g. dairy rich in calcium, but no iron
Introduction

Empirical evidence linking ASFs to child growth is varied

- Handful of ASF interventions do find sizeable growth impacts
- Nutrition-sensitive livestock interventions also sometimes show signs of impact, but typically also use behavioral interventions
- Observational studies link growth to livestock ownership (East Africa)
- Historical studies link adult heights to ASF consumption patterns

Weak evidence on constraints to ASF consumption among children

- Economic studies focus on constraints to household consumption
- Sociological studies focus on cultural constraints (e.g. eggs in Africa)
- Nutrition interventions assume knowledge is the major constraint
In light of these knowledge gaps, this paper offers three contributions

1. **ASF consumption patterns**: Use DHS data on 112,553 children aged 6-23 months from 46 developing countries

2. **ASFs & stunting associations**: Use this dataset to estimate associations between dietary patterns and stunting; go beyond aggregated diversity metrics to look at specific food groups

3. **Constraints to ASF consumption**: We look at price, wealth and “knowledge” constraints to document the main factors driving ASF consumption patterns in poor countries
Data

- Data on 112,553 children from 46 countries covered by the Demographic Health Surveys (DHS) between 2006 and 2014
- **Child diets:** Since mid 2000s DHS mothers asked which of 12 food groups their youngest child consumed in the past 24 hours.

### Table 1. Food groups listed in the DHS phases 5 & 6

<table>
<thead>
<tr>
<th>Aggregated food groups in DDS (7 groups)</th>
<th>Disaggregated food groups (12 groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Starchy staples</td>
<td>(1) Grains; (2) Roots/tubers</td>
</tr>
<tr>
<td>(2) Legumes/nuts</td>
<td>(3) Legumes/nuts</td>
</tr>
<tr>
<td>(3) Vitamin-A rich fruits/vegetables</td>
<td>(4) Vit-A rich fruits; (5) Vit-A rich vegetables</td>
</tr>
<tr>
<td>(4) Other fruits/vegetables</td>
<td>(6) other fruits (7) dark green leafy vegetables, (8) other vegetables</td>
</tr>
<tr>
<td>(5) Dairy</td>
<td>(7) Cow’s milk; (8) Infant formula</td>
</tr>
<tr>
<td>(6) Eggs</td>
<td>(9) Eggs</td>
</tr>
<tr>
<td>(7) Flesh foods</td>
<td>(10) Meat/organs; (11) Fish</td>
</tr>
<tr>
<td></td>
<td>(12) Fortified infant cereals</td>
</tr>
</tbody>
</table>
Data

- **Stunting**: height-for-age Z score < -2
- **ASF prices**: Use “calorie price ratios” (CPRs) from Headey et al’s (2017) analysis of 2011 International Comparison program data
- CPR is the price of 1 calorie of cheapest food in a given food group relative to 1 calorie of cheapest staple cereal in each country

### Table 3. Classification of cereals & specific ASF products in ICP 2011 data

<table>
<thead>
<tr>
<th>Food group</th>
<th># products</th>
<th>Specific products used to construct minimum price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>13</td>
<td>Rice (5), bread products (5), maize flour, maize, tortilla</td>
</tr>
<tr>
<td>Cow’s milk, fresh</td>
<td>2</td>
<td>Pasteurized fresh milk, unskimmed or low-fat</td>
</tr>
<tr>
<td>Cow’s milk, long-life</td>
<td>3</td>
<td>Condensed milk, powdered milk, UHT</td>
</tr>
<tr>
<td>Meat, fresh</td>
<td>20</td>
<td>Whole chicken (2 ), chicken breast, chicken leg; Beef/veal (7 varieties), Lamb/mutton (4 varieties), Pork (4 varieties), Goat (1 variety); all unprocessed.</td>
</tr>
<tr>
<td>Chicken eggs, fresh</td>
<td>2</td>
<td>Large brown eggs, medium brown eggs</td>
</tr>
<tr>
<td>Fish, fresh</td>
<td>5</td>
<td>Fresh Carp, Mackerel or Tilapia; canned Sardines or canned Tuna</td>
</tr>
</tbody>
</table>
Methods

• **Descriptives:** unweighted consumption patterns by child age
• **Graphical evidence:**
  • LPOLY graphs of stunting by age and ASF consumption by age;
  • Stunting by age for ASF=1 and ASF=0 sub-samples;
• **Multivariate regressions:** pooled across country with survey fixed effects (averages of within-country variation), saturated with control variables (wealth, education, health services, WASH, etc)
• **Age disaggregation:** benefits of improved diets not instantaneous but cumulative, so expect larger effects for older kids (e.g. 18-23m)
• **Dietary disaggregation:** going to split sample into kids achieving or not achieving minimum dietary diversity
• **Problems:** Omitted variables bias, attenuation bias, imprecision...
### Table 4. Stunting and dietary indicators by region, children 6-23 months of age

<table>
<thead>
<tr>
<th>Region</th>
<th>Stunting (%)</th>
<th>Diet diversity 0-7 groups</th>
<th>Min. diet diversity (MDD)</th>
<th>At least 1 ASF</th>
<th>MDD=0 and 1+ ASFs</th>
<th>MDD=1 and 1+ ASFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latin America &amp; Caribbean</td>
<td>23.6%</td>
<td>4.0</td>
<td>63.6%</td>
<td>84.3%</td>
<td>66.7%</td>
<td>99.2%</td>
</tr>
<tr>
<td>North Africa &amp; Western Asia</td>
<td>25.8%</td>
<td>2.9</td>
<td>37.0%</td>
<td>76.6%</td>
<td>81.2%</td>
<td>99.4%</td>
</tr>
<tr>
<td>South, Central &amp; South-East Asia</td>
<td>37.1%</td>
<td>2.3</td>
<td>21.1%</td>
<td>57.9%</td>
<td>59.7%</td>
<td>96.7%</td>
</tr>
<tr>
<td>Western &amp; Central Africa</td>
<td>32.5%</td>
<td>2.0</td>
<td>16.6%</td>
<td>52.4%</td>
<td>54.9%</td>
<td>95.4%</td>
</tr>
<tr>
<td>Eastern &amp; Southern Africa</td>
<td>37.3%</td>
<td>2.2</td>
<td>16.9%</td>
<td>49.1%</td>
<td>47.3%</td>
<td>91.7%</td>
</tr>
<tr>
<td>All</td>
<td>31.9%</td>
<td>2.6</td>
<td>28.8%</td>
<td>61.8%</td>
<td>47.4%</td>
<td>97.3%</td>
</tr>
</tbody>
</table>
**Table 5. Dietary patterns by region, children 6-23 months of age**

<table>
<thead>
<tr>
<th></th>
<th>Latin America &amp; Caribbean</th>
<th>North Africa &amp; West Asia</th>
<th>South, Central &amp; SE Asia</th>
<th>Western &amp; Central Africa</th>
<th>Eastern &amp; Southern Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dairy</strong></td>
<td>57.5%</td>
<td>64.9%</td>
<td>38.4%</td>
<td>20.8%</td>
<td>18.7%</td>
</tr>
<tr>
<td><strong>Eggs</strong></td>
<td>47.3%</td>
<td>30.9%</td>
<td>15.8%</td>
<td>12.2%</td>
<td>13.0%</td>
</tr>
<tr>
<td><strong>Meat/fish</strong></td>
<td>56.3%</td>
<td>30.9%</td>
<td>23.2%</td>
<td>39.7%</td>
<td>33.6%</td>
</tr>
<tr>
<td><strong>White/red meat</strong>*</td>
<td>53.1%</td>
<td>24.1%</td>
<td>13.6%</td>
<td>15.5%</td>
<td>17.1%</td>
</tr>
<tr>
<td><strong>Fish</strong>*</td>
<td>NA</td>
<td>8.0%</td>
<td>12.8%</td>
<td>31.5%</td>
<td>21.1%</td>
</tr>
</tbody>
</table>
### Table 7. Least squares regressions of stunting against aggregated food groups for the full sample of children and MDD=0 children

<table>
<thead>
<tr>
<th>Age range (months)</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-14</td>
<td>-0.010</td>
<td>-0.005</td>
<td>-0.037***</td>
<td>-0.038***</td>
</tr>
<tr>
<td>Dietary range</td>
<td>Full</td>
<td>Full</td>
<td>Full</td>
<td>Full</td>
</tr>
<tr>
<td>Any ASF</td>
<td>-0.010</td>
<td>-0.007</td>
<td>-0.040***</td>
<td>-0.026**</td>
</tr>
</tbody>
</table>

- Fruits also have significant associations
## Table 8. Regressions of stunting against individual ASFs

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age range (months)</td>
<td>12-14</td>
<td>15-17</td>
<td>18-20</td>
<td>21-23</td>
</tr>
<tr>
<td>Dairy</td>
<td>0.003</td>
<td>0.001</td>
<td>-0.020**</td>
<td>-0.036***</td>
</tr>
<tr>
<td>Eggs</td>
<td>0.004</td>
<td>-0.004</td>
<td>-0.007</td>
<td>-0.017*</td>
</tr>
<tr>
<td>Meat/fish</td>
<td>-0.017**</td>
<td>-0.026***</td>
<td>-0.040***</td>
<td>-0.026***</td>
</tr>
<tr>
<td>Observations</td>
<td>20,454</td>
<td>18,997</td>
<td>17,761</td>
<td>15,912</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.110</td>
<td>0.126</td>
<td>0.143</td>
<td>0.151</td>
</tr>
</tbody>
</table>

- Fish tends to have stronger associations than red/white meat
- Region-specific results more heterogenous
- Fruits also have significant associations
High prices constrain dietary diversification

Table 3. Cereal-relative calorie price ratios for various foods, by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Roots &amp; tubers</th>
<th>Legumes</th>
<th>Cow's milk, fresh</th>
<th>Cow's milk, Proc.</th>
<th>Chicken eggs</th>
<th>Meat</th>
<th>Fish</th>
<th>Fortified baby cereal</th>
</tr>
</thead>
<tbody>
<tr>
<td>High income countries</td>
<td>1.6</td>
<td>1.2</td>
<td>3.2</td>
<td>2.2</td>
<td>3.0</td>
<td>2.0</td>
<td>4.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Latin America &amp; Caribbean</td>
<td>1.2</td>
<td>2.2</td>
<td>3.9</td>
<td>3.0</td>
<td>4.9</td>
<td>3.2</td>
<td>3.4</td>
<td>9.6</td>
</tr>
<tr>
<td>North Africa &amp; Western Asia</td>
<td>2.1</td>
<td>2.1</td>
<td>10.1</td>
<td>3.1</td>
<td>6.1</td>
<td>6.2</td>
<td>6.0</td>
<td>16.1</td>
</tr>
<tr>
<td>South, Central &amp; South-East Asia</td>
<td>1.5</td>
<td>2.0</td>
<td>7.8</td>
<td>3.8</td>
<td>6.2</td>
<td>6.5</td>
<td>5.3</td>
<td>16.4</td>
</tr>
<tr>
<td>Western &amp; Central Africa</td>
<td>1.0</td>
<td>16.5</td>
<td>4.0</td>
<td>9.9</td>
<td>5.3</td>
<td>5.0</td>
<td>5.0</td>
<td>23.4</td>
</tr>
<tr>
<td>Eastern &amp; Southern Africa</td>
<td>1.7</td>
<td>13.9</td>
<td>5.8</td>
<td>9.1</td>
<td>5.6</td>
<td>6.1</td>
<td>6.1</td>
<td>18.6</td>
</tr>
</tbody>
</table>
Constraints to ASF consumption: Eggs

Fig 1. Predictors of 24-hr recall egg consumption among kids 6-23m

Halving relative egg price predicts a 15-point increase in egg consumption among young kids.
Constraints to ASF consumption: Dairy

- Halve own price*
- Double cereal yields*
- Double GDP per capita*
- Double urbanization*
- Peace to Conflict*
- Lowest to richest wealth tercile
- Give mother 9+ years schooling
- Give father 9+ years schooling
- Universal to zero open defecation
- Switch to universally improved water
- Stop breastfeeding
- Urban to rural
- No access to hospital/clinic access

Predicted change in consumption prevalence

0% 2% 4% 6% 8% 10% 12% 14% 16% 18% 20%
Constraints to ASF consumption: Meat

- Halve own price*
- Double cereal yields*
- Double GDP per capita*
- Double urbanization*
- Peace to Conflict*
- Lowest to richest wealth tercile
- Give mother 9+ years schooling
- Give father 9+ years schooling
- Universal to zero open defecation
- Switch to universally improved water
- Stop breastfeeding
- Urban to rural
- No access to hospital/clinic access

Predicted change in consumption prevalence:

-10% -8% -6% -4% -2% 0% 2% 4% 6% 8% 10%
Constraints to ASF consumption: Fish

- Halve own price*
- Double cereal yields*
- Double GDP per capita*
- Double urbanization*
- Peace to Conflict*

Lowest to richest wealth tercile
Give mother 9+ years schooling
Give father 9+ years schooling
Universal to zero open defecation
Switch to universally improved water
Stop breastfeeding
Urban to rural
No access to hospital/clinic access

Predicted change in consumption prevalence

-10% -5% 0% 5% 10% 15%
Constraints to dietary diversification

• Poor people face a double economic burden: poverty & high prices
• Why are nutrient-rich foods so expensive?

• Highly perishable; difficult to trade long distance
• Limited trade means relative prices largely set by local productivity levels
• Productivity is low in poor countries: e.g. backyard poultry very widespread, but children don’t eat eggs
• Egg prices are lower when poultry is commercialized

F1. Egg prices & share of chickens in intensive systems

Linear fit: coef = -0.08 [CI -0.10-0.07]; R-sq = 0.60
Conclusions

• Nutritionists have long emphasized important nutrient properties of ASFs, including renewed interest in protein quality

• Only limited evidence linking ASF consumption to improved growth outcomes, and little work exploring constraints to ASF consumption

• In this paper we find:
  1. **ASF consumption still low in Africa & Asia:** ~50% of kids with 1+ ASFs
  2. **Diverse ASF consumption patterns:** fish strikingly important in many countries where dairy is less important; meat/egg consumption low
  3. **ASF consumption strongly associated with growth:** consuming a diverse array of ASFs seems more beneficial than any single ASF
  4. **ASFs are very expensive relative to cereals:** especially true for fresh milk and eggs; fish and meat relatively cheap in some places
  5. **Multiple constraints to ASF consumption:** High prices are a constraint for all ASFs, and wealth often a constraint (especially for diary)
Conclusions

What explains high prices of most ASFs?

• Perishability/tradability are major factors:
• Eggs/fresh milk hard to transport without efficient value chains (Totally different from cereals, pulses, roots, tubers, etc)
• Inability to import perishable foods means their prices are set by local productivity levels: poor countries are unproductive!!
• In contrast, flesh foods can be moved as live animals, salted, chilled

Sector-specific constraints

• Dairy: livestock diseases & climate are major constraints; why don’t Africans consume more powdered milk?
• Eggs: Scale economies are huge, but poor countries are beset by backyard systems that are attractive because of low inputs required; but low input means low out; also potentially significant health risks
Conclusions

Policy implications

1. Focus on dietary diversification, but ensure that it includes a strong emphasis on ASFs, including multiple ASFs

2. Knowledge constraints may still be important, but critical to use production, value chain and trade policies to reduce ASF prices

3. Factor in environmental implications: vast differences in GHG emissions from different types of ASF production (chicken & fish)

4. Factor in human health externalities: livestock production has zoonotic disease risks, including enteric and pulmonary infections