Linking Ag, Nutrition, & Health: Updates from the FTF Nutrition Innovation Labs

Speakers
Patrick Webb, Tufts University
Eileen Kennedy, Tufts University
Shibani Ghosh, Tufts University
Jeffrey Griffiths, Tufts University
Gerald Shively, Purdue University

Facilitator
Zachary Baquet, USAID Bureau for Food Security

August 6, 2013
Zachary Baquet is a Knowledge Management Specialist at USAID/BFS. Prior to joining BFS, he was a AAAS Science & Technology Policy Fellow in USAID’s Office of Agriculture where he worked on food security, the integration of climate change and agriculture programming, and knowledge management issues. He received his Ph.D. in 2004 from the University of Colorado Boulder where he studied the development of the mammalian nervous system and models of Huntington’s disease.
Robert Bertram
USAID Bureau for Food Security

Dr. Bertram is Director of USAID’s Office of Agriculture Research and Transformation, where he works on building stronger research ties between the US community, the international centers, and partners in Europe and Japan. Dr. Bertram comes from a plant breeding and genetics background, with degrees from UC Davis, the University of Minnesota and the University of Maryland. Dr. Bertram served on the CGIAR Genetic Resources Policy Committee, as a technical advisor to the International Treaty on Plant Genetic Resources and chaired the FAO Commission on Genetic Resources for Food and Agriculture from 2002 to 2004.
Maura Mack
USAID Bureau for Food Security

Maura D. Mack is a Nutrition Advisor in the USAID/BFS Office of Agricultural Research and Policy. She has served 13 years with USAID on long-term assignments in the Philippines, Afghanistan, and at USAID Headquarters, and short-term assignments in Ecuador, Ethiopia, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, and the Gambia. Maura also has 15 years of US domestic experience working on diverse public health issues, primarily in the US-Mexico border region. She has an MPH in Nutrition from UC-Berkeley and an interdisciplinary PhD in nutrition, agriculture, and agricultural economics from the University of Arizona.
Patrick Webb
Tufts University

Patrick Webb is Dean for Academic Affairs at the Friedman School of Nutrition Science and Policy at Tufts University in Boston, and one of the Program Directors for the Feed the Future Nutrition Innovation Lab. Until 2005, he worked for the United Nations World Food Programme in Rome as Chief of Nutrition. During that time he was part of the MDG Hunger Task Force reporting to Secretary General Kofi Annan. Earlier, he spent 9 years with IFPRI, living in Ethiopia, Niger, and The Gambia, working on food and agriculture policies and nutrition interventions. He heads up the food aid quality review for the Office of Food for Peace.
Eileen Kennedy
Tufts University

Eileen Kennedy is Professor of Nutrition and former Dean of the Tufts University Friedman School of Nutrition Science and Policy. Prior to this, she was Adjunct Professor, Columbia University, Mailman School of Public Health. From 1994 to 2001 she served in senior positions in the Clinton Administration. She was the founding executive director of the USDA Center for Nutrition Policy and Planning, the organization responsible for the Dietary Guidelines for Americans and the Food Guide Pyramid. Her research focuses on the effects of governmental and non governmental policies and programs on health, nutrition, food security and welfare.
Shibani Ghosh
Tufts University

Shibani Ghosh is Senior Scientist at the Nevin Scrimshaw International Nutrition Foundation (INF) and Adjunct Assistant Professor at the Friedman School of Nutrition Science and Policy at Tufts University. She is a nutritionist with over 10 years experience in the area of public health nutrition. Her research interests include effects of amino acids on health and nutrition in developing countries, improving complementary foods for prevention of malnutrition in children, and translation of innovative basic and clinical sciences research into applied evidence based community interventions.
Jeffrey Griffiths
Tufts University

Jeffrey Griffiths, Director of USAID’s Innovation Lab for Nutrition-Africa, has worked at the intersection of health and nutrition for 30 years. Current projects are based in Uganda, Ghana, Ethiopia, and Malawi. He is a Professor of Public Health and of Medicine at Tufts University School of Medicine, and holds adjunct appointments at the Friedman School of Nutrition Science and Policy, School of Engineering, and Cummings School of Veterinary Medicine. By training he is a pediatrician and internist with expertise in infectious diseases and the influence of the environment on health.
Gerald Shively is a Professor of Agricultural Economics at Purdue University. He currently serves as Associate Department Head and Director of the M.S. and Ph.D. programs in Agricultural Economics. He received his Ph.D. in Agricultural and Applied Economics from the University of Wisconsin-Madison in 1996. Working in collaboration with students and a world-wide network of colleagues, he conducts research on a range of topics related to poverty, economic development and the environment in developing regions of the world. He is the author of more than 60 peer reviewed journal articles and numerous other publications.
Repaving the pathways:

What do we need to know about processes that support program impacts?

Patrick Webb
USAID August 2013
Nutrition Innovation Lab – Phase I (2010-2015)

- **Delivery science research** – policy and program-relevant empirical studies on agriculture-nutrition linkages.

- **Human and institutional capacity-building** – education, training, workshops, curricular development, etc.

- **Platforms for leveraging complementary resources** for research – collaborative networking with other innovation labs, A4HN, LCIRAH, and other donors (DFID, AusAID, Norad, UNICEF) and maybe Gates, NIH, etc.
“There is no existing literature that explicitly tests whether...nutrition-sensitive growth really has a large impact on changes in malnutrition over the medium term.”

Nutrition Innovation Lab – over-arching questions

- In what ways do investments in agriculture achieve significant measurable impacts in nutrition? Can impact pathways be empirically demonstrated?

- How can large-scale programs best incorporate such knowledge into cost-effective multi-sectoral interventions to improve nutrition?

- How can policy and program implementation processes be enhanced to support both nutrition-specific and nutrition-sensitive actions?
Policy and program implementation processes

There is “limited empirically-based research on the sociopolitical factors that influence national policy formulation, including the ability to generate effective policy [and program] traction and resources.

This may in part be because policy decisions are complex, ambiguous and involve many actors with varying aims, perspectives and power.”

What's the right way to pick the respondent for a household survey?

I have just come back from the pilot for a survey on perceptions of inequality in Lao Cai, near the northern border of Vietnam. Many tourists visit via the overnight train from Hanoi to trek through the green hills filled with terraced rice paddies and see something of the culture of the region's ethnic minority groups. Despite all the tourist money, the region remains one of Vietnam's poorest.

The story of persistent ethnic minority poverty in Vietnam is one I will save for a future post. Here I want to write about an issue that came up during our pilot: how to select respondent(s) within the household.

There are many guides to household survey design (here's one) with extensive discussion of sampling design, but they typically give minimal attention to choosing the respondent(s).
Bardasi et al. (2010) show that who reports can matter “even for seemingly objective information.”

“Who provides the information matters, and it matters more in some cases than others.

People in the household might all respond the same way when reporting on simple measures of household conditions, e.g. the material used for the roof, but for much of what is captured in surveys different people in the household will have different responses.”

## He Said, She Said

<table>
<thead>
<tr>
<th>Question</th>
<th>Discordance (% of total)</th>
<th>M = y, F = n %</th>
<th>F = y, M = n %</th>
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<td>Personally ate few balanced meals</td>
<td>11.9</td>
<td>38.3</td>
<td>61.7</td>
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<tr>
<td>Family ate few balanced meals</td>
<td>9.9</td>
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<td>62.0</td>
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<td>Personally could not purchase snacks</td>
<td>51.9</td>
<td>8.4</td>
<td>91.6</td>
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<tr>
<td>Family could not purchase snacks</td>
<td>20.0</td>
<td>59.4</td>
<td>40.6</td>
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<tr>
<td>Personally food on credit from a local shop</td>
<td>41.5</td>
<td>92.4</td>
<td>7.6</td>
</tr>
<tr>
<td>Family took food on credit from a local shop</td>
<td>33.9</td>
<td>68.0</td>
<td>31.9</td>
</tr>
<tr>
<td>Personally borrowed food from neighbors</td>
<td>34.1</td>
<td>4.1</td>
<td>95.9</td>
</tr>
<tr>
<td>Family borrowed food from neighbors</td>
<td>29.4</td>
<td>53.4</td>
<td>46.6</td>
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</table>

Source: Coates et al. (2010) “He Said, She Said.” *Food Security*
<table>
<thead>
<tr>
<th>Female Food Insecurity Score Tercile</th>
<th>Food Insecure -- Low (0-1)</th>
<th>Food Insecure -- Medium (2-4)</th>
<th>Food Insecure -- High (5-13)</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Food Insecure -- Low (0-1)</td>
<td>31.4 (181)</td>
<td>7.6 (44)</td>
<td>0.5 (3)</td>
<td>39.6 (228)</td>
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<td>Food Insecure--Medium (2-4)</td>
<td>6.1 (35)</td>
<td>13.0 (75)</td>
<td>7.6 (44)</td>
<td>26.7 (154)</td>
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<tr>
<td>Food Insecure--High (5-13)</td>
<td>1.4 (8)</td>
<td>8.3 (48)</td>
<td>24.0 (138)</td>
<td>33.7 (194)</td>
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<tr>
<td>Total</td>
<td>38.9 (224)</td>
<td>29.0 (167)</td>
<td>32.1 (185)</td>
<td>100.0 (576)</td>
</tr>
</tbody>
</table>

Source: Coates et al. (2010) “He Said, She Said.” *Food Security*
Projects Don't Fail, People Do

By John McCormick | Posted 2005-01-13

Related Articles
- A Q&A About Holiday Gift-Giving in the Office
- Automated Controls Reduce Errors and Costs
- Bad Hires Are a Drain on the Bottom Line
- Battling Intellectual Property Thieves

The rule known in scientific and philosophical circles as Occam’s razor stipulates that when multiple theories are available to explain a problem, the simplest one is preferred.

Organizations have struggled with information-technology projects for decades. Businesses have applied various management theories and implemented assorted software tools to straighten out the mess. Yet these projects continue to falter.

Private Clouds Will Use Hybrid Infrastructure — The Role of Mainframes in Cloud: To Meet the Full Range of Reliability and Security Needs

The Standish Group, an information-technology consultancy that tracked about 10,000 projects across all organizations in 2004, classified 53% of them as “challenged”—meaning they were delayed or over budget. And, it says, 18% failed outright.

The Office of Management and Budget (OMB) put half of the 1,200 federal-government technology projects in the fiscal 2005 budget—621 in all—on a “watch list” because it felt those efforts were falling short in areas such as performance measures and project management.
Nutrition Council

Planning Commission ↔ Min. of Finance ↔ Min. of Food Security & Research ↔ Min. of Inter-Provincial Coordination ↔ Provincial secretaries from relevant departments

Department of Health
Department of Food
Department of Agriculture
Department of Education
WASH

District Nutrition Implementation Unit

EDO Health ↔ EDO Educ ↔ EDO Sanitation ↔ EDO Agriculture ↔ …

District Health Officer ↔ … (map other actors)

Basic Health Unit ↔ … (map other actors)

Teacher ↔ Lady Health Worker ↔ Community Midwife… (map other actors)

Source: Bhutta et al. (2013) Pakistan
Note:  

*** significant contributor, *** moderate contributor, ** contributor, * possible contributor

Source: Swart et al. (2008) *Nutrition: Primary Health Care Perspective* (Durban)
### Defined Goal:
Health and Well-being of Nepalis Improved and Sustained

**Strategic Objective:** To Improve the Nutritional Status of Women and Children Under Two Years of Age

| Intermediate Result 1: Household (HH) health and nutrition behaviors are improved. | Intermediate Result 2: Women and children increase use of quality nutrition and health services. | Intermediate Result 3: Women and their families increase consumption of diverse and nutritious foods. | Intermediate Result 4: Coordination on nutrition between government and other actors is strengthened. |
Legend

- Orange: Mountain Districts
- Pink: Hill Districts
- Green: Terai
- Circle: Sentinel Sites

Cross-Policy and donor coordination
Cross-ministry coordination
Sector Coordination
Service Delivery
Sample size for ‘process’ interviews?

- Lapping et al. (2012) Vietnam, 22 policy makers

- Pelletier et al. (2012) Bolivia, Peru, Guatemala: “We employed semi-structured interviews with selected stakeholders and key informants...; we engaged several staff members in discussions.”

- Pelletier et al. (2011) Ethiopia, Senegal, Uganda, the Philippines, Thailand: “Accounts of the nutrition policy process were elicited [from] 18 respondents from 12 countries [and ] 6 respondents from donors or NGOs were asked to comment.”
<table>
<thead>
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<th>Central/national</th>
<th>Institutions/Individuals</th>
<th>Interviews per site</th>
<th>Number of sites</th>
<th>Total interviewed</th>
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<td></td>
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<td>10</td>
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<td></td>
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<tr>
<td></td>
<td>INGOs, UN, USAID, World Bank, National Nutrition Group, DFID</td>
<td>10</td>
<td>1</td>
<td>10</td>
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<tr>
<td></td>
<td><strong>Academic</strong></td>
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<td></td>
<td>Tribhuvan University, Patan University, Padma Kanya University</td>
<td>5</td>
<td>1</td>
<td>5</td>
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<tr>
<td><strong>District level</strong></td>
<td><strong>Government</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agriculture, health, nutrition, water supply, sanitation, local development officers, other officials</td>
<td>8</td>
<td>21</td>
<td>168</td>
</tr>
<tr>
<td></td>
<td><strong>NGO</strong></td>
<td></td>
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<td></td>
<td>Main implementing LNGO, NTAG and Local Chapter of NGO Association</td>
<td>3</td>
<td>21</td>
<td>63</td>
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<td><strong>Ilaka Level</strong></td>
<td><strong>Government</strong></td>
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<td>8</td>
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<td>168</td>
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<td><strong>VDC Level</strong></td>
<td><strong>Government</strong></td>
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<tr>
<td></td>
<td>From 21 VDC health facility posts, agricultural offices, social mobilizer</td>
<td>3</td>
<td>21</td>
<td>63</td>
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<tr>
<td><strong>Ward Level</strong></td>
<td><strong>Government</strong></td>
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<td></td>
<td>Health Worker, Agricultural Extension worker and Social Mobilizer in selected wards</td>
<td>3</td>
<td>63</td>
<td>189</td>
</tr>
<tr>
<td><strong>Total Sample</strong></td>
<td></td>
<td></td>
<td></td>
<td>676</td>
</tr>
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</table>
1. **Vertical coherence.** Do individuals in chain of authority share common understanding of policy agendas, problems, technical issues, capacity needs and constraints.

2. **Horizontal coherence.** Do individuals with *similar* levels of authority share a common understanding.

3. **Collaboration dynamics.** What are determines effective collaboration? Does KAP change over time? Does this enhance effectiveness?

4. Policy/program **fidelity as an outcome** of vertical and horizontal coherence. Is effective roll out and scale up determined by coherence?

5. Policy and Program Fidelity **as a determinant of nutrition outcomes.** Do measures of coherence serve as explanatory variables for nutrition outcomes?
Take-home messages:

1. Delivery science is not a luxury. Understanding *how* impact achieved (not just *if* achieved), and ‘real’ costs, critical to USAID going forward at scale. Empirically populating pathways (biological, economic and institutional) is key.

2. Role of individuals matters in institutions, as in households (but who to ask and what to ask of whom?). How analyzed?

FEED THE FUTURE INNOVATION LAB
For Collaborative Research on Nutrition

Mission Statement
The Feed the Future Innovation Lab for Collaborative Research on Nutrition is a USAID funded project implemented by the Friedman School of Nutrition Science and Policy at Tufts University.

The mission of the Nutrition Innovation Lab is to discover how integrated interventions of agriculture, nutrition and health can achieve large-scale improvements in maternal and child nutrition in Asia and Africa and enhance institutional and human research capacity around agriculture, health and nutrition in Africa and Asia through graduate level training (MS and PhD) and support for short courses and conferences.

Second Annual Scientific Symposium
The Institute of Medicine at Tribhuvan University and Johns Hopkins Bloomberg School of Public Health, in collaboration with the Nutrition Innovation Lab, will hold the Second Annual Scientific Symposium on August 13-14, 2013.

Science and Policy for Health, Agriculture, Nutrition & Economic Growth will bring together scientists, policy makers, and program implementers to discuss and exchange ideas on how to improve nutrition in the context of health, agriculture and economic growth.

Nutrition Innovation Lab: Asia
The Nutrition Innovation Lab Asia works in Nepal. Partners in Nepal include the Schools of Public Health at Harvard University and Johns Hopkins University, the College of Agriculture at Purdue University and the College of Agricultural, Environmental, and Natural Sciences at Tuskegee University, the Institute of Medicine at Tribhuvan University, Development Alternatives, Inc., the Nepal Technical Advisory Service, Unicef, and others.

Nutrition Innovation Lab: Africa
The Nutrition Innovation Lab Africa works in Uganda and Malawi. In Uganda we work with the School of Public Health at Harvard University, the College of Agriculture at Purdue University and the College of Agricultural, Environmental, and Natural Sciences at Tuskegee University, the International Food Policy Research Institute, Gulu University and Makerere University and Development Alternatives, Inc.
Unraveling the Puzzle of Agriculture Nutrition Linkages

Eileen Kennedy, D.Sc.
Tufts University
Nutrition Innovation Lab
Agriculture Nutrition Linkages

• Not a new concept

• 1992 International Conference on Nutrition
  
  – Marriage of Agriculture and Nutrition to promote better Health

Twenty Years later

The marriage needs some help
Lancet Series 2013

Figure 1: Framework for actions to achieve optimum fetal and child nutrition and development

Source: Black et al, “Maternal and child undernutrition and overweight in low-income and middle-income countries” The Lancet, June 2013
Lancet Series

• Direct Nutrition Interventions

• Pregnant Women
  - Balanced Energy Protein Supplementation
    • One strategy to reduce SGA risk by about 34%
  - But.... Cost per recipient high $972
Lancet Series 2013

Source: Black et al, “Maternal and child undernutrition and overweight in low-income and middle-income countries” The Lancet, June 2013
Agriculture – Nutrition: Competing Pathways

Agriculture – Nutrition: Competing Pathways

Source: Gillespie, Harris, Kadiyala, IFPRI Discussion Paper 01187, June 2012
Impacts of Agriculture on Nutrition

“The current state of empirical evidence for impacts on nutrition ascribed to agricultural interventions is weak and mixed at best”

Recurring Theme

• Key Informant Interviews
  – Nepal and Ethiopia

• How Can Agriculture Help Improve Nutrition??
  – Specifics, including mechanisms, not another pathway model
NO MORE Pathways

- What works
- Assumptions in unpacking the links
Evidence

• Evidence of the effectiveness of targeted agricultural programs on maternal and child nutrition, with the exception of vitamin A, is limited

• Strengthening of nutrition goals and actions and rigorous effectiveness assessments are needed.
Unpacking Nutrition

• Mechanisms

• Biological plausibility
Birth Weight

- Timing
- Process
- Dose Response
Homestead Production

- Nepal – Multi Sector Nutrition Plan Sept 2012
- Ethiopian- National Nutrition Program Guide, June 2013
Nepal

- Action Against Malnutrition Through Agriculture – June 2012
- Homestead Production plus Essential Nutrition Actions
Homestead Production

- Increased production and consumption of micro nutrient rich fruits and vegetables
- Poultry Production / Consumption
- More animal source protein
- Increasing women’s income through marketing
Essential Nutrition Actions

Behavior Change through Nutrition Education and Demonstrations

Emphasis on maternal and child, age 2 and under
Links between Agriculture and Fetal Outcomes

- Maternal weight

  Birth Weight

- Erroneous Conclusion:
  - Agriculture/Nutrition ineffective
Improved Fetal Outcome

• Outcome
  – Birth Weight
• Mechanisms
• Diet Diversity
  – Caloric Intake
  – MN Foods
  – Animal Protein
• Knowledge
• Income
• Determinants
  – Maternal Weight Gain
Agricultural Intervention

Dietary diversity

- Increased Caloric Intake
- Increased Animal Protein
- Increased Micro Nutrient Rich Foods

Maternal Weight Gain

Birth Weight
Agricultural Intervention

Increased Knowledge

Dietary diversity

Increased Caloric Intake
Increased Animal Protein
Increased Micro Nutrient Rich Foods

Maternal Weight Gain

Birth Weight
Agricultural Intervention

Knowledge

Dietary Diversity

Increased Caloric Intake

Increased Animal Protein

Increased Micro Nutrient Rich Foods

Maternal Weight Gain

Birth Weight

+ = positive

?= cannot determine magnitude of effect

* = significant <.005

Source: HKI Final Report Evaluation AAMA, June 2012, Kathmandu
Next Steps

• Need to get beyond statements that “evidence is lacking”

• SO.....
  – Agreement on guidelines for research designs and metrics for complex interventions.
  – Repository for emerging data – sharing
Can This Marriage Be Saved?
Animal Source Protein and Stunting

Shibani Ghosh
Nutrition Innovation Laboratory
Asia and Africa
Presentation Overview

- Link between protein quality and stunting
- Protein sources in Nepal
- Protein sources in Uganda and link to stunting
Data Sources

• FAO STAT food balance sheet data (1961-2005)
  – Per capita daily food availability of 116 commodities in 214 countries and regions over 45 years
  – UNICEF data on prevalence of stunting
• FAOSTAT data for Nepal (1961-2005)
• Baseline data from Uganda panel survey
  – Dietary pattern (24 hour recall)
  – Anthropometric data (weights and heights)
Sources of Protein (2005)

~ 40% combined animal source and legume source proteins*

Percent of total protein

* Analysis by Pellett and Young 1990 to meet limiting amino acid needs
Utilizable protein, prevalence of stunting and prevalence of protein inadequacy by region in 2005

Ghosh et al 2013
<table>
<thead>
<tr>
<th></th>
<th>Total protein (g/capita/day)</th>
<th>Utilizable Protein (g/capita/day)</th>
<th>Stunting prevalence&lt;sup&gt;1&lt;/sup&gt;</th>
<th>GDP (US $ per capita/yr)</th>
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</thead>
<tbody>
<tr>
<td>Energy&lt;sup&gt;2&lt;/sup&gt; (kcal/capita/day)</td>
<td>0.848</td>
<td>0.841</td>
<td>-0.644</td>
<td>0.525</td>
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<td>Total protein&lt;sup&gt;2&lt;/sup&gt; (g/capita/day)</td>
<td>1.000</td>
<td>0.983</td>
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<td>Utilizable Protein&lt;sup&gt;2&lt;/sup&gt; g/capita/day</td>
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<td>Stunting prevalence&lt;sup&gt;2&lt;/sup&gt;</td>
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<td>-0.465</td>
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<td>GDP per capita&lt;sup&gt;2&lt;/sup&gt;</td>
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</table>

<sup>1</sup> Defined as the percentage of children under five years of age in a particular country who fall below -2 standard deviations for height-for-age z-score

<sup>2</sup> All coefficients are significant at p < 0.001
The association between prevalence of stunting and total and utilizable protein supply (g/capita/day), for 115 countries

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Energy (kcal/capita/day)</th>
<th>Total protein (g/capita/day)</th>
<th>Utilizable protein (g/capita/day)</th>
<th>Ln GDP (US$ per capita/yr)</th>
<th>Constant</th>
<th>Adjusted R square</th>
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<td>Stunting (^1)</td>
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<td>-6.58</td>
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<td></td>
<td>p=0.022</td>
<td>NS</td>
<td>P&lt;0.000</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Ghosh et al 2013
Percent Contribution of different food groups to protein supply in South Asia (Year 2005: Data source- Food Balance sheets)

* Analysis by Pellett and Young 1990 to meet limiting amino acid needs
Animal Source Foods in the diet

N=1332 index children under the age of 2
Growth Pattern in Ugandan children under 2

N=1950 index children under the age of 2

Mean Z-scores with standard deviations

Age of Index Children

WAZ  HAZ  WHZ
Stunting * Cow’s milk

- Chi Square Test: p=0.018
- Children who consumed cow’s milk were 38% less likely to be stunted

Significant differences in height for age Z-scores
P=0.009 (T test)
Chi Square Test: p=0.015
Children consuming meat are 50% less likely to be stunted

No significant difference in Mean Z-scores
Livestock Production

* p<0.001
Factors in Milk

**Fig. 1.** Possible associations between milk consumption, growth and health. Modified from Hoppe et al. [1].
Effects of Meat versus Milk

- RCT school feeding study: rural Embu District, Kenya
- Causal link between animal-source food intake and changes in micronutrient nutrition and growth, cognitive, and behavioral outcomes.
- Twelve primary schools randomly assigned to 1 of 4 groups (Grade 1).
- Local plant-based dish *githeri* supplemented with meat, milk, or fat and control
- The Meat group
  - the steepest rate of increase on cognitive tests and arithmetic test scores.
  - the greatest increase in % time spent in high levels of physical activity
  - Doubling of upper midarm muscle area
- The Milk group
  - only younger and stunted children showed a greater rate of gain in height
  - Smaller degree of increase in upper mid arm muscle area
- The Plain *githeri* and Meat groups performed better over time than the Milk and control groups ($P < 0.02–0.03$) on arithmetic tests

Neumann et al 2007
### Conclusions

- Relationship between protein quality and stunting
- Type of protein source and linear growth patterns
- Animal source foods: highly bioavailable form of macro and micronutrients
- Can affect linear growth and lean body mass
- The relationship between livestock production, access and utilization of animal source foods, growth and cognition
Why isn’t food enough?

Mycotoxins, Environmental Enteropathy & the Gut Microbiome

Jeffrey K. Griffiths, MD MPH&TM
August 6, 2013
Nutrition Interventions – why aren’t they enough?

ADOLESCENT, PRECONCEPTION, GESTATIONAL, AND MATERNAL NUTRITION ADEQUATE CALORIES (PROTEINS, FATS, CARBOS) IN ALL LIFE STAGES DIVERSITY OF MICRONUTRIENTS, VITAMINS, HIGH QUALITY PROTEINS OPTIMAL BREASTFEEDING, RESPONSIVE FEEDING PRACTICES, STIMULATION GOOD COMPLEMENTARY FEEDING 6-23 MONTHS, DIETARY DIVERSITY WEALTH, EDUCATION – [BE SURE TO CHOOSE YOUR PARENTS WELL] Others.....

Lancet 2013
It’s not just what you eat…
It’s your external and internal environment

**MYCOTOXINS**: FUNGAL FOOD TOXINS WHICH IMPAIR GROWTH AND IMMUNITY

**ENVIRONMENTAL ENTEROPATHY**: INFLAMED, LEAKY, DYSFUNCTIONAL INTESTINES

THE GUT **MICROBIOME** - GUT BACTERIA GONE BAD
Drying Cassava Dec 8\textsuperscript{th} 2012, Kamwenge: note green/yellow fungal discoloration

Photo: J K Griffiths  Uganda December 2012
Aflatoxins (aflatoxins are a subset of mycotoxins)

- Produced by *Aspergillus* fungus
- Known – hepatoxic & cause liver cancer in people
- Known in mammals to cause growth faltering and ↓ *in utero* growth (e.g. low birth weight)
- Associated* with lower birth weight, growth, stunting, and wasting in children
- Associated* with lower CD4 and higher viral loads (e.g. worse immunity) in people with HIV
- Widespread exposure in sub-Saharan Africa, SE Asia; maize, peanuts, many other crops.

*Some criticize these studies for only being “associative” - but it is *unethical* to give aflatoxins to people. Prospective studies of exposure and outcomes are needed to show “causation.”
Gong et al (BMJ, 2002) showed that **stunting** and weight for age was inversely related to blood aflatoxin levels in Gambia ($p < 0.001$, $R^2 = 0.37$). Jolly *et al* have shown the same in Ghana.
Aflatoxins II

• Contamination occurs in the field; promoted by poor post-harvest storage.

• Passed *in utero* and in breast milk to children

• Complementary food (e.g. porridge made from maize) is frequently contaminated – as are milk, eggs, chickens, animal meats...

• Prevention: storage without moisture/oxygen; dispersal of natural variant *Aspergillus* which lacks toxin; test and condemn crops/foods

• Needed: markets for aflatoxin-free foods!
Aflatoxin is in breast milk – could this have an impact on disease transmission? No one knows.
High potential for domestic animals and people to contaminate household environment with feces
Poor Sanitation / Hygiene. Fecal Contamination of Domestic Environment

Fecal Ingestion Infants/Children and Enteric Infections

(1) Increased gut permeability (2) Bacteria (and gut contents) leak into body (3) Intestinal Inflammation

ENVIRONMENTAL ENTEROPATHY

In studies dating to 1993, 43% of stunting explained by increased gut permeability
ENVIRONMENTAL ENTEROPATHY (EE)

People living in contaminated environments have leaky, chronically inflamed intestines.

EE - Short blunterd villi, tissue is infiltrated with inflammatory cells. 15% less protein and 5% less carbohydrate is absorbed. ↑ nutritional needs, bacteria leak into body, leads to anemia.

Bad bacteria are likely cause.

Korpe & Petri, Trends in Molecular Medicine June 2012, Vol. 18, No. 6
Environmental Enteropathy occurs when people live in contaminated environments. It is reversible. For example, US Peace Corps volunteers develop EE when they live in rural African villages. When they return to the US, their EE goes away.

The absence of fecal material – be it human or animal – in the environment both prevents and “treats” EE.

**Water/sanitation is critical to this separation.**

- Dean Spears has looked at open defecation as a marker of sanitation using 140 DHS data sets from 60 countries.

How much stunting is due to poor sanitation (and possibly EE?)

---

**How much international variation in child height can sanitation explain?**

Dean Spears*

First circulated: 10 December 2012
This version: 17 January 2013
Key findings Spear’s analysis of 140 DHS from 65 ‘developing’ countries

- Open defecation (certainly a marker of a “contaminated environment”) is linked to a **1.24 S.D. decrease** in the height of children.

- **Sanitation alone** accounts for **54%** of the between-country height variation (next slide).

- Open defecation and a lack of sanitation in an household, along with country GDP, predict child height **more than** mother’s height or education; governance; or infrastructure.
Note going from > 80% without sanitation (far right) to 0% without sanitation moves the HAZ score from under -2 to just under -1. Thus “real world” DHS data analysis suggests a clean environment does lead to decreased stunting.

Figure 1: Open defecation predicts child height, across DHS survey round country-years
Solid OLS regression lines weight by country population; dashed lines are unweighted.
Poor populations:
Will likely eat aflatoxins in foods.
> 99% will have environmental enteropathy in the absence of good water/sanitation.
Lacking WASH and barriers to fecal contamination, they will have a different spectrum of gut bacteria (the gut microbiome) than people with good WASH
Microbiome modulates your immune system

Could malnourished children benefit from being given a new microbiome?

Less Diverse Microbiome

Malnourished Child Microbiome Includes More Pathogens and Actively Promotes Weight Loss in Malnourished Children

Fecal Transplant: Better Insulin Sensitivity and ↑ gut butyrate

Microbiome Actively Promotes Obesity and Insulin Resistance

Microbiome of 1000-1150 species produces amino acids, short-chain fatty acids, and others which feed intestinal cells and shift your metabolic stance

Diverse Microbiome

Less Diverse Microbiome

INSIDE YOUR GUT
317 Malawian twins studied first 3 years of life.

- 50% both well nourished;
- 43% discordant (one well, one malnourished);
- 7% both were malnourished.

Both twins in discordant pairs received RUTF, a therapeutic food. Gut microbiomes (MB) studied: RUTF → transient MB improvement.
Gnotobiotic (sterile gut) mice – given Normal or Kwashiorkor Microbiomes from Malawian Children

- Mice given normal bacteria — maintained their weight
- The bacteria found in children with kwashiorkor malnutrition actively promoted weight loss in these mice –
- Mice given Kwashiorkor bacteria – lost 1/3 of their body weight in 18 Days
Maize, groundnuts
Key staple crops

Aspergillus spp. + moisture + warm temperature = Aflatoxin formation

Enteropathy – permeable intestine with documented increased nutrient needs, state of chronic inflammation
Microbiome – less diverse, abnormal nutrient utilization by flora

Diet, Societal Conditions
Diet: poor diversity, inadequate caloric & micronutrient intake, leading to immunosuppression
Pathogen exposure: Widespread food, water, environment contamination

Clinical Manifestations:
Cycle of repeated infections
Worsening nutritional status – stunting, underweight, IUGR

Agricultural interventions

Leaky Inflamed Intestine (EE)

WASH interventions

Nutrition interventions

Aflatoxin ingestion, duodenal uptake - Metabolites bind to DNA, proteins – can measure in blood, urine, tissues
Immunosuppression
Take-Home: healthy growth requires:

✓ Adequate, varied nutrition with enough calories, micronutrients, and vitamins

✓ The absence of environmental toxins such as aflatoxin – immunosuppression, poor intra-uterine and post-natal growth, liver toxicity

✓ A clean environment which prevents environmental enteropathy, with its chronic inflammation and higher nutritional needs

✓ A normal gut microbiome which does not starve its host of nutrients and promote weight loss
Thanks!

Questions: jeffrey.griffiths @ tufts.edu

Photo: JK Griffiths Tanzania 2008
Agriculture and child nutrition: evidence from Nepal and Uganda

Gerald Shively (shivelyg@purdue.edu)
Department of Agricultural Economics, Purdue University
August 6, 2013
Children below 5 years (n=5237) by agroecological zone (from left to right, means = -2.27, -2.02, -1.89)

Very high incidence of severe stunting in Nepal indicated by large proportion (here 50%) of kids below -2

Mean for a “healthy” population = 0

Source: DHS 2006
Typical approach: multiple regression
HAZ, 2006 data for rural U5s in Nepal

```
. reg haz agemos sex agemom educmom educdad handwashing open_defecation
```

<table>
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<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 1571</th>
</tr>
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<td>Model</td>
<td>464.595358</td>
<td>7</td>
<td>66.3707655</td>
<td>F(  7, 1563) = 43.11</td>
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<td>Residual</td>
<td>2406.62219</td>
<td>1563</td>
<td>1.53974549</td>
<td>Prob &gt; F = 0.0000</td>
</tr>
<tr>
<td>Total</td>
<td>2871.21755</td>
<td>1570</td>
<td>1.82880099</td>
<td>R-squared = 0.1618</td>
</tr>
</tbody>
</table>

|          | Coef.     | Std. Err. | t     | P>|t|  | [95% Conf. Interval] |
|----------|-----------|-----------|-------|------|---------------------|
| haz      |           |           |       |      |                     |
| agemos   | -0.0221323 | 0.00186   | -11.90| 0.000 | -0.0257806 to -0.018484 |
| sex      | 0.0441683  | 0.0626797 | 0.70  | 0.481 | -0.0787769 to 0.1671136 |
| agemom   | -0.0056044 | 0.0055155 | -1.02 | 0.310 | -0.0164229 to 0.0052141 |
| educmom  | 0.1342081  | 0.0494852 | 2.71  | 0.007 | 0.0371439 to 0.2312724 |
| educdad  | 0.0264448  | 0.0098482 | 2.69  | 0.007 | 0.0071276 to 0.0457619 |
| handwashing | 0.1003726  | 0.0225514 | 4.45  | 0.000 | 0.0561385 to 0.1446067 |
| open_defec | -0.1810857 | 0.0743327 | -2.44 | 0.015 | -0.326888 to -0.0352834 |
| _cons    | -1.421244  | 0.2074276 | -6.85 | 0.000 | -1.828109 to -1.014378 |
Agriculture’s Importance: Employment and Earnings

Key NIL research question:
Can we add insights regarding the role of agriculture in shaping nutritional outcomes?

Desired statistical approach based on something like:

\[ Z = f(\text{child characteristics, mom's characteristics, health infrastructure, agricultural capacity and characteristics, market access, participation, input and output prices, growing conditions}) \]

Variables are measured at different spatial scales, which makes it a bit tricky…
MODIS - NDVI

Moderate Resolution Imaging Spectroradiometer Climate Modeling Grid

Normalized Difference Vegetation Index

NDVI=(NIR-RED)/(NIR+RED)

Previous uses of NDVI:
- identifier of the start of the growing season (Brown & de Beurs, 2008)
- famine early warning systems network (FEWSNET)
- anticipating food aid needs in advance of food security crises (Funk & Brown, 2006)

http://svs.gsfc.nasa.gov/vis/a000000/a003700/a003707/NDVIflatmap.mp4
NDVI Values for Nepal and Uganda, 2000-2011

Uganda: greener w/less variance
Interannual NDVI Anomalies by Ecological Zone in Nepal

2006 winter and summer drought
2008/2009 winter drought

Not so good  Good
The mechanics of matching

Temporal dimension: what periods are critical for child growth?

5 year-old child measured

Relevant period for “short-term” wasting

2004 2005 2006 2007 2008 2009 2010 2011

Child in utero Year of birth Relevant for “stunting”

Spatial and agronomic dimensions:

what months correspond to the relevant growing season for the major crops being grown in the child’s vicinity?
Uganda: whz vs. ndvi (in utero)

0.0011 \times (850-275) = 0.64 \text{ z-score gain}

“crop-specific” pre-harvest period for the zone

broad range of responsiveness

source: UDHS 2006 and NASA
## HAZ: Uganda

<table>
<thead>
<tr>
<th>Source</th>
<th>variable</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td>DHS child</td>
<td>child age (months)</td>
<td>-0.016***</td>
<td>-0.014***</td>
<td>-0.014***</td>
<td>-0.014***</td>
<td>-0.014***</td>
</tr>
<tr>
<td></td>
<td>twin (0/1)</td>
<td>-0.828***</td>
<td>-0.878**</td>
<td>-0.831***</td>
<td>-0.802***</td>
<td>-0.818***</td>
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<td>anemic (0/1)</td>
<td>-0.416***</td>
<td>-0.346***</td>
<td>-0.337***</td>
<td>-0.357***</td>
<td>-0.357***</td>
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<tr>
<td>DHS mother</td>
<td>mother's BMI (kg/m2)</td>
<td>0.029**</td>
<td>0.020</td>
<td>0.022*</td>
<td>0.021*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mother’s age (year)</td>
<td>0.027***</td>
<td>0.021*</td>
<td>0.022*</td>
<td>0.022*</td>
<td></td>
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<tr>
<td></td>
<td>breastfeeding time (months)</td>
<td>-0.019***</td>
<td>-0.018***</td>
<td>-0.017***</td>
<td>-0.017***</td>
<td></td>
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<tr>
<td></td>
<td>mom currently breastfeeding (0/1)</td>
<td>-0.224**</td>
<td>-0.203**</td>
<td>-0.190*</td>
<td>-0.191*</td>
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<tr>
<td>DHS father</td>
<td>wealth index score (/10000)</td>
<td>0.013**</td>
<td>0.013**</td>
<td>0.014**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and HH</td>
<td>urban (0/1)</td>
<td>0.040**</td>
<td>0.375***</td>
<td>0.328**</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>internally displaced (0/1)</td>
<td>-0.612*</td>
<td>-0.455*</td>
<td>-0.435*</td>
<td></td>
<td></td>
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<tr>
<td>UNHS (district level)</td>
<td>crop yield (kg/100ha)</td>
<td></td>
<td>-0.034*</td>
<td>-0.035*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>market participation (sales/production)</td>
<td></td>
<td>-0.987**</td>
<td>-0.965**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>purchased input use (%)</td>
<td></td>
<td>0.689**</td>
<td>0.687**</td>
<td></td>
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</tbody>
</table>

Source: 2006 UDHS (n=2,158); geographic controls and non-significant variables not shown. * denotes significance at 10%, ** 5%, and *** 1% test levels.
### WHZ: Uganda

<table>
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<th>Source</th>
<th>variable</th>
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<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td><strong>DHS child</strong></td>
<td>child age (month)</td>
<td>0.010***</td>
<td>0.013***</td>
<td>0.013***</td>
<td>0.013***</td>
<td>0.013***</td>
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<tr>
<td></td>
<td>twin (0/1)</td>
<td>-0.292**</td>
<td>-0.310**</td>
<td>-0.301**</td>
<td>-0.278**</td>
<td>-0.272**</td>
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<tr>
<td></td>
<td>bcg vaccine (0/1)</td>
<td>0.309**</td>
<td>0.268*</td>
<td>0.269*</td>
<td>0.263*</td>
<td>0.261*</td>
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<tr>
<td></td>
<td>anemic (0/1)</td>
<td>-0.216***</td>
<td>-0.147***</td>
<td>-0.162***</td>
<td>-0.169***</td>
<td>-0.173***</td>
</tr>
<tr>
<td><strong>DHS mother</strong></td>
<td>mother's BMI (kg/m2)</td>
<td>0.075***</td>
<td>0.077***</td>
<td>0.078***</td>
<td>0.078***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mother pregnant (0/1)</td>
<td>-0.166**</td>
<td>-0.174**</td>
<td>-0.173**</td>
<td>-0.173**</td>
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<tr>
<td></td>
<td>breastfeeding time (months)</td>
<td>-0.014***</td>
<td>-0.013***</td>
<td>-0.013***</td>
<td>-0.013***</td>
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<td><strong>NDVI</strong></td>
<td>recent_growing_season</td>
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<td></td>
<td></td>
<td></td>
<td>0.002*</td>
</tr>
</tbody>
</table>

**Effect of greenness, or lack of clouds?**

Source: 2006 UDHS (n=2,158); geographic controls and non-significant variables not shown. * denotes significance at 10%, ** 5%, and *** 1% test levels.
HAZ: Nepal, 2011

<table>
<thead>
<tr>
<th>Variable</th>
<th>HAZ</th>
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<td>Urban</td>
<td>0.2701**</td>
</tr>
<tr>
<td>Age</td>
<td>-0.1168***</td>
</tr>
<tr>
<td>Age²</td>
<td>0.0014***</td>
</tr>
<tr>
<td>Vaccines</td>
<td>0.0184**</td>
</tr>
<tr>
<td>Mother’s Education</td>
<td>0.7568***</td>
</tr>
<tr>
<td>Second Quintile</td>
<td>0.1640*</td>
</tr>
<tr>
<td>Middle Quintile</td>
<td>0.1811*</td>
</tr>
<tr>
<td>Fourth Quintile</td>
<td>0.1995*</td>
</tr>
<tr>
<td>Highest Quintile</td>
<td>0.2444**</td>
</tr>
<tr>
<td>Flush Toilet</td>
<td>0.2548**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>HAZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH crop yield (kg/ha)</td>
<td>0.00004**</td>
</tr>
<tr>
<td>HH crop diversity</td>
<td>0.0520**</td>
</tr>
<tr>
<td>Diversity*Education</td>
<td>-0.0475***</td>
</tr>
<tr>
<td>HH cereals</td>
<td>0.4164</td>
</tr>
<tr>
<td>HH roots</td>
<td>0.9176</td>
</tr>
<tr>
<td>HH pulses</td>
<td>0.4593</td>
</tr>
<tr>
<td>HH fruits</td>
<td>0.9251*</td>
</tr>
<tr>
<td>HH vegetables</td>
<td>0.6967*</td>
</tr>
<tr>
<td>HH animal protein</td>
<td>0.2434*</td>
</tr>
</tbody>
</table>

Source: 2011 NLSS (n=1,786); geographic controls and non-significant variables not shown. 
$R^2=0.24$; * denotes significance at 10%, ** 5%, and *** 1% test levels.
WHZ and HAZ in Nepal, 2006 vs. 2011

Changes in means:

unconditional

After accounting for:

child factors
& hh factors
& mother’s
& ag + weather

**WHZ**

+ 0.175
+ 0.162
+ 0.105
+ 0.090
+ 0.059

**HAZ**

+ 0.251
+ 0.247
+ 0.141
+ 0.127
+ 0.206

(1) Much (2/3) of the improvement in WHZ can be explained by observable factors, including weather and agriculture.

(2) Much less of the observed improvement in HAZ can be explained by observables.
Take-away messages for Nepal and Uganda

• **Standard explanations seem robust to the inclusion of agriculture, but may not fully account for nutritional improvements over time.** The importance of child, mother and health factors are sometimes strengthened by the inclusion of a broader set of factors related to agricultural potential and performance. However, short-run changes in nutritional outcomes seem highly sensitive to agriculture.

• **The connection between agricultural performance and nutritional outcomes is not always clear.** Drilling down helps. Household-level indicators of agricultural activity seem to be better predictors of nutritional outcomes than district-level variables.

• **Climate may matter, but perhaps not as much as we think.** Outside of extremely extreme events, and beyond semi-arid environments prone to strong droughts, separating the climate signal from the “noise” may be difficult. Big correlations are not likely to be hiding in the data.
Thank you for joining us!

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You can also visit the event page to post comments & questions.

**Stay In Touch**

Contact Us:
agrilinks@agrilinks.org

OR

Julie MacCartee
USAID/BFS
jmaccartee@usaid.gov

**Upcoming Events**

August hiatus - See you in September!

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