Tufts UNIVERSITY | Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy

Linking Nutrition-Health-Agriculture

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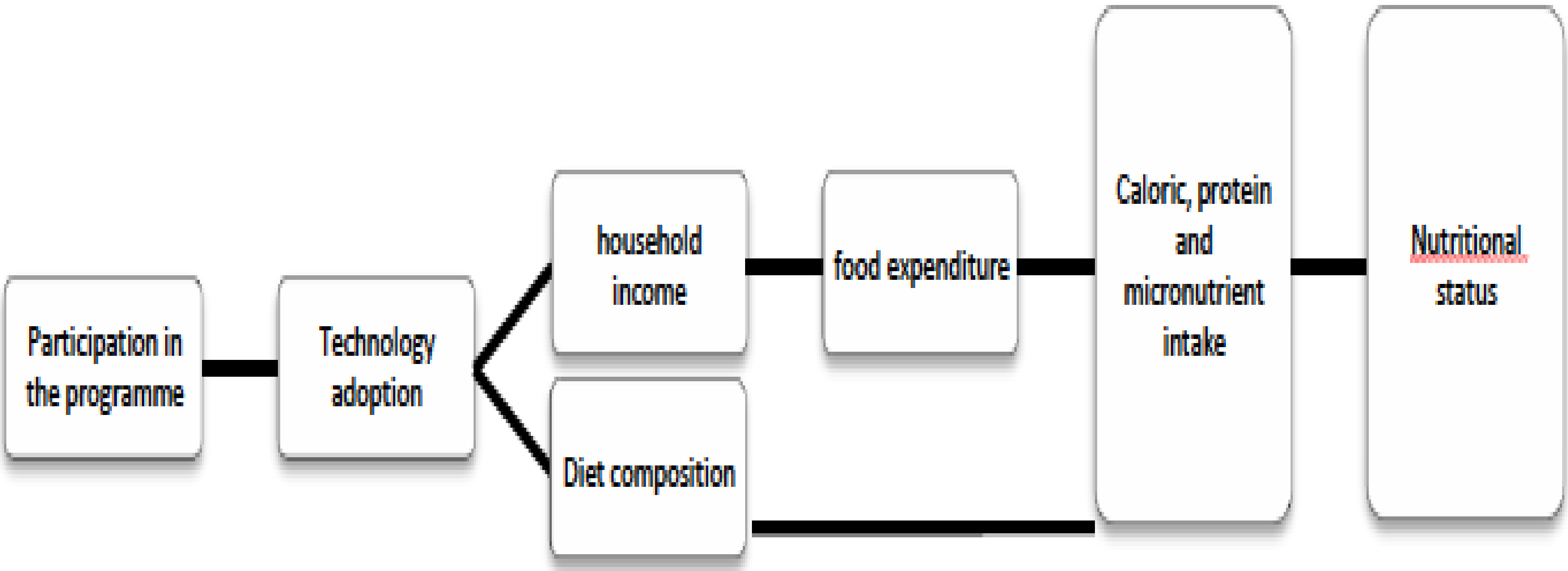
Linking Nutrition outcomes to Agriculture

- Agriculture=Food=/=Nutrition
- Agriculture- Water- Infection- Stunting
- Agriculture practices-Food Safety- Stunting

Agriculture=Food=/=Nutrition

Theoretical Framework Example



Masset et al 2011

Friedman School
of Nutrition Science and Policy

Systematic review of agricultural interventions that aim to improve children’s nutritional status by improving the incomes and diet of the rural poor.

Systematic review

A systematic review of agricultural interventions that aim to improve nutritional status of children

by Edoardo Masset
Lawrence Haddad
Alex Cornelius
Jairo Isaza-Castro

May 2011

Masset et. al. (2011)
Agricultural interventions show...

a) Positive impact on farm output.
b) “Poor evidence of impact on households’ income.”
c) “Little evidence…on changes in diets of the poor.”

d) None assessed if interventions improve quality of whole diet.
e) 9 studies tested impact on Vitamin A (only 4 were positive).
f) “No evidence of impact on stunting, wasting.”

Review paper	System. review?	Number of studies screened	Studies reviewed	Period of studies retained	Agriculture activities included	Important conclusions
Ruel (2001)	N	Not specified	14	1995-1999	Home gardens, aquaculture, BCC*	➢ "information now available is inadequate." ➢ "basic information on efficacy is needed."
Berti et al. (2004)	N	36	30	1985-2001	Home gardens, animals, cash cropping, credit	➢ "mixed results in improving nutrition." ➢ "negative effects were not uncommon."
Leroy and Frongillo (2007)	Y	Not specified	14	1987-2003	Animals aquaculture, poultry, credit, BCC	➢ "only 4 studies evaluated impact on nutritional status and found effect." ➢ "integrated [activities] generally found positive results."
World Bank (2007)	N	Not specified	52	1985-2007	All forms of agriculture	➢ "agricultural interventions not always successful in improving nutrition."
Bhutta et al. (2008)	Y	Not specified	29	1985-2004	Home gardens, animals, small ruminants, BCC	➢ "dietary diversification strategies have not been proven to affect nutritional status or micronutrient indicators on a large scale."
Kawarazuka (2010)	Y	Not specified	23	2000-2009	Aquaculture	➢ "data on improved dietary intake to nutritional status were scarce." ➢ "nutritional outcomes not demonstrated."
Masset et al. (2011)	Y	7,239	23	1990-2009	Biofortification, home gardens, aquaculture, husbandry, dairy	➢ "very little evidence was available on changes in the diet of the poor." ➢ "no evidence of impact on stunting, wasting and underweight."
Arimond et al. (2011)	N	>2,000	39	1987-2003	All forms of agriculture	➢ "few agricultural interventions with nutrition objectives scaled up." ➢ "many of the studies… weakly designed."
Girard et al. (2012)	Y	3,400	37	1990-	Home gardens, biofortification, BCC, husbandry	➢ "estimates for effects on stunting…were not significant."

Nutrition is about choices

Banerjee and Duflo (2011) ***Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty***

They advocate "careful thinking about incentives and behavior" at household *and* institutional levels.

Direcção De Economia, Ministério Da Agricultura, República De Moçambique

February 2012 • Research Report 72E

An Introduction to Nutrition-Agriculture Linkages

Kimberly Chung
Michigan State University

Fig 1: Ag-Nutrition Linkages at the Household and Intra-Household Levels

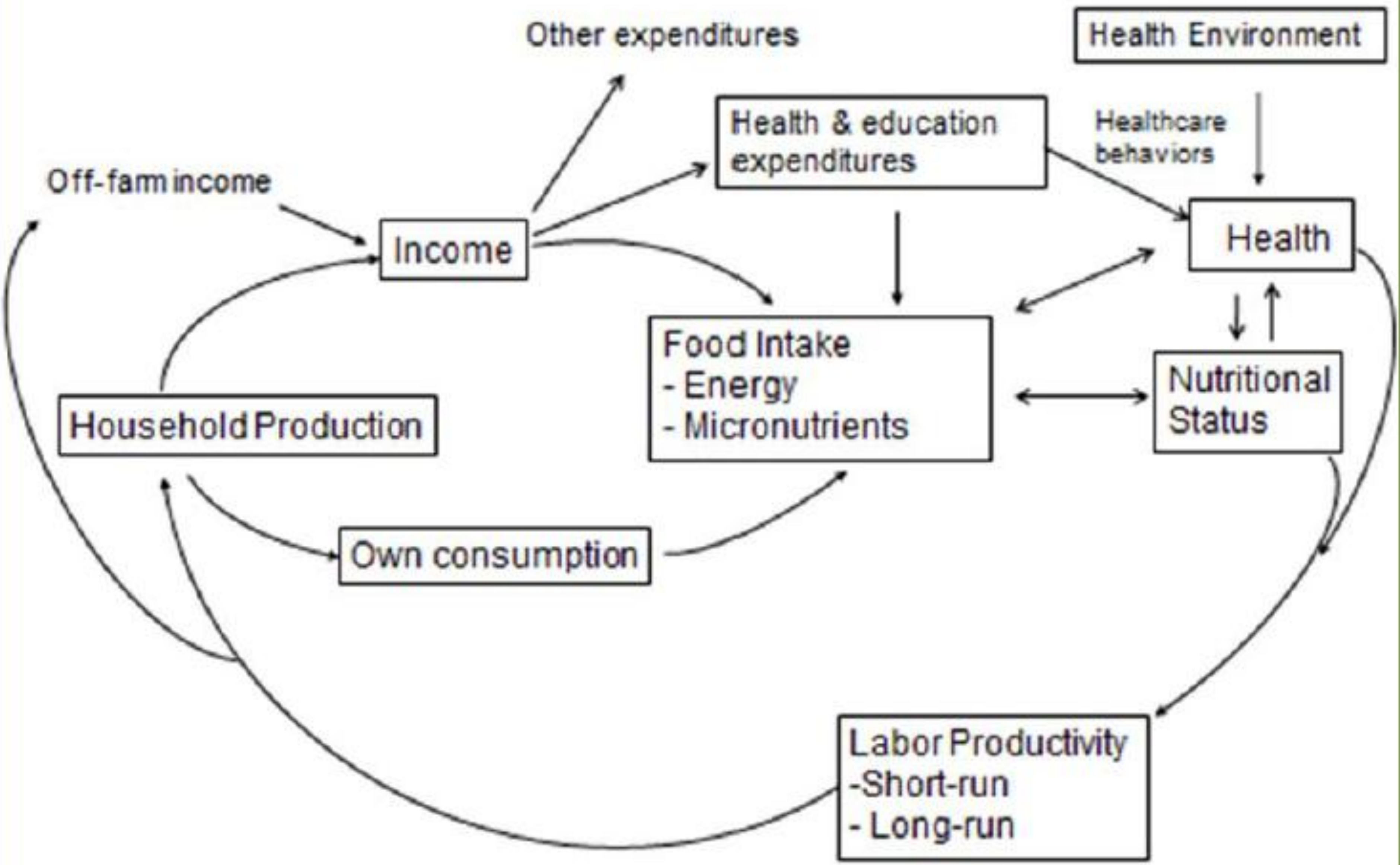


Figure 2: The Trickle Down Approach to Improving Nutrition thru Agriculture

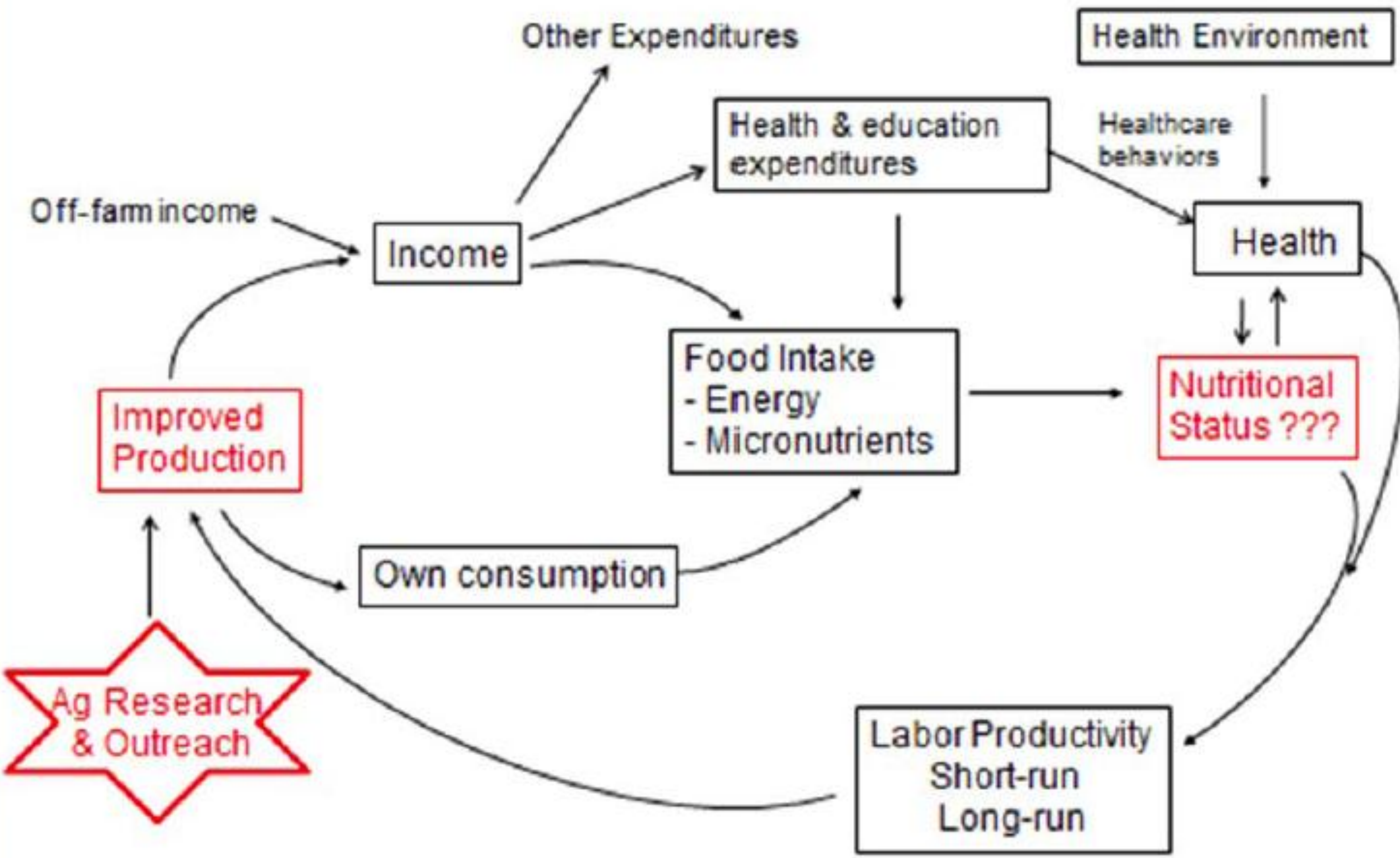
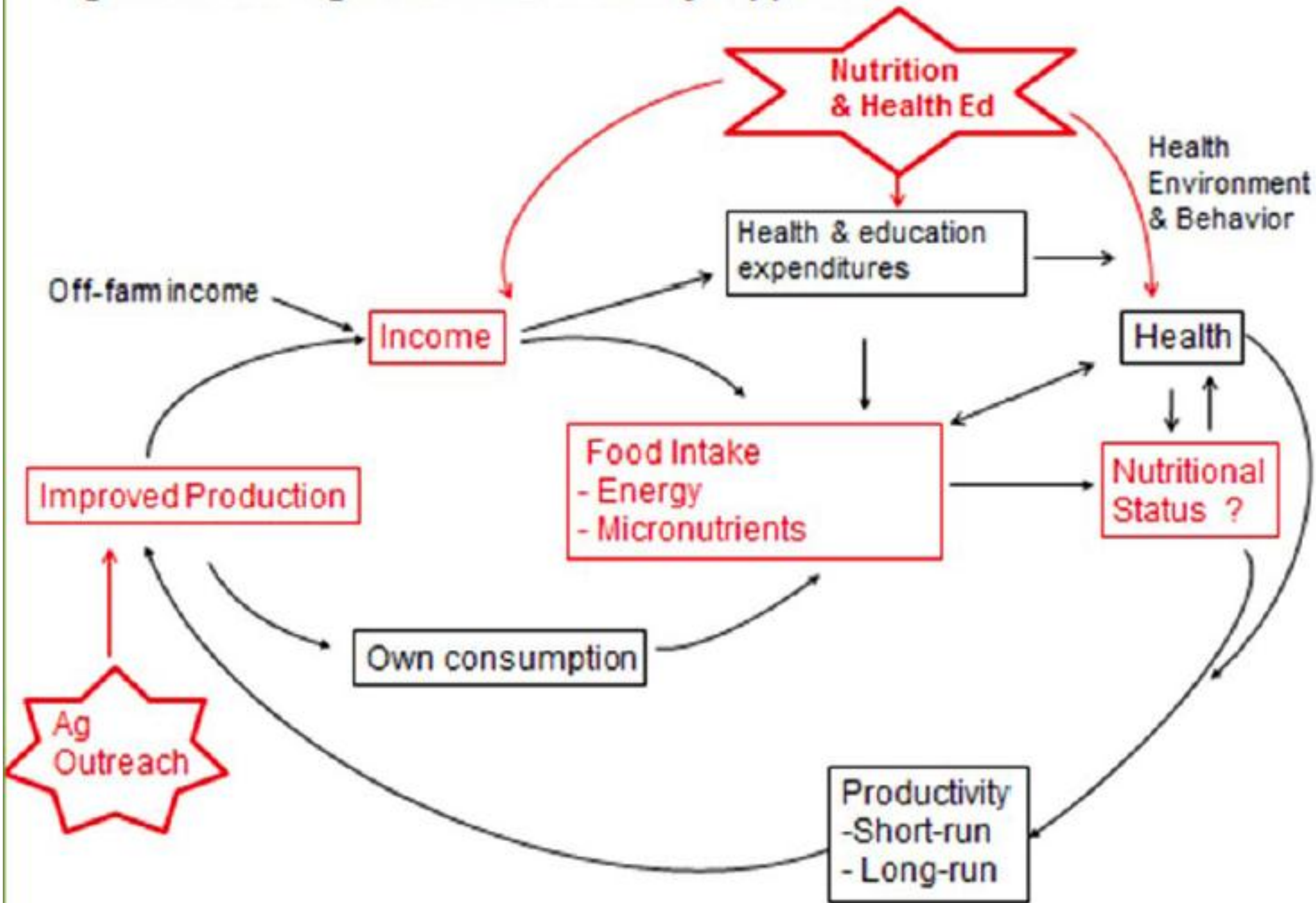


Figure 4: The Ag-Based Diet Diversity Approach



“Changes should be monitored at each link within the chain, with the **understanding that changes to nutritional status will be the last to be affected**. Given the complexity of these linkages it is important to think beyond advocating for a single approach and to instead think about building a larger, coherent strategy that comprises many varied approaches.”

Chung 2012

Agriculture- Water- Infection- Nutrition

- Thesis: Eliminating stunting & malnutrition will require provision of adequate and diverse diets;
  - Environmental contamination
  - Prevention of infectious diseases

Big Picture Thesis 2: Stunting

FOOD DEFICITS

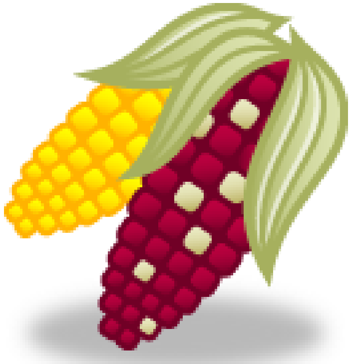
1/3RD STUNTING ADDRESSED BY ADEQUATE DIET

~ 40% OF STUNTING

WASH – CLEAN ENVIRONMENT

'DIARRHEAL DISEASE' ONLY ACCOUNTS FOR MUCH SMALLER % OF GROWTH DEFICITS THAN WASH DEFICIT (5-15% VS 40%).

AFLATOXIN – COULD ACCOUNT FOR 40% OF STUNTING (WEST AFRICA DATA)



Water needed for crops, for farm animals (meat protein is good), to keep farmers hydrated and fit for work, …. Irrigation, reservoir construction

What else does the water carry?

AGRICULTURAL WASTEWATER

ORGANISM	TYPICAL SOURCE
ROTAVIRUS	HUMANS; PERHAPS ANIMALS
HEPATITIS A	HUMANS
HEPATITIS E	HUMANS, **SWINE**
E. coli (bacteria)	**CATTLE,** HUMANS
Shigella species	HUMANS
Salmonella enterica (bacteria)	**CATTLE, POULTRY, SWINE, HUMANS**
Campylobacter jejuni (bacteria)	**POULTRY**
*Cryptosporidium** (protozoan)	**CATTLE,** HUMANS**, OTHER FARM ANIMALS**
*Microsporidia** (fungus)	**FARM AND DOMESTIC ANIMALS,** HUMANS
* Causes chronic diarrhea, wasting, malnutrition in people with HIV/AIDS	
Cryptosporidium – a leading cause of diarrhea children < 24 months; known to cause stunting; and children have x 4 risk of death in next year	

Pathogens in Rural and Agricultural Water and Watersheds. USDA 2010

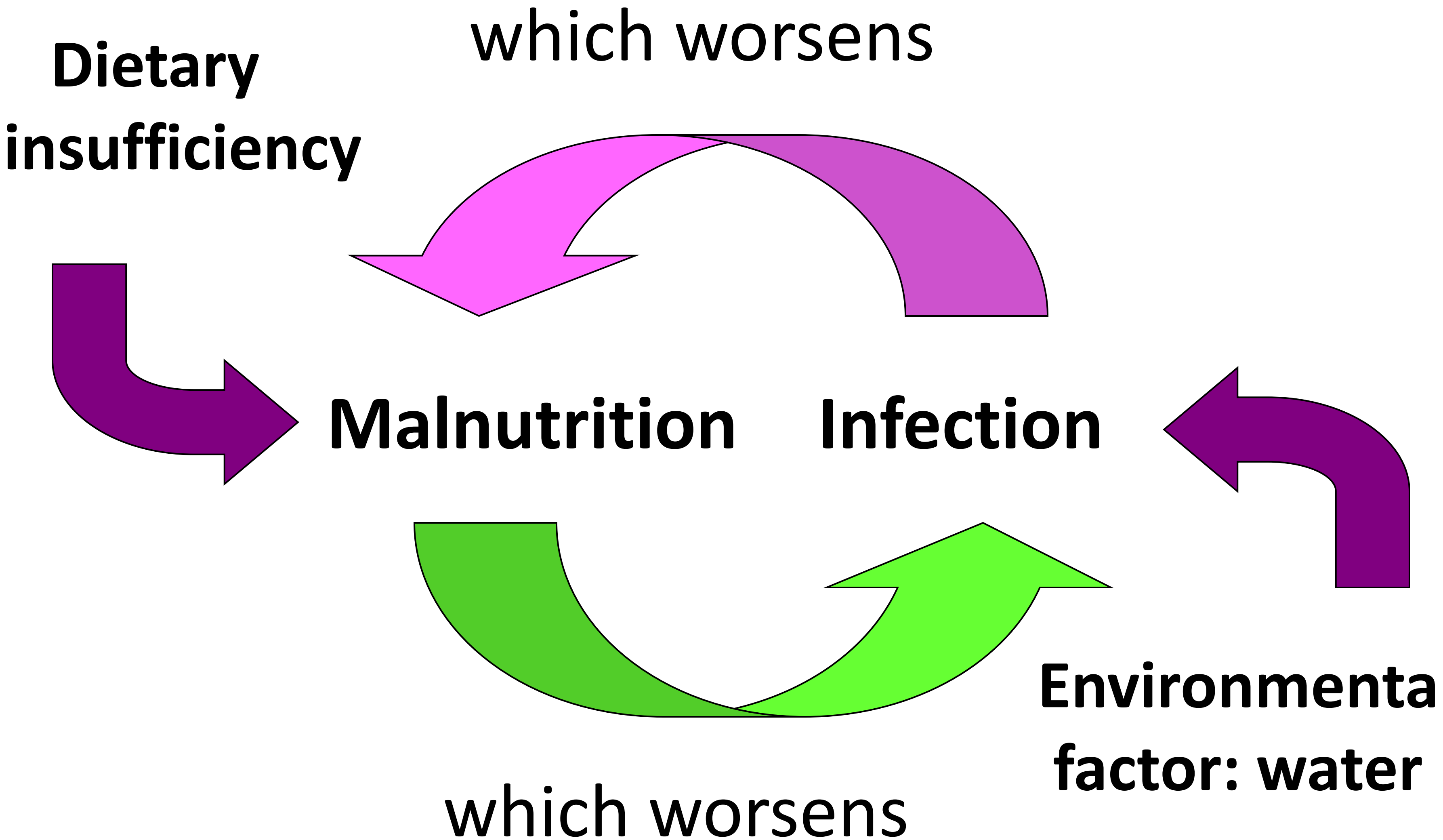
Agriculture in Urban Nairobi: Sewage

Left: broken sewage main in field. Right: lush fields.

Farmers work in contaminated fields; crops contaminated with human pathogens; go home to families carrying tools & wearing boots that have been in sewage…

High potential for domestic animals and people to contaminate household environment

Photo: J K Griffiths Ethiopia August 2012



<u>Stunting is strongly related to gut injury and permeability –</u>
<u>‘environmental enteropathy</u> ’ –

Poor Sanitation / Hygiene. Fecal Contamination of Domestic Environment

Fecal Ingestion Infants/Children and Enteric Infections

(1) Intestinal Inflammation (2) Increased gut permeability (3) Bacteria get into body via leaky gut (4) **Entire Immune System gets activated**

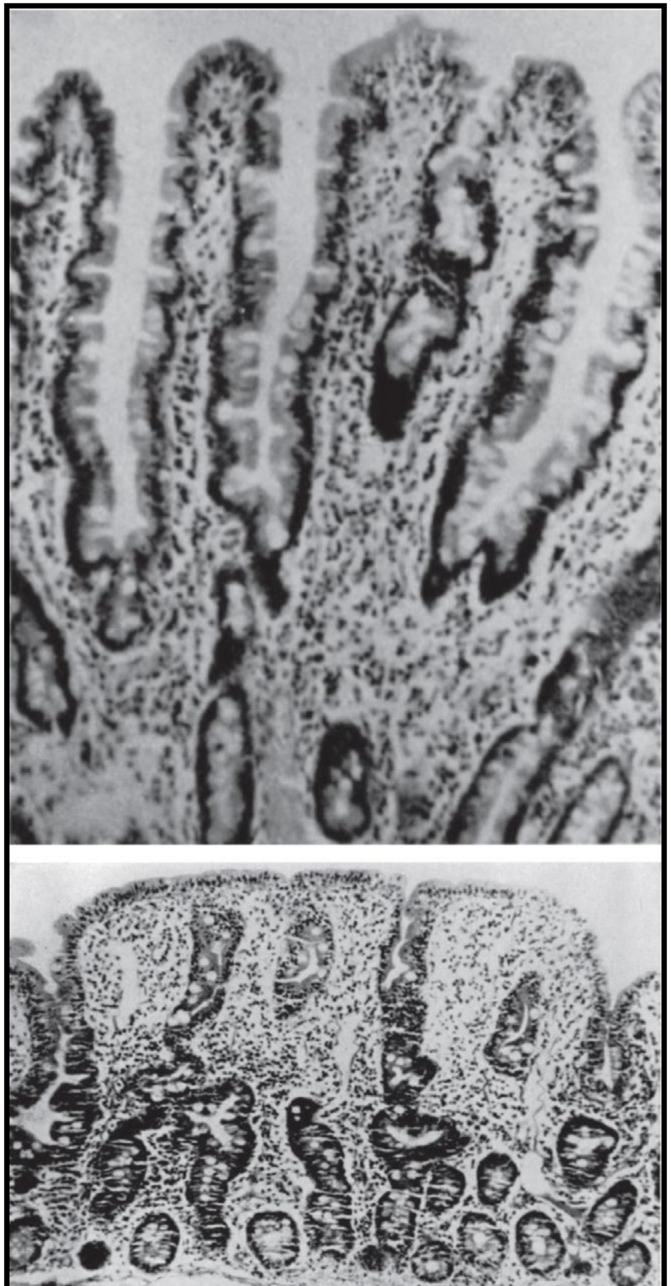
ENVIRONMENTAL ENTEROPATHY

Malabsorption & Malnutrition; Oral Vaccine Failure; ↑ Risk of Infection; ↑ Morbidity/Mortality, ↓ Cognition, Economic Potential

Permeability (L)

- Larger molecules can pass through the barrier
  - Antigens, viruses and bacteria that continually stimulate an <u>acute but often subclinical immune response</u>

- The permeability associated with diarrhea is transient and disappears within 5 days
- Permeability associated with EE is chronic



Nice normal intestine. Note long skinny finger-like villi, which absorb nutrients

ENVIRONMENTAL ENTEROPATHY

EE -Nasty blunted villi, and tissue is infiltrated with inflammatory cells. **EE is a state of chronic inflammation**

Korpe & Petri, Trends in Molecular Medicine June 2012, Vol. 18, No. 6

Environmental Enteropathy

Children in highly contaminated environments have leaky, chronically inflamed intestines

5% less carbohydrate,

15% less protein absorption

Zinc malabsorption

Vitamin B 12

Leak lets ‘dirty’ contents of gut into body; chronic inflammation uses up/diverts nutrients, leads to anemia…

Malnourished Children have less diverse, different gut microbiomes

Bacteria Shared With Animals

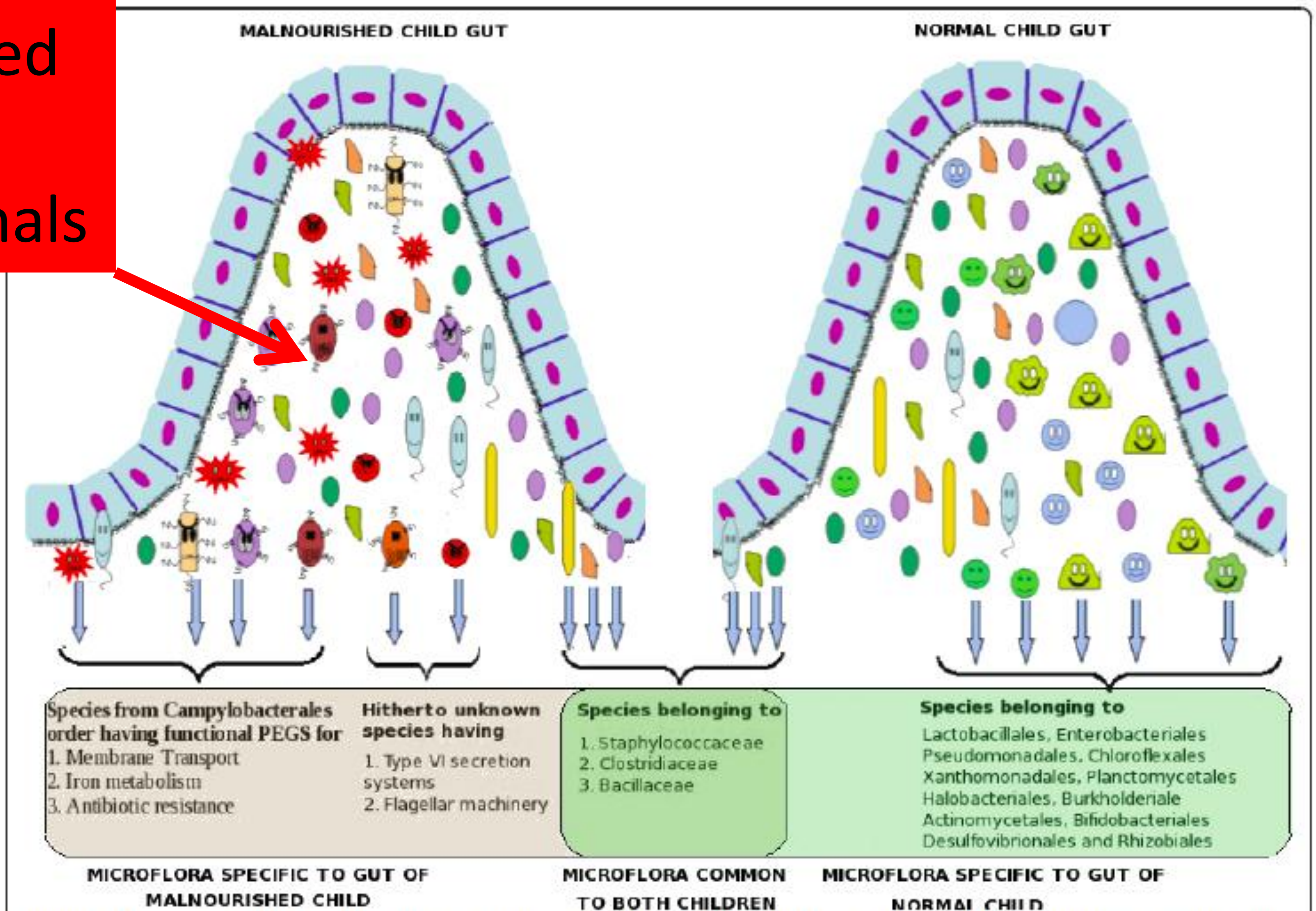


Figure 4 Schematic diagram indicating the overall differences between microbial communities residing in the gut of a malnourished and a healthy child.

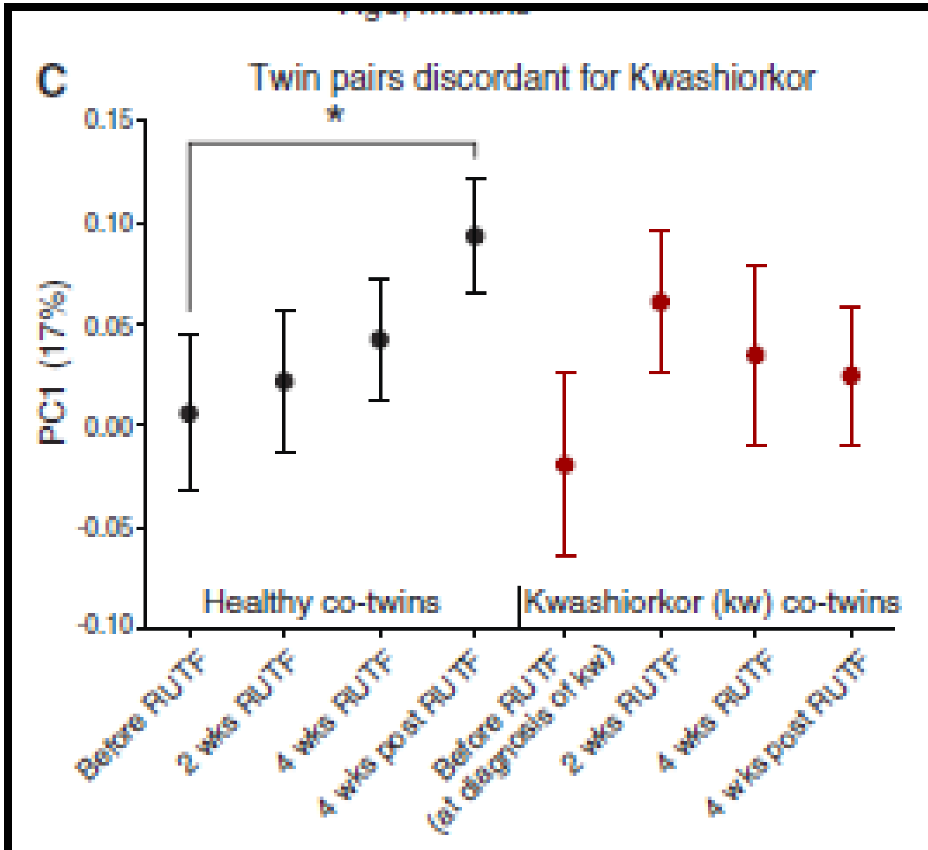
Gupta *et al. Gut Pathogens* 2011, 3:7
http://www.gutpathogens.com/content/3/1/7

Gut Microbiomes of Malawian Twin Pairs Discordant for Kwashiorkor

Michelle I. Smith,[1*] Tanya Yatsunenko,[1*] Mark J. Manary,[2,3,4] Indi Trehan,[2,3] Rajhab Mkakosya,[5] Jiye Cheng,[1] Andrew L. Kau,[1] Stephen S. Rich,[6] Patrick Concannon,[6] Josyf C. Mychaleckyj,[6] Jie Liu,[7] Eric Houpt,[7] Jia V. Li,[8] Elaine Holmes,[8] Jeremy Nicholson,[8] Dan Knights,[9,10]† Luke K. Ursell,[11] Rob Knight,[9,10,11,12] Jeffrey I. Gordon[1]‡

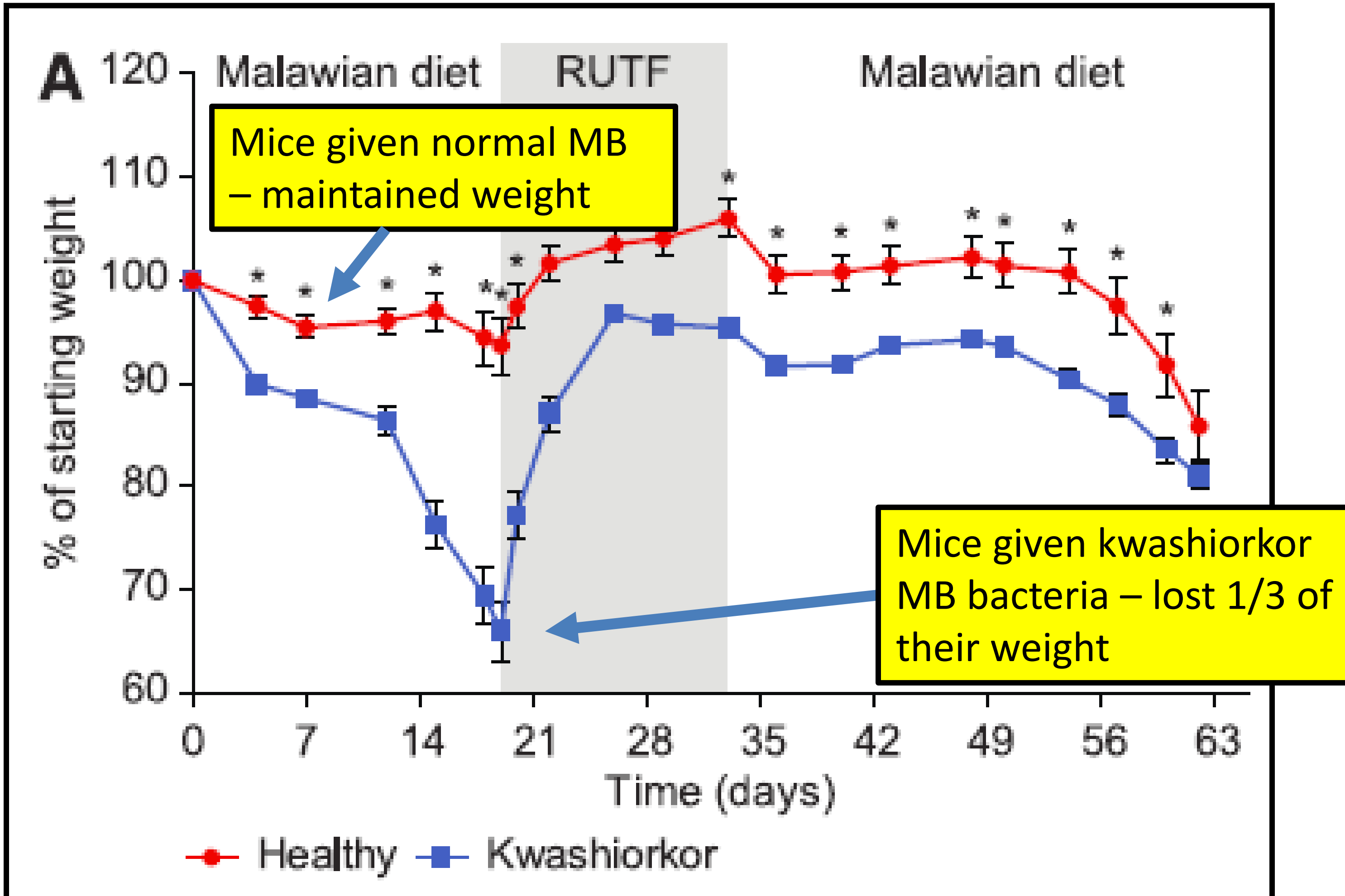
Science 339:548-554.
1 February 2013

- 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.



Then...

Gnotobiotic (sterile gut) mice – given either Normal or Kwashiorkor MB



1. Stunting occurs in setting of ubiquitous Environmental Enteropathy (EE). 43% of stunting related to EE in Gambia.

and:

2. Gut microbiomes of malnourished children are abnormal, and appear to actually promote weight loss and malnutrition

Solutions

- **Classic household water & sanitation**

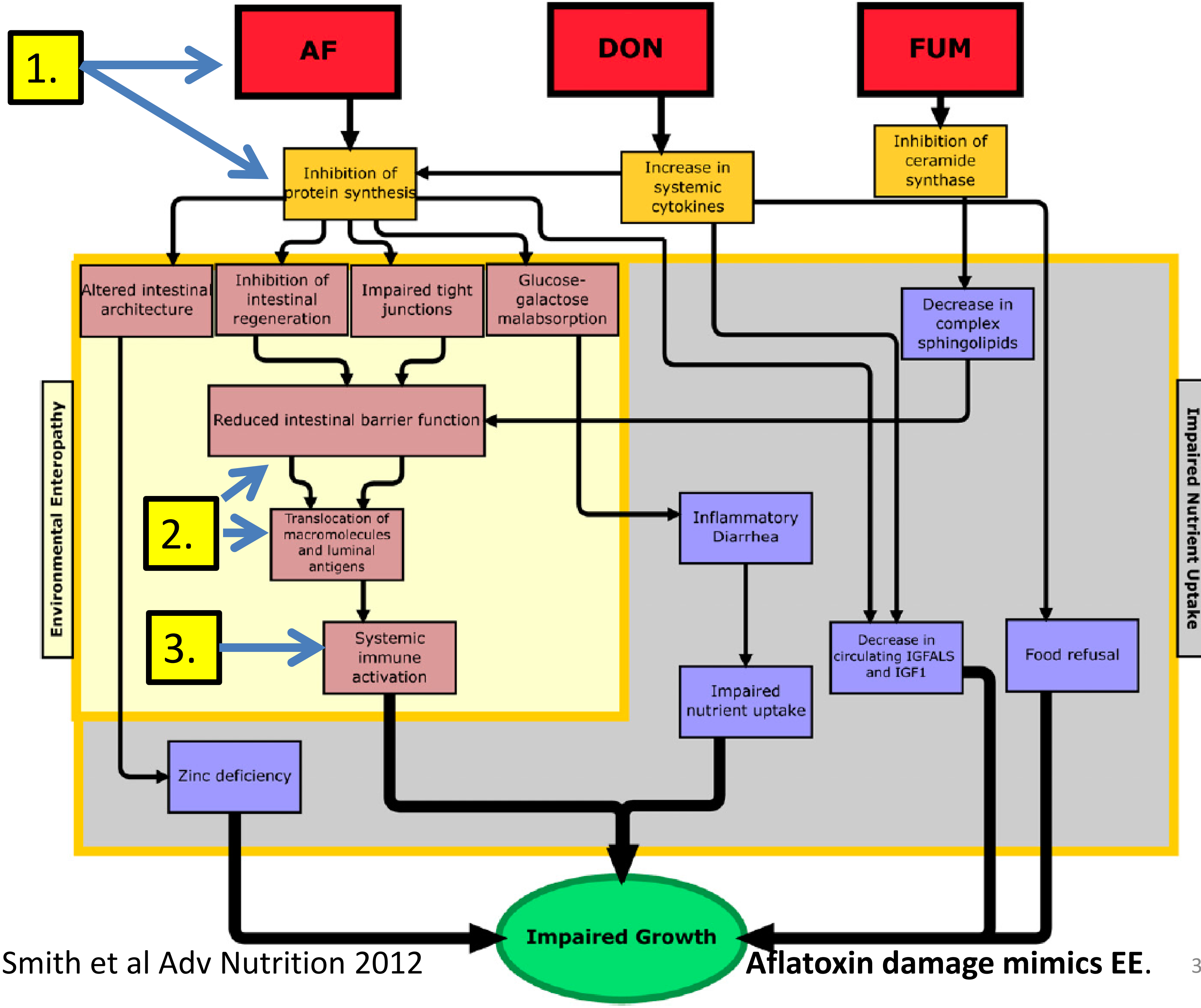
- **Agricultural practices**
  - Farm practices to control spread of disease are well known
  - **Keeping animals out of human water supplies**

January 4 2013: FDA proposes rules to “ensure water used in irrigation meets standards…”

Agriculture practices-Food Safety-Stunting

Aflatoxins

- Historically, well known cause of liver cancer.
- If large doses eaten, cause rapid death (likely from liver failure).
- Cause stunting, low birth weights in animals.
- Aflatoxins present in dried foods; human breast milk; cow milk, poultry, eggs, and meat if animals given feed with aflatoxins.
- *Recent* data highly suggestive it is a cause of stunting, low birth-weight, enhanced risk of infectious diseases in human populations



LE Smith et al Adv Nutrition 2012

Aflatoxin damage mimics EE.

CONTAMINATED WATER / POOR HYGIENE
(PATHOGENS, OTHER STUFF IN WATER)

ENVIRONMENTAL ENTEROPATHY & STUNTING

AFLATOXIN (MYCOTOXIN) INGESTION
(FUNGI NEED WATER/MOISTURE TO GROW)

P. Turner et al showed (Lancet 2005) these 5 methods reduced blood aflatoxins by 60%:

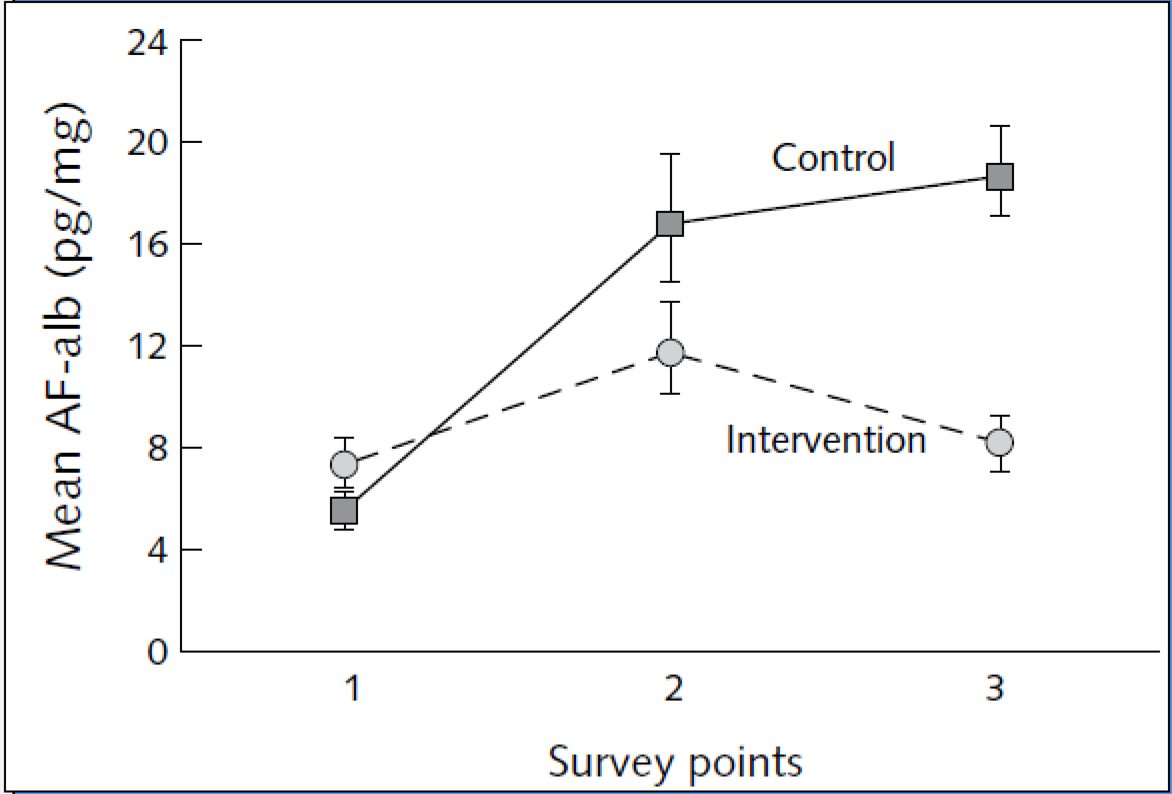
1. Sun dry thoroughly on mats, not ground;

2. hand sort and discard moldy nuts;

3. use fiber (not plastic) sacks for storage;

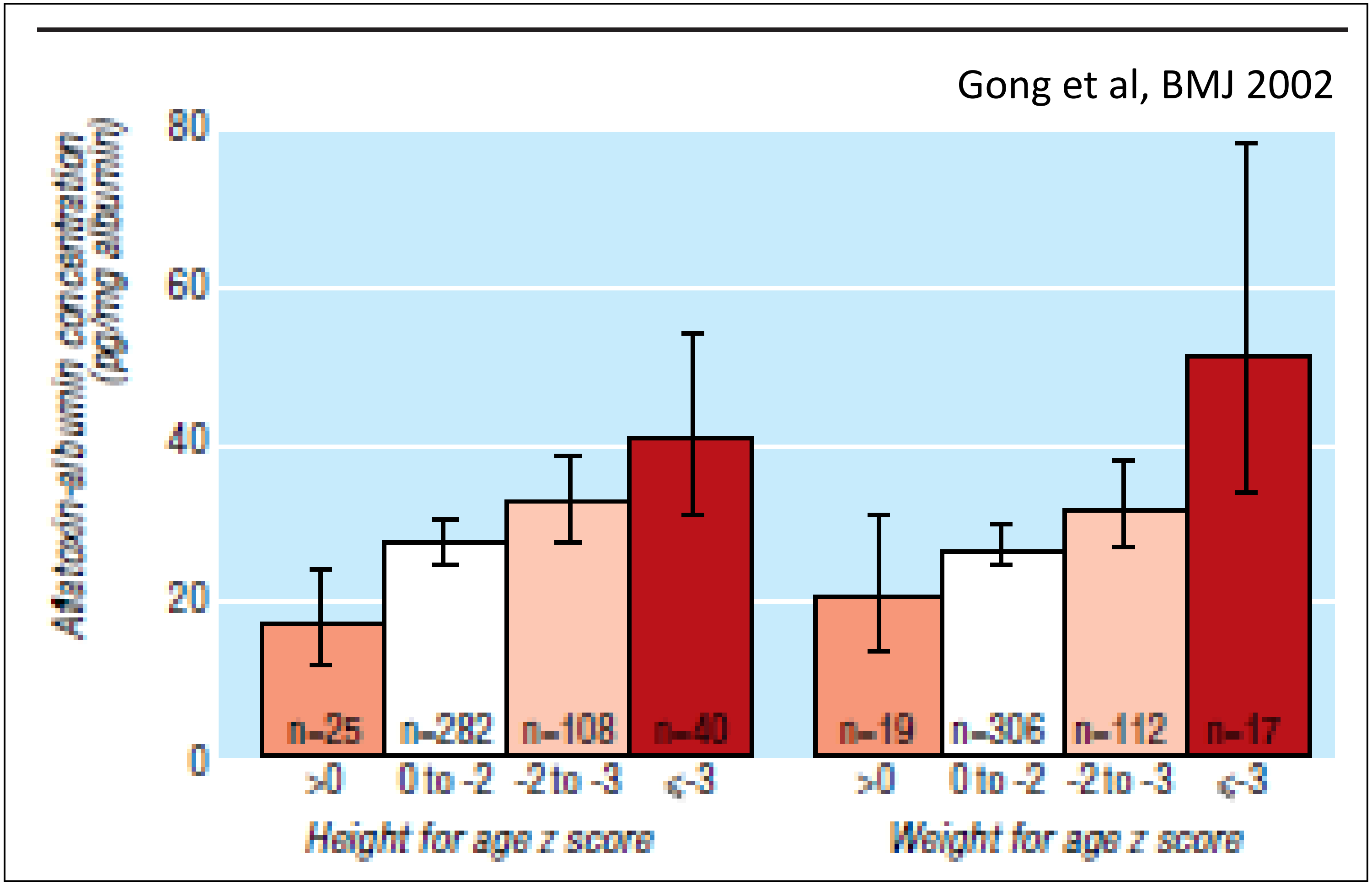
4. store storage sacks on pallets, above the ground;

5. spray insecticide on ground under the pallets to reduce insect damage.

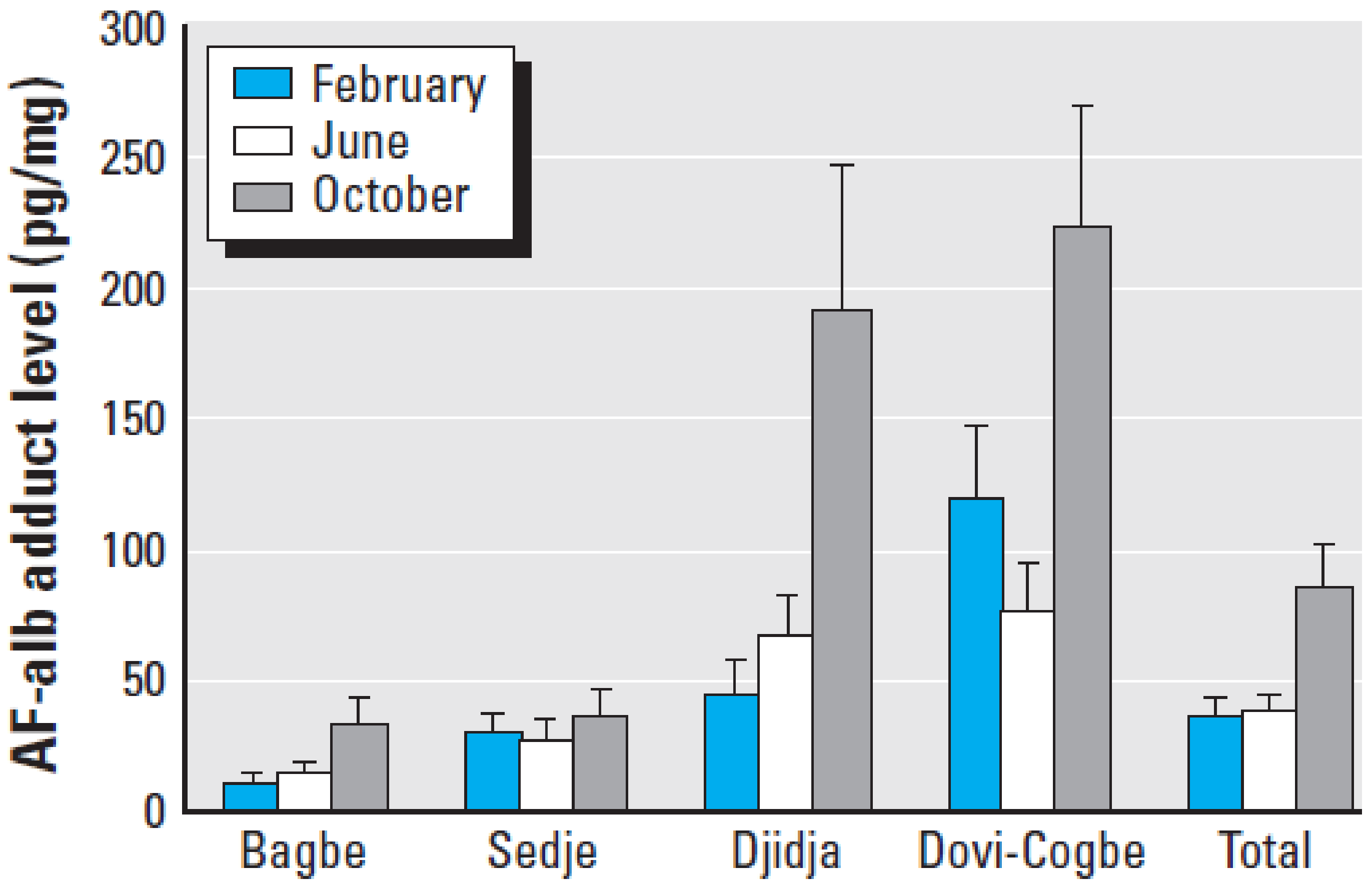


Post-Harvest Handling Can Decrease Aflatoxins in Those Who Eat the Groundnuts

- Gong et al (BMJ, 2002) showed that **stunting** and **underweight** were inversely related to aflatoxin levels in Gambia. Jolly and colleagues (Peanut Innovation Lab) have shown the same in Ghana.

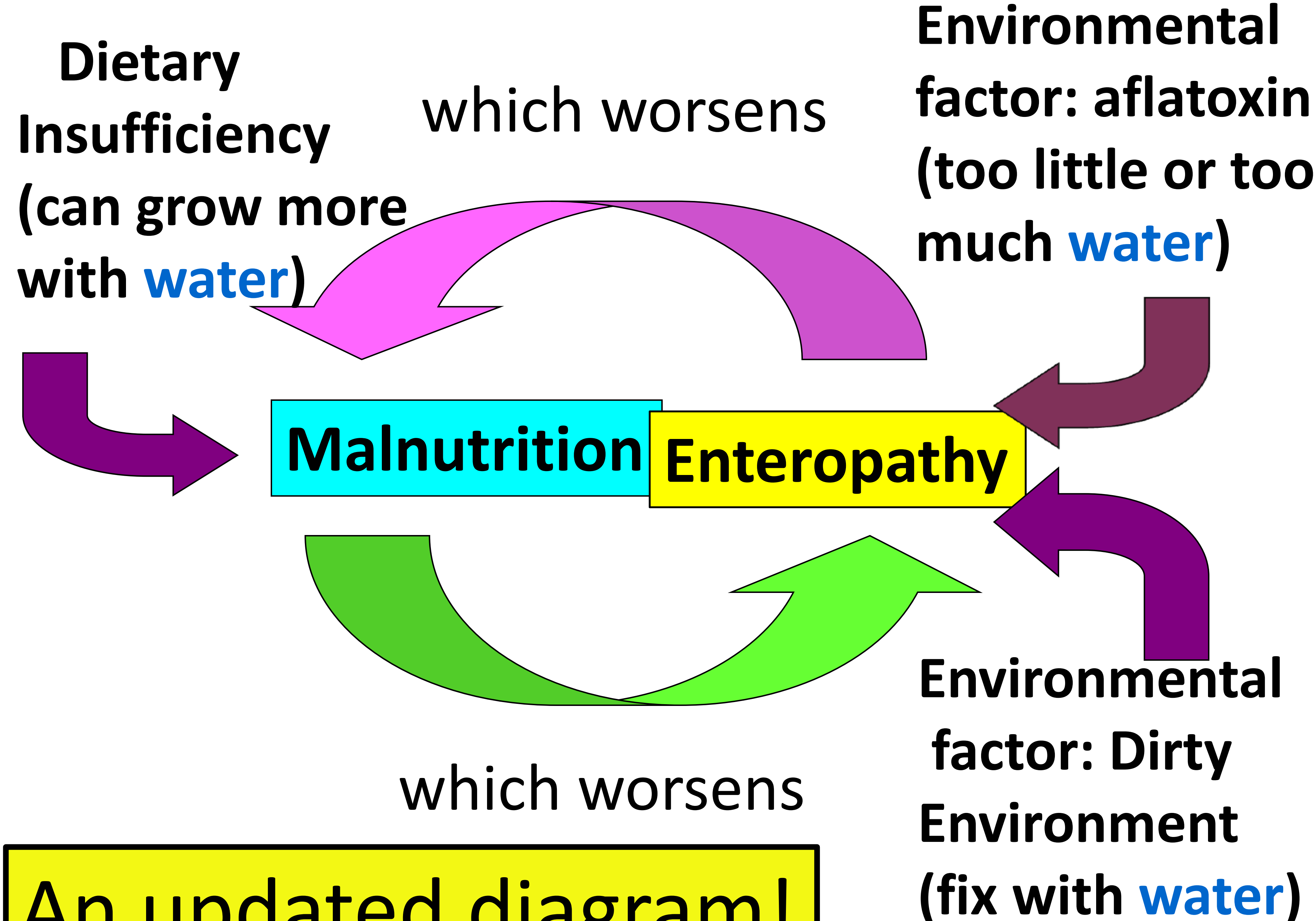


- The same group (Gong et al, 2004) showed marked seasonal and site variation in aflatoxin levels by season in four villages. Note many human blood levels are 50-250 pg/mg of albumin.



<u>How much stunting does aflatoxin cause?</u>

- Turner et al (2007) prospectively studied Gambian infants. They linked maternal and infant aflatoxin exposure to subsequent growth.
- **They estimated that a child with a blood aflatoxin level of 1 (instead of 100) pg/mg at age 16 weeks <u>ended up a full SD taller</u> at 12 months of age.** Each log drop e.g. 100→ 10, led to a 0.5 HAZ score improvement. A 2 log drop (100→ 1) led to a 1.0 HAZ score (1 SD) taller child.



An updated diagram!

Conclusion

- Linkages are complex
- Agriculture-food-nutrition links need to be confirmed through rigorous research
- Recent science: contaminated environments, infections, and toxins adversely change the child’s gut via EE.
- Agricultural practices in association with water and sanitation practices should be considered as points of intervention

Thanks!

Photo: JK Griffiths Tanzania 2008

Talk version 3 updated Feb 19 2013