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Mapping Nutrition Innovation Lab Research: How does it all fit together?

Patrick Webb

USAID
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Tufts UNIVERSITY | GERALD J. AND DOROTHY R. Friedman School of Nutrition Science and Policy

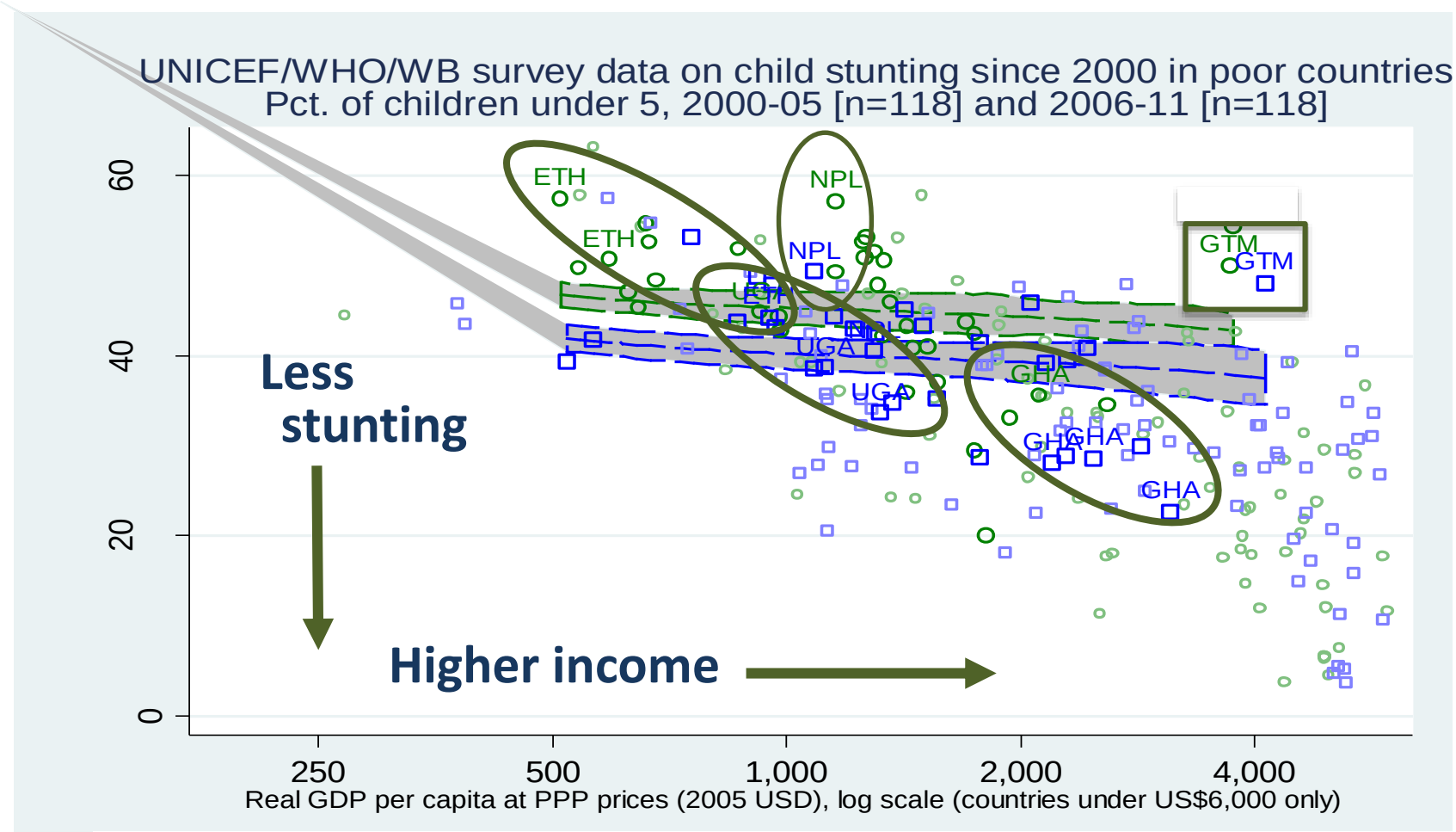
The Problem (simply put…)

"Chronic malnutrition rates have not declined significantly over the years despite increased income from high value crops.

A new approach to resolution of this problem is required."

USAID/Guatemala Portfolio Review 2013

Progress of Feed the Future Countries



Data visualization by the FTF Nutrition Innovation Lab, from W.A. Masters et al., "Nutrition Transition and Agricultural Transformation: A Preston Curve Approach", forthcoming in *Agricultural Economics,* 2016.

Ongoing and Planned Nutrition Innovation Lab Research

➢ Uganda	FTF intervention zones
➢ Nepal	Nationally representative
➢ Bangladesh	FTF intervention zone
➢ Egypt	Single study site
➢ Cambodia	Program-specific study
➢ Malawi	TBD
➢ Ethiopia	Program-specific study
➢ Timor Leste	Nationally representative
➢ Global (secondary datasets)	FTF and high burden countries

Nutrition Innovation Lab: Core Research Questions

- What measurable impacts do **investments in agriculture** have on nutrition (positive and/or negative)?

- Does the **quality of nutrition governance** (political and institutional commitment and capacity) affect the effectiveness and impact of nutrition policies and programs?

- What **biological mechanisms** must be better understood when designing interventions to accelerate improved nutrition?

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Supply of key foods to diets (1980-2009, 124 countries)

More of this in national food supply…	Reduces stunting	Reduces heart disease
Cereal grains	X	√
Meat	√	X
Dairy products	√	X
Vegetable oils	X	X
Fruit	√	√
Vegetables	√	X

100 kcal/cap /day increase in food supply statistically correlated with each outcome

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How do Climatic Anomalies Impact Nutrition?

- Timing of pregnancy (mothers' diets) and birth affects later child growth.
- Weather anomalies matter more where markets poorly integrated.
- Weather anomalies matter less where livelihoods less agriculture-focused.

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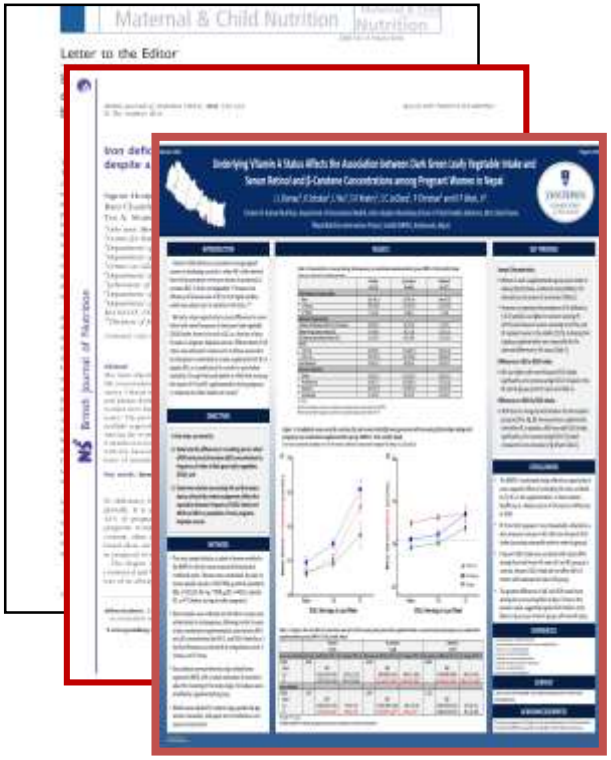
How do Key Foods Impact Nutrition?

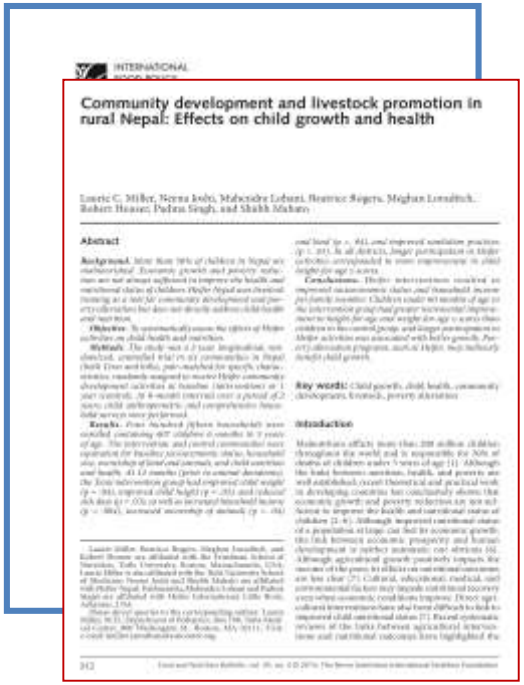


- How we measure diet diversity needs to be improved.
- Bioavailability is key (not just amount). In peri-urban Nepal intake iron-rich food high, bioavailability low. Yet anemia low thanks to 90% iron supplementation.
- Eating green leafy veg (GLV) 7 times/week improves serum Vit A, but only for Vit A deficient women!

If You Grow a Food do you eat more of it?

- Maybe. In Uganda, growing more fruit/veg associated with more in diet.

- Children of livestock owners in Nepal less stunted…but little ASF intake. Benefit via income more than protein?


INTERNATIONAL

Community development and livestock promotion in rural Nepal: Effects on child growth and health

Abstract

Introduction

- Livestock owners in Uganda do consume more milk and meat. Children 50% less likely to be stunted if consuming either. But may also have more malaria…

Does Agriculture Diversity Matter for Nutrition?

- Low intake of micronutrients still seen in 'diverse' diets where key foods lacking.
- Diet diversity derives as much from market access as 'production diversity', but production diversity matters where market integration is low.
- High reliance on own output (even if diverse) correlated with higher probability of stunting. Access to off-farm income and markets matters.

How Does Integrated Programming Impact Nutrition?

- Depends on outcome and time-frame.
- Nepal: 2 year Heifer intervention showed no change at 24m, but big fall at 48m (wasting). Stunting fell little.
- Ethiopia: children in households in PSNP have WHZ 0.6 points higher than non-participants – over time. But depends on access to underemployed labor.

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Ground-truthing change in Nepal

Rate of change 2013-2014	Suaahara	Non-Suaahara
Routine use improved feed (poultry)	43.1***	17.5***
Home garden ownership	25.7***	17.5***
NGO worker visited children in home	0.4	-0.8***
Women's 7 day intake fruit/veg	0.5	-0.6***
Women's Diet Diversity Score	0.1	-0.2***
% moderate wasting (<-2SD - >-3SD)	-1.7	0.7
% children stunted (<-2SD)	-1.8	2.4**

Significant at *<0.1 **<0.05 ***<0.01 (T-test)

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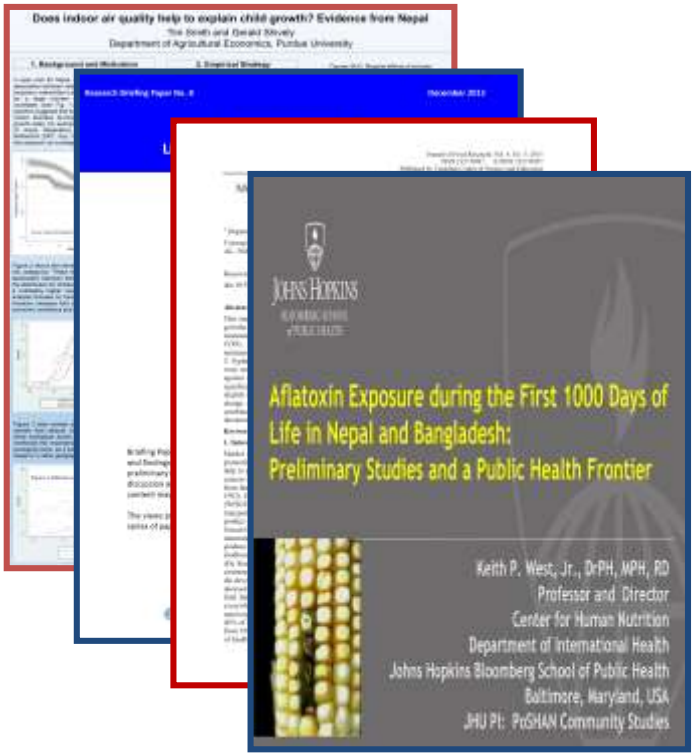
Programming Insights So Far

Integrated large-scale programmes:

a) Do represent a viable 'nutrition sensitive' form of intervention to improve nutrition.
b) Impacts can take time to manifest.
c) Complementarity of actions critical.
d) Can be trade-offs (especially with rapid scaling).
e) Sustainability requires building on and protecting gains ('less loss' may be a win…)

How do Health Threats Impact Nutrition?



- **Air quality.** Smoke impairs child health and growth.
- **Open defecation** – yes (close link with wasting).
- **Food safety/hygiene**. Need technologies as well as behaviors.
- **Mycotoxins.** Suggestive evidence of link to child growth.

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Prevalence of poverty &
Prevalence of underweight & stunted children

OBJECTIVE
INCLUSIVE AGRICULTURE SECTOR GROWTH

OBJECTIVE
IMPROVED NUTRITIONAL STATUS
(WOMEN & CHILDREN)

Improved agricultural productivity

Increased investment in agriculture

Increased employment opportunities in targeted value chains

Increased resilience of vulnerable communities

Improved access to diverse quality services

Programs and policies to support agriculture sector growth

Programs and policies to increase access to markets and facilitate trade

Programs and policies to reduce inequities

Programs and policies to support positive gains in nutrition

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Nutrition Innovation Lab Partnerships

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HARVARD SCHOOL OF PUBLIC HEALTH
Powerful ideas for a healthier world

PASS ON THE GIFT HEIFER INTERNATIONAL

Helen Keller INTERNATIONAL

MINIA UNIVERSITY

SEAMEO RECFON

GULU UNIVERSITY

PURDUE UNIVERSITY

WorldFish

TUSKEGEE UNIVERSITY

LCIRAH
Leverhulme Centre for Integrative Research on Agriculture and Health

HORTICULTURE INNOVATION LAB

UCDAVIS
UNIVERSITY OF CALIFORNIA

SUAAHARA
Building Strong & Smart Families

AQUAFISH INNOVATION LAB

DAI

NASA

COLUMBIA UNIVERSITY

IFPRI

unicef

SPRING
Strengthening Partnerships, Results, and Innovations in Nutrition Globally

INF
INTERNATIONAL NUTRITION FOUNDATION

MAKERERE UNIVERSITY

NARC
Nepal Agricultural Research Council

BECAUSE OF ME

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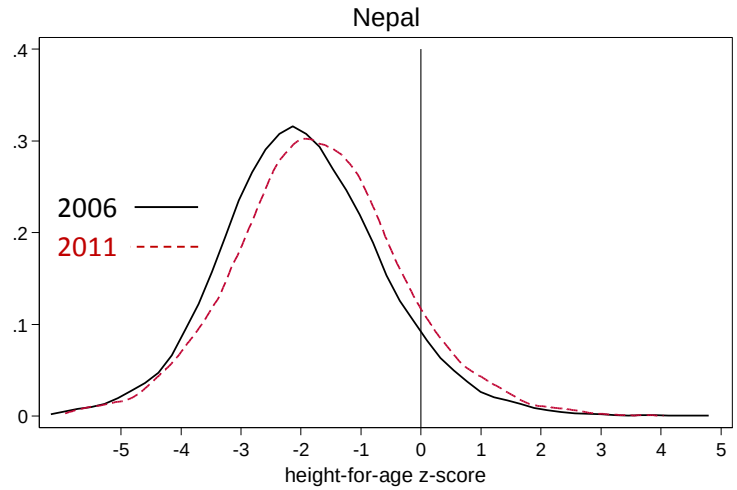
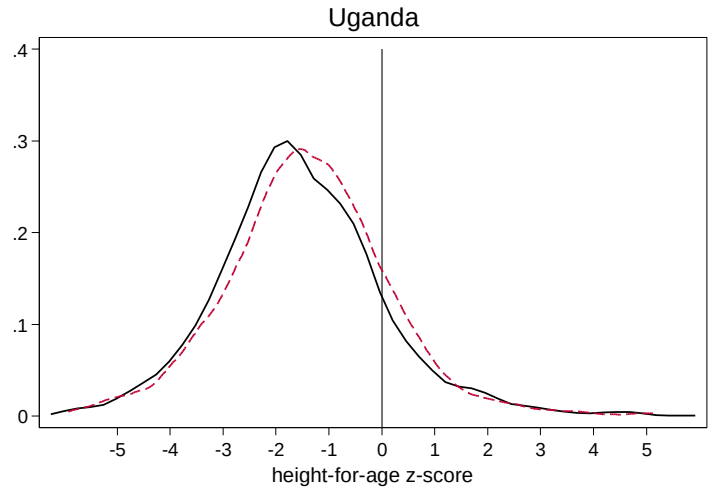
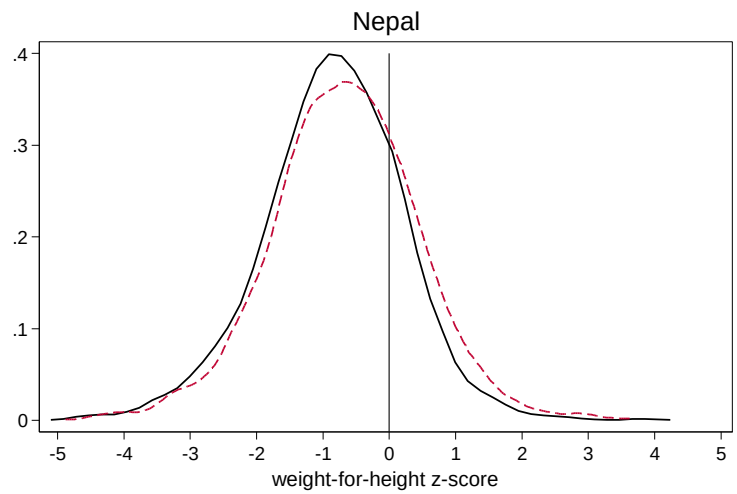
Climate, Agriculture & Nutrition:
tightly wedded or loosely meshed?

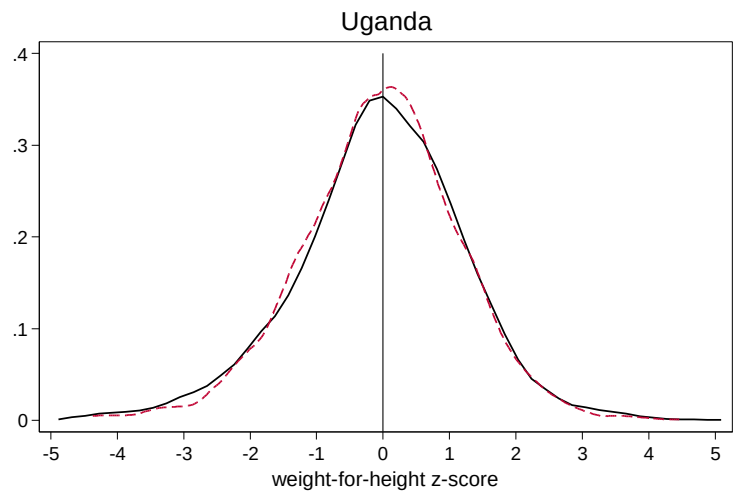
Gerald Shively

PURDUE UNIVERSITY



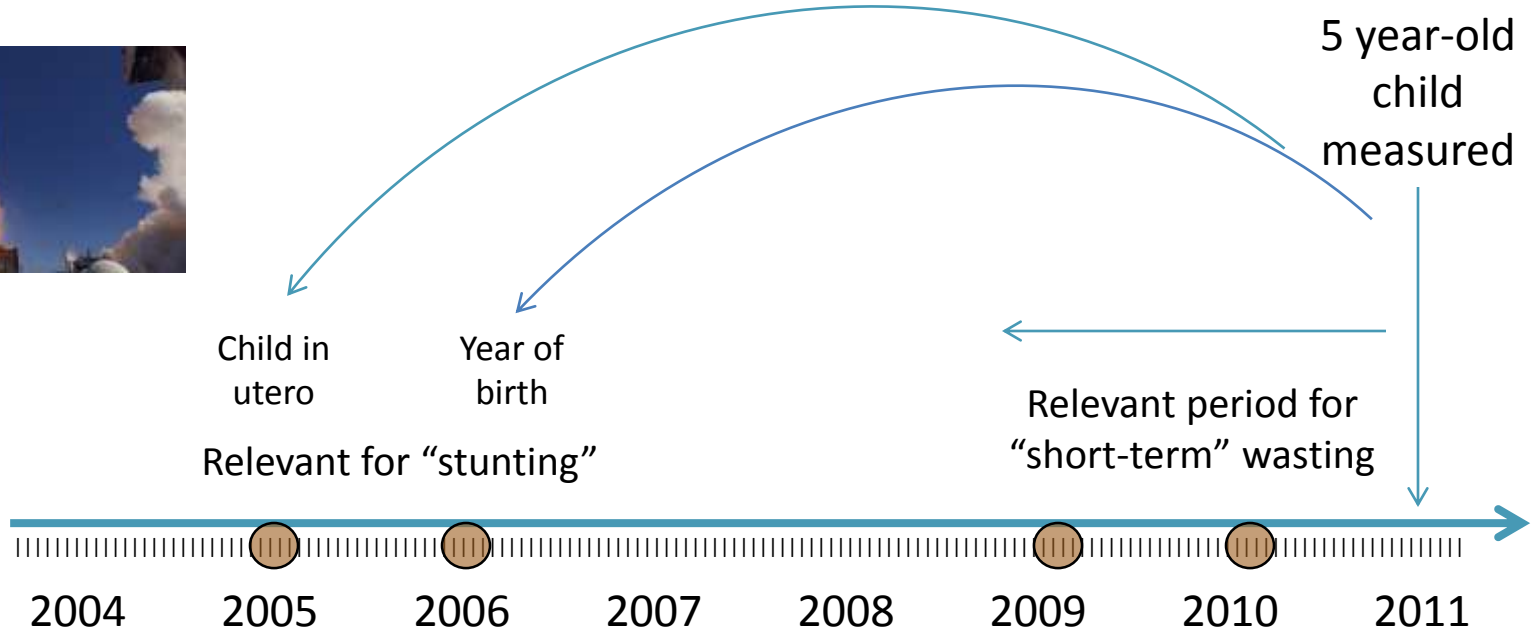






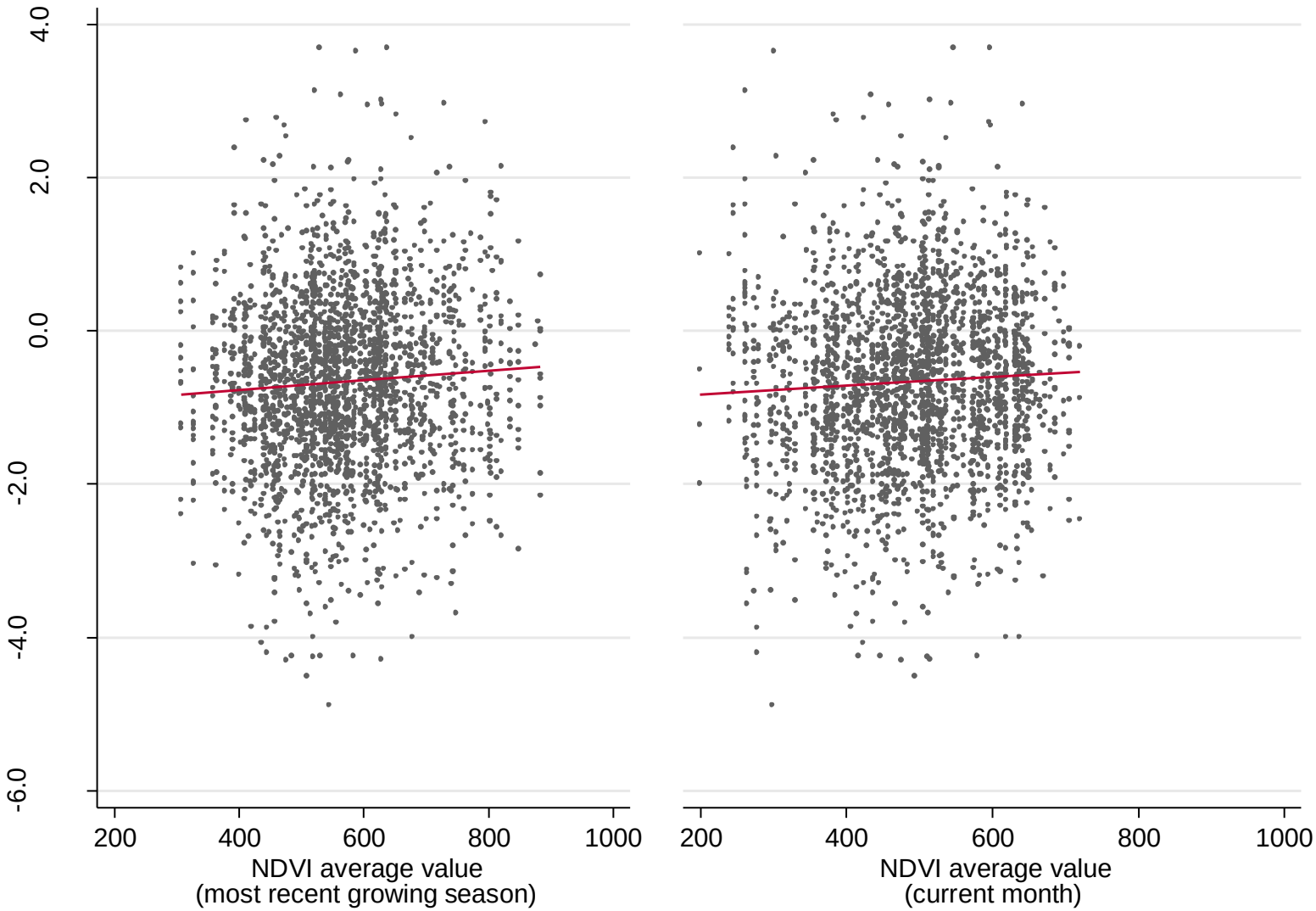
Source: unweighted DHS data

1. Matching on time: what periods are critical for child growth?



2. Matching across space and agronomy: what are the growing seasons for the most important crops?

Adapted from Brown, Grace, Shively, Johnson and Carroll (2014). "Using Satellite Remote Sensing and Household Survey Data to Assess Human Health and Nutrition Response to Environmental Change." *Population and Environment* 36(1): 48-72.



Note: WHZ in Nepal (n=2,335 children below 5 years; unweighted DHS data 2006 & 2011). Source: Shively, Sununtnasuk and Brown (2015) "Environmental Variability and Child Growth in Nepal." *Health and Place* 35: 37-51.

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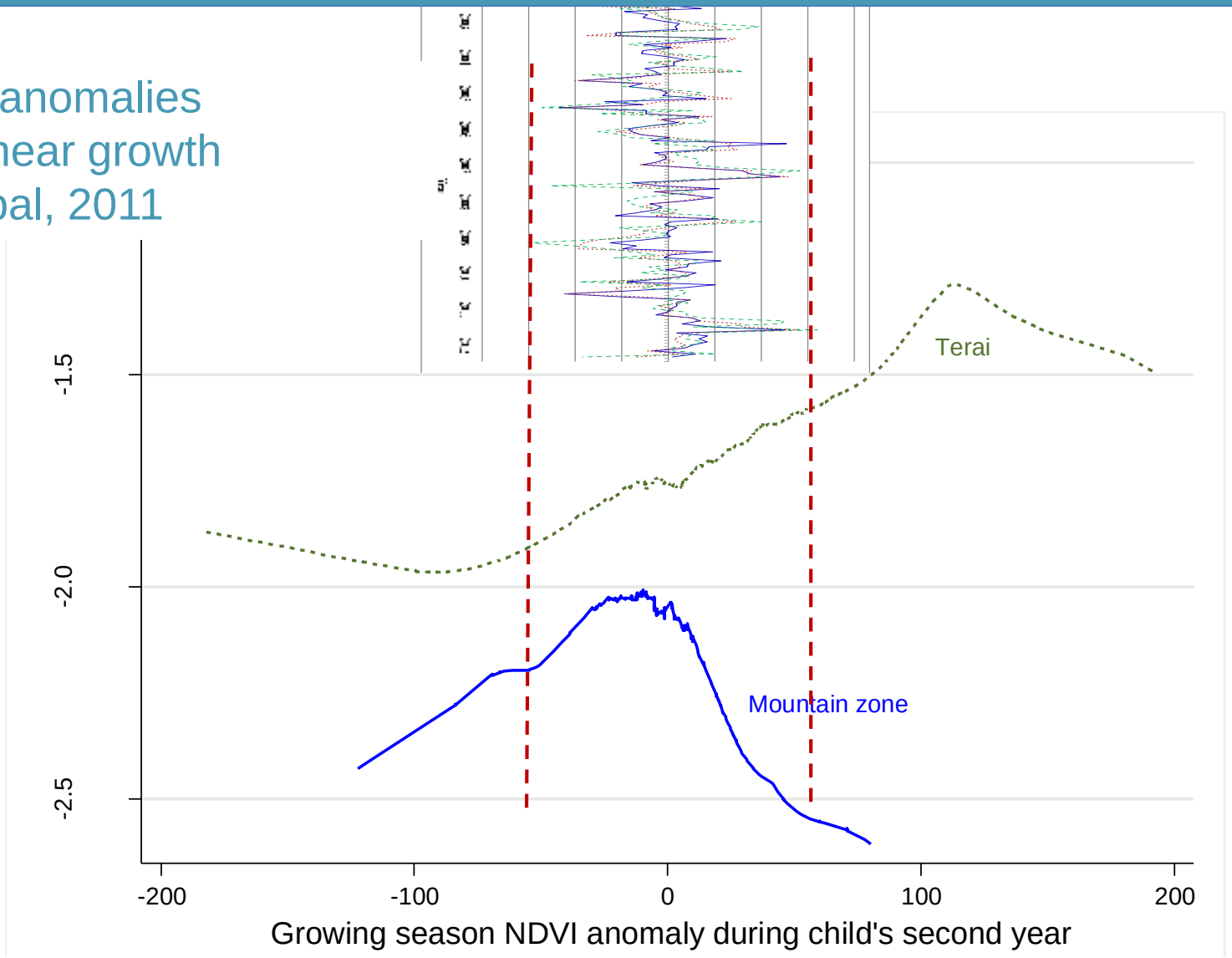
NDVI anomalies and linear growth in Nepal, 2011



Source: Shively, Sununtnasuk and Brown (2015) "Environmental Variability and Child Growth in Nepal." Forthcoming in *Health and Place*.
Based on 2011 Nepal DHS; children > 24 months only; n=273 (mountain zone), n=556 (Terai)

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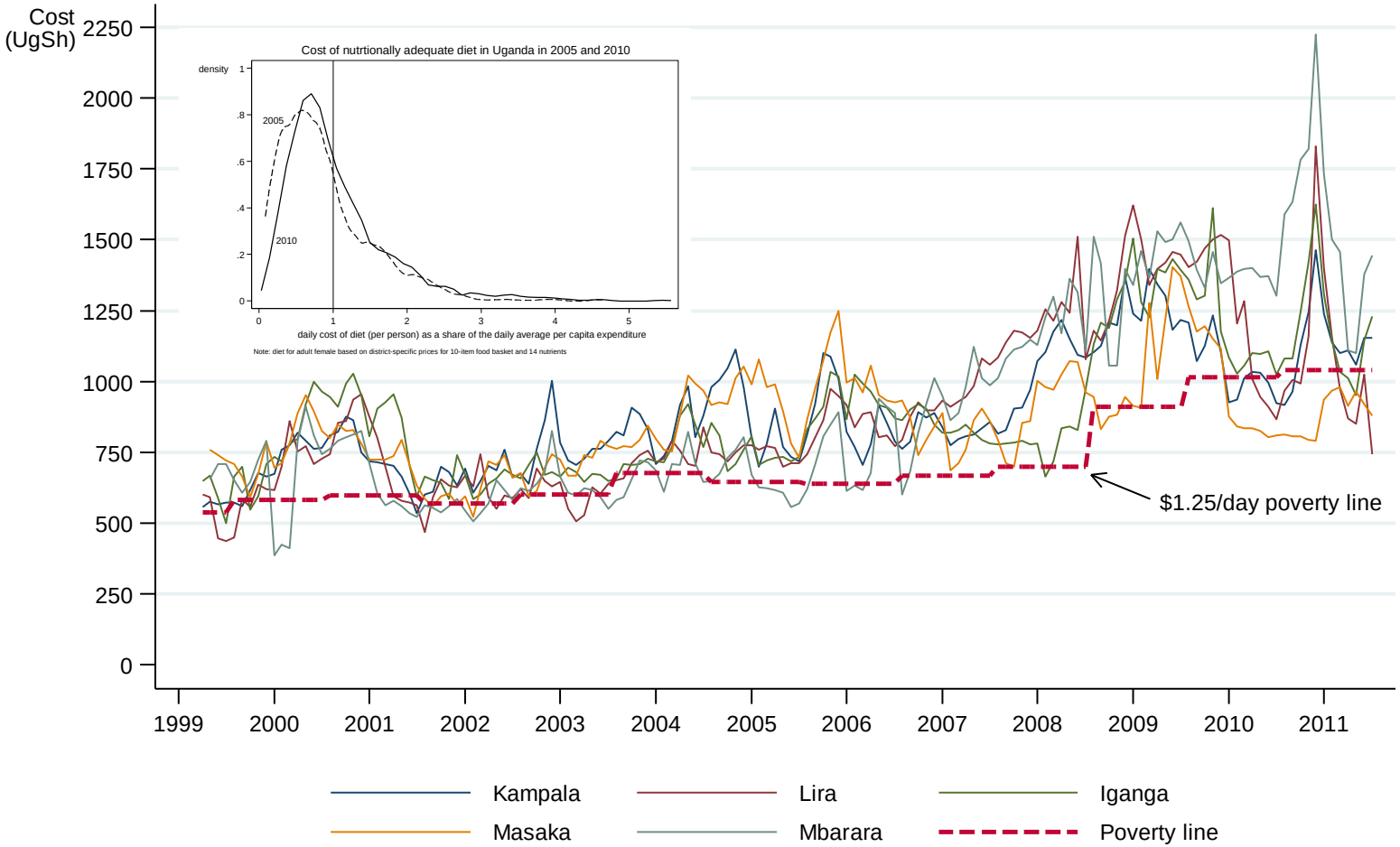
Least-cost Nutritionally-adequate Diet for Uganda



Poverty line is based on the World Bank's global poverty standard of $1.25 a day using PPP GDP (LCU per international $).
Reference group for diet is adult women, using US RDA for 14 nutrients following Hotz et al. (2012).
Least-cost monthly food baskets constructed using retail prices for 10 commodities.

Three policy messages for Nepal and Uganda:

- **Household-level drivers are robust to inclusion of agriculture and weather, but do not fully account for nutritional improvements over time.**
  - Child and mother characteristics and health matter most.
  - Sometimes they complement ag, sometimes substitute (e.g. mothers' education)
  - Policy 50/25/25 rule: 50% on child & mother, 25% on HH, 25% on context

- **Links between agriculture and nutrition hinge on productivity and diversity.**
  - Short-run indicators more sensitive to weather than long-run indicators.
  - HH-level agricultural activity better predictor than district-level variables.
  - Commercialization is not always bad; subsistence usually is.

- **Weather matters, but not as much as we think (in the short-run).**
  - Strongest correlations found in environments prone to droughts.
  - Associations between environmental conditions and child growth heterogeneous.
  - Outcomes are sensitive to departures from normality.
  - Connections between nutrition and weather are strongest where HHs isolated.
  - Infrastructure (broadly defined) is very key to buffering shocks.

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Production Diversity and Women's Dietary Diversity in Nepal

Shibani Ghosh

(On behalf of the entire Nutrition Innovation Lab team working in and on Nepal)

OBJECTIVES & METHODS

Objective: To understand the relationship of production diversity and women's dietary diversity by agro-ecology in Nepal

- Panel 1 survey data for POSHAN: 21 sites, 4286 households and 4509 women interviewed
- Nationally representative sample accounting for agro-ecology
- Women's Diet Diversity Score: 8 food groups
- Production diversity: Count of all crops and livestock species produced/raised
- Poisson distribution to fit the models
- Accounting for clustering (using GEE)

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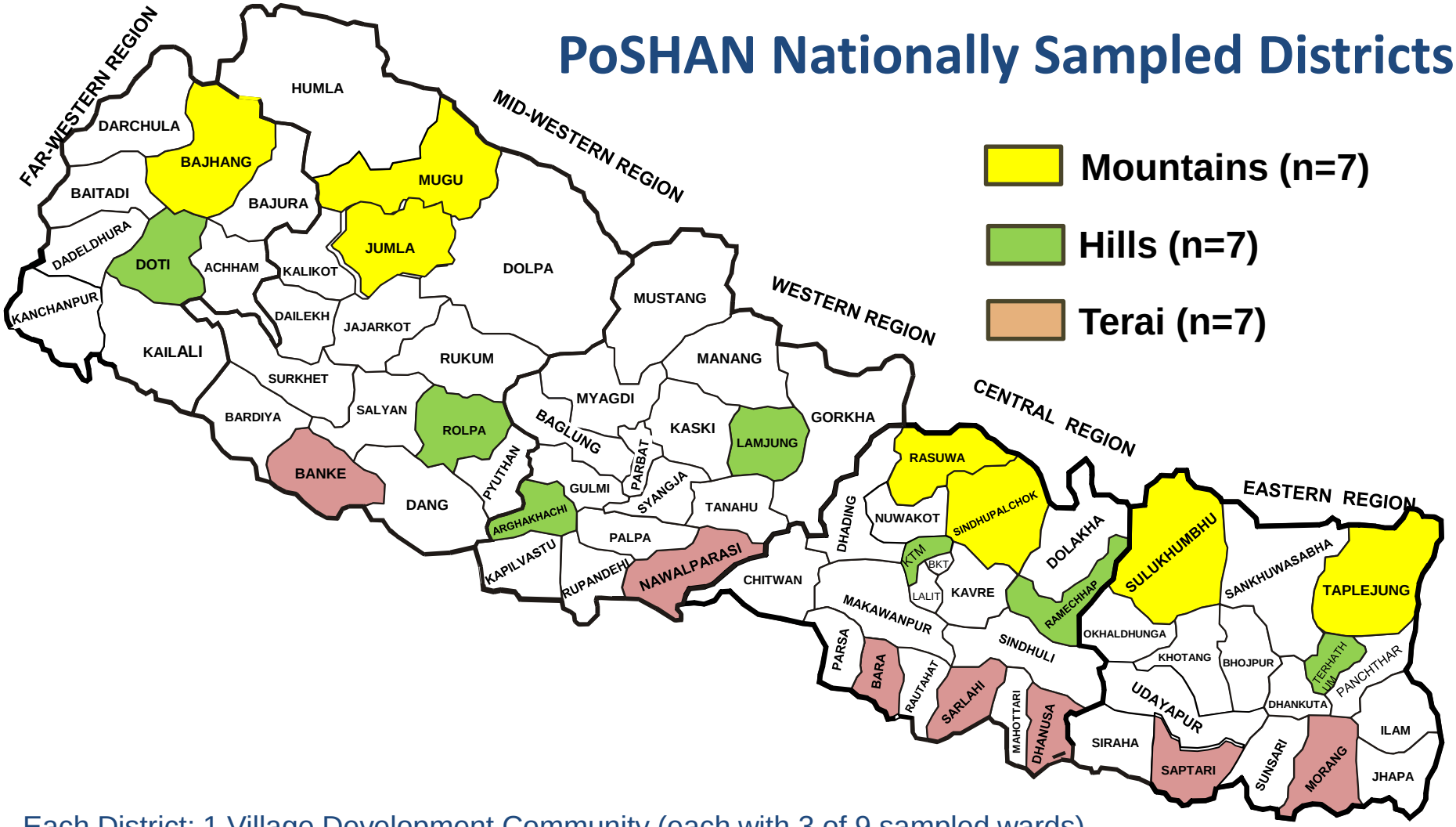
PoSHAN Nationally Sampled Districts



Each District: 1 Village Development Community (each with 3 of 9 sampled wards)
N = ~5000 households with preschool children
Annual assessments: May-July 2013, 2014; partial (post-quake) 2015

DESCRIPTIVE STATISTICS

	TOTAL	HILLS		MOUNTAINS		TERAI	
	Mean (SD)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median
Production diversity	7.54 (7.45)	10.75 (8.85)	11 (16)	7.95 (7.68)	7 (14)	5.87 (5.99)	4 (8)
Women's Dietary diversity score	5.73 (1.38)	5.57 (1.54)	6 (3)	5.31 (1.50)	5 (2)	5.93 (1.22)	6 (2)
Market distance (miles)	0.62 (1.41)	0.28 (0.31)	0.24 (0.29)	0.19 (0.48)	0.089	0.92 (1.80)	0.56 (0.85)

FREQUENCY OF CONSUMPTION OF FOOD GROUPS BY WOMEN

Food Groups	Median (IQR)
Staples (Cereals and Tubers)	31 (27, 37)
Nuts and Legumes	10 (5, 15)
Animal Source Foods	5 (2, 11)
Dark Green Leafy Vegetables	2 (1, 4)
Vitamin A Rich Fruits and Vegetables	1 (0, 4)
Other Fruits and Vegetables	10 (5, 17)
Oil/Fats	18 (14, 21)

PRODUCTION DIVERSITY, AGRO-ECOLOGY, MARKET ACCESS AND INCOME

Parameter	Estimate	Standard Error
Intercept	1.6890***	0.0192
Production diversity	-0.0097***	0.0023
Production diversity squared	0.0004***	0.0001
Hills	0.1556**	0.0565
Terai	0.0567**	0.0153
Production diversity x Hills	-0.0056**	0.0021
Production diversity x Terai	0.0042**	0.0015
Market distance	-0.1439*	0.0735
Hills x Market distance	-0.1295	0.2671
Terai x Market distance	0.1437*	0.0735
Off-farm income (dummy)	0.0443**	0.0147
On-farm income (dummy)	0.0117	0.0109
Production diversity x off-farm income	0.0002	0.0012
Production diversity x on-farm income	-0.0008	0.0011

***: p<0.0001 **: p< 0.01 * :p<0.05

ROBUSTNESS

- Type of household, education of HH head, Age of HH head, farm size, household size
  - Relationships maintained and significant within the **context of agro-ecology**
  - **Market distance** still negatively associated with women's diet diversity in the Hills and positively associated in the Terai
  - **Off farm income** significant and positively associated with women's dietary diversity
- Tested differences by crop versus livestock diversity

CONCLUSIONS

- Production diversity and women's dietary diversity vary by agro-ecology.
- Market distance negatively (strongly) associated with women's DD.
- Off-farm income interactions with DD positive, irrespective of agro-ecology
- Agricultural interventions focusing on scale up of activities that target production diversity need to consider benefits relative to geographic location and markets

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Influences of Markets & Home Production on Nutritious Food Intake

PoSHAN Community Studies, Nepal

JOHNS HOPKINS
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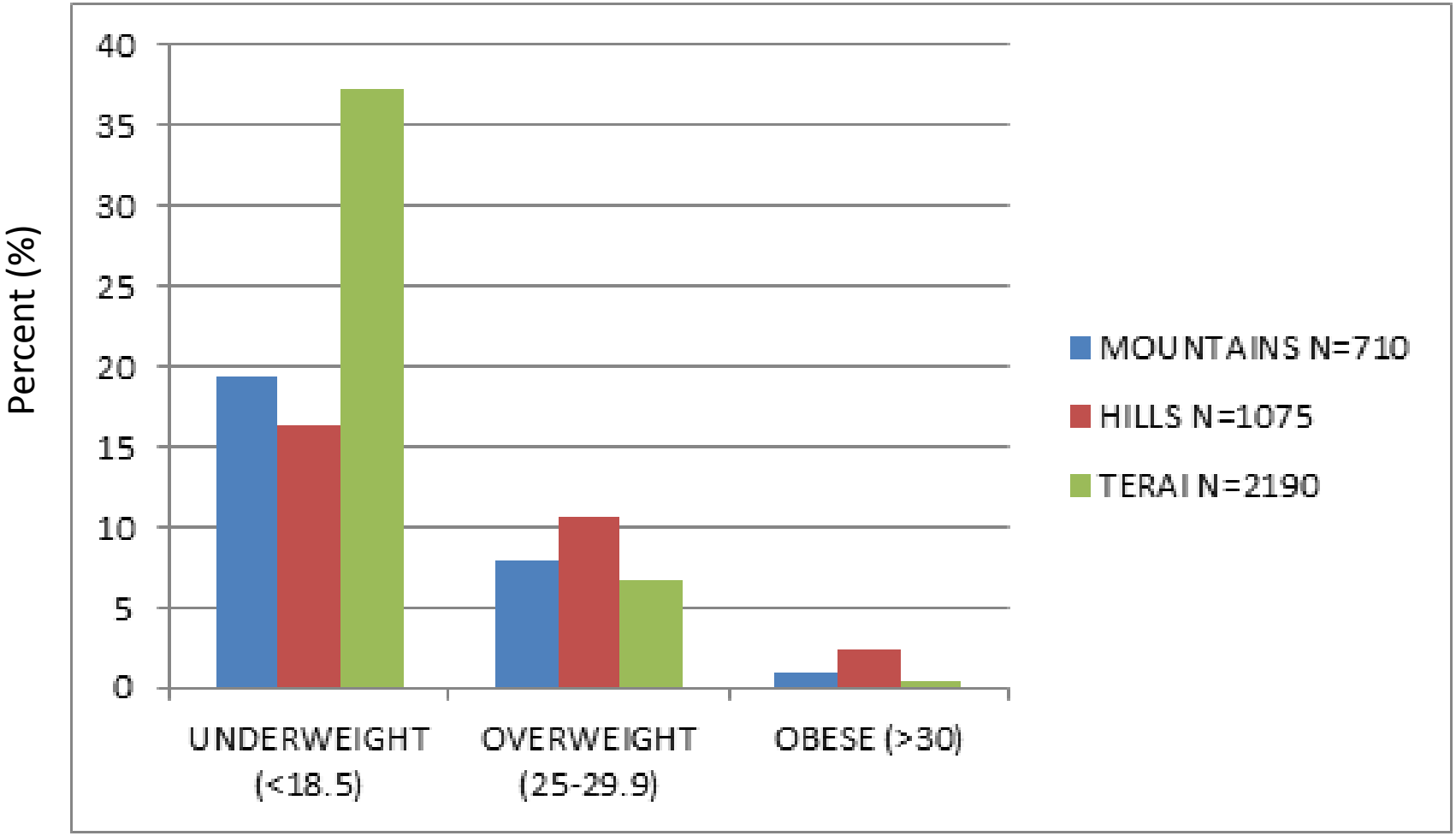
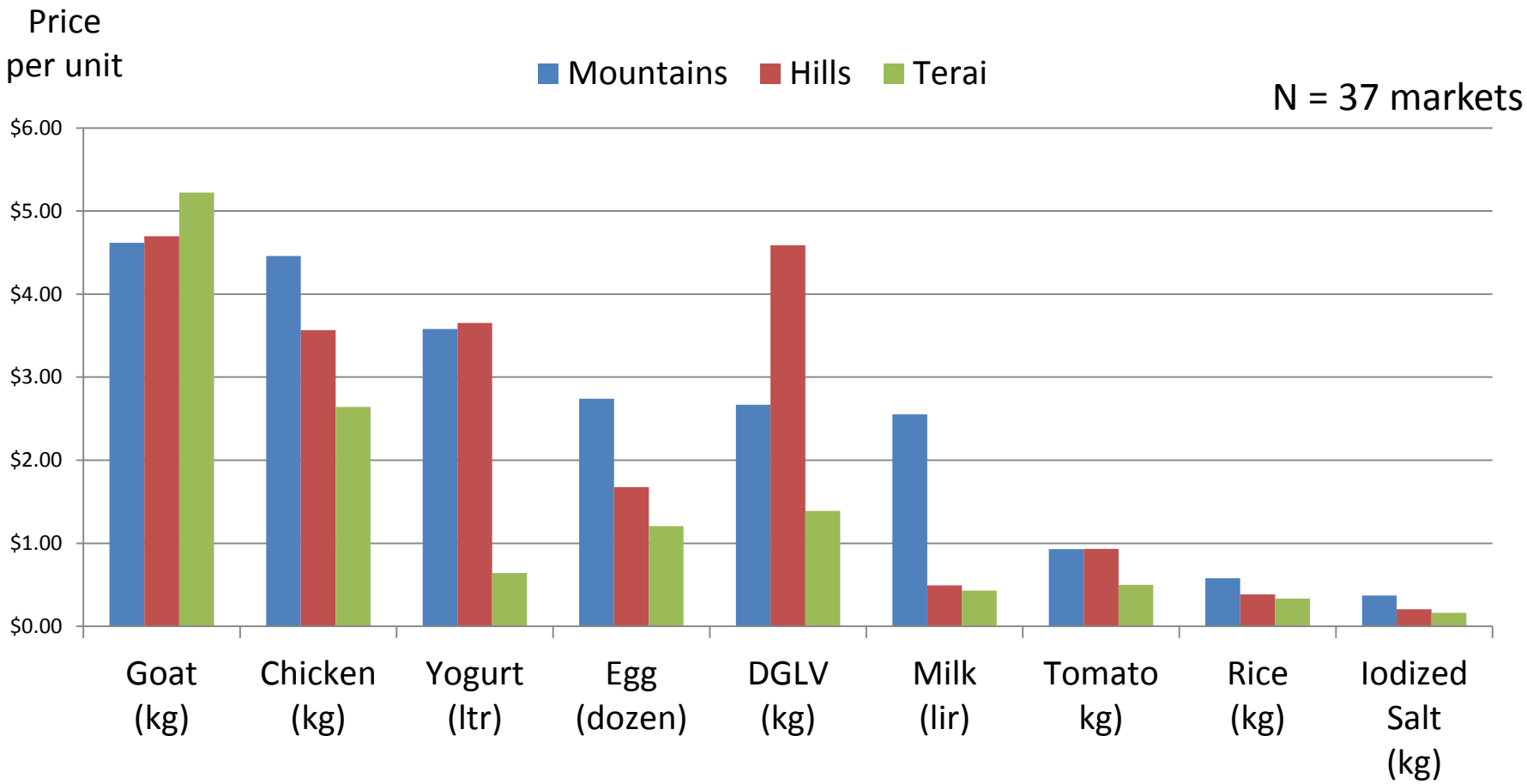
of PUBLIC HEALTH

Maternal thinness, especially the Terai; Some overweight…

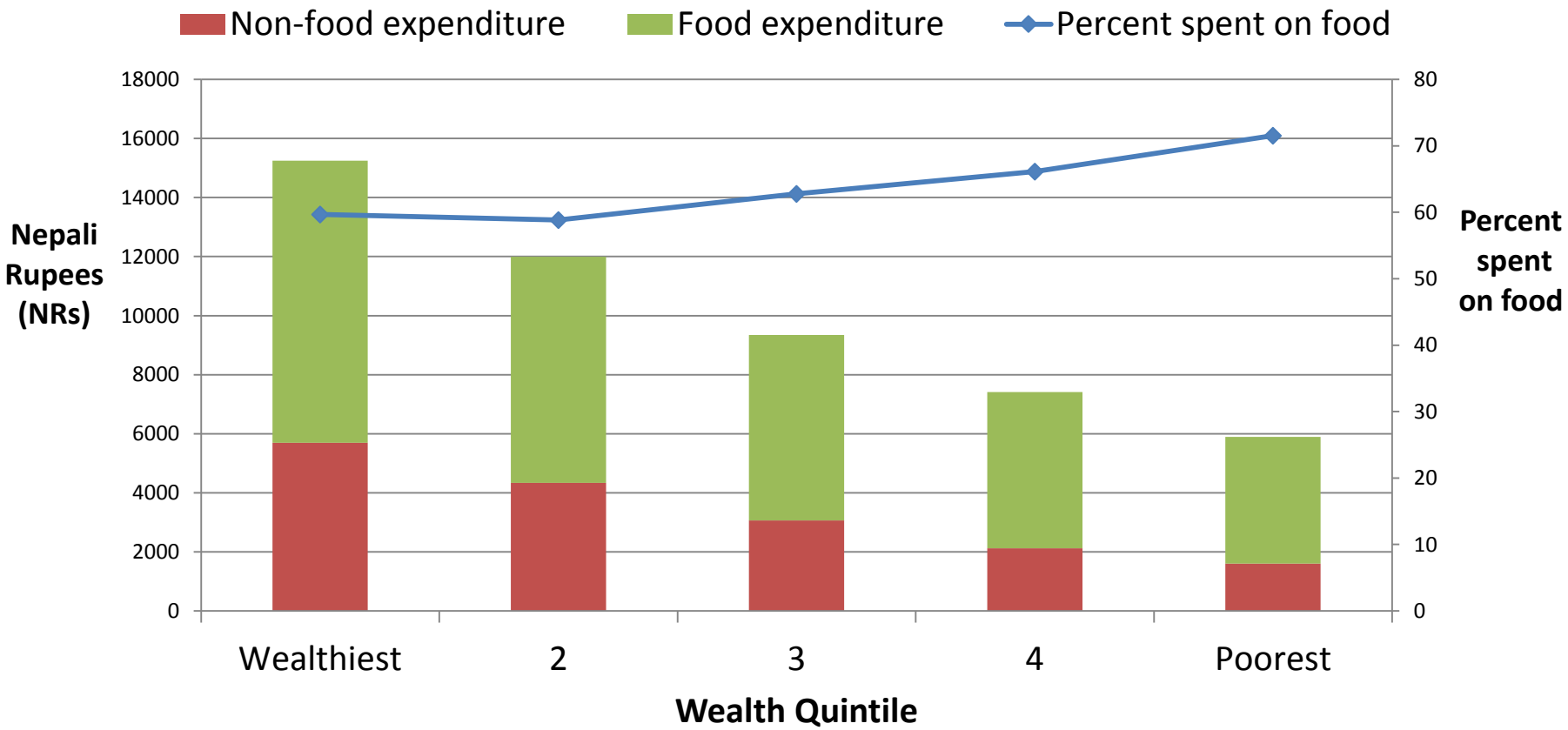


Market Prices (USD) by Zone
Generally Highest in Mountains



Household Median Monthly Expenditure (NRs) for Non-Food and Food Items

Wealthier households spend more money.
Poorer HHs spend a higher % of total expenditure on food.



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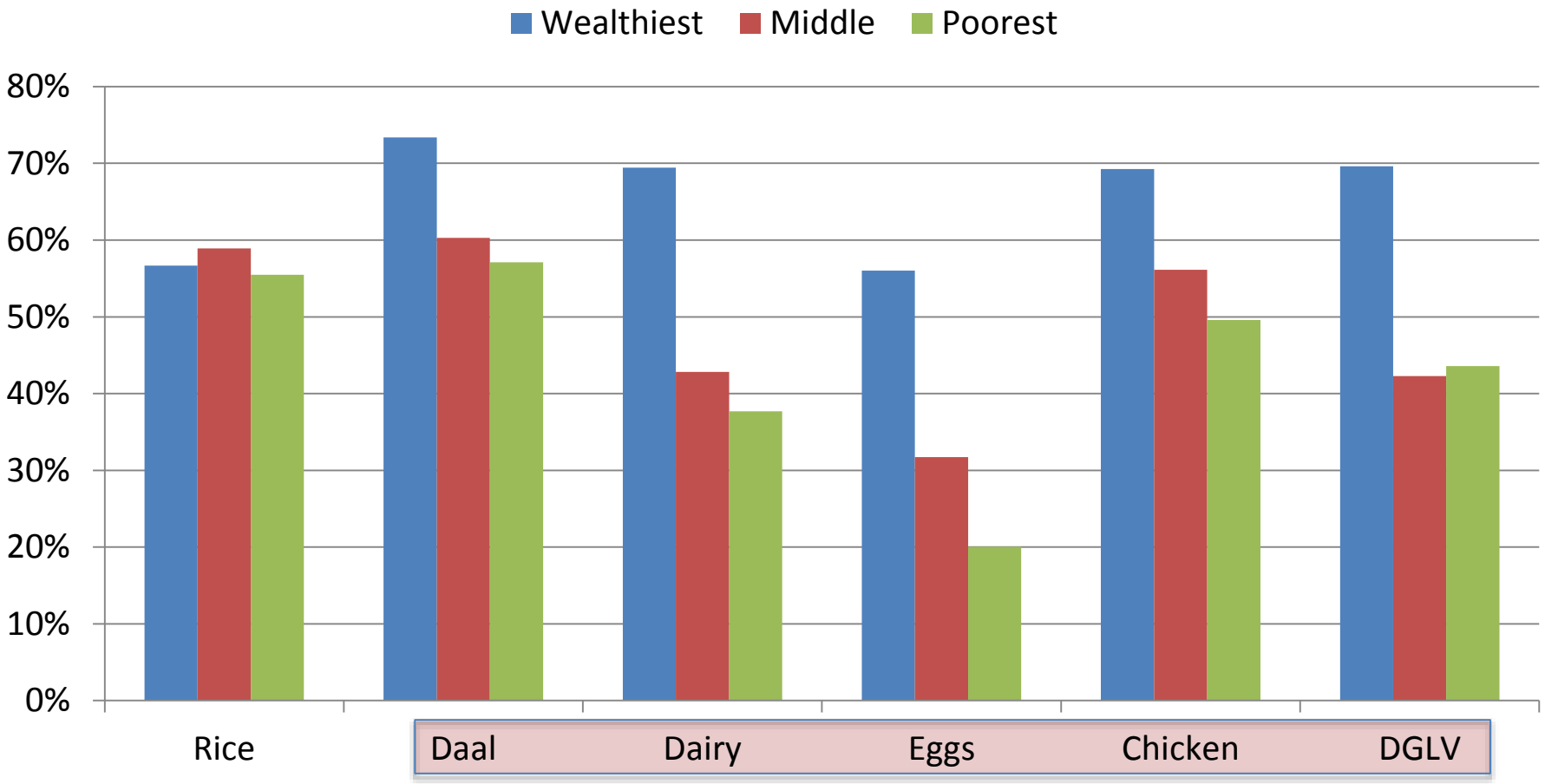
Household Purchase of Nutritious Foods is Low

(especially among poor households)



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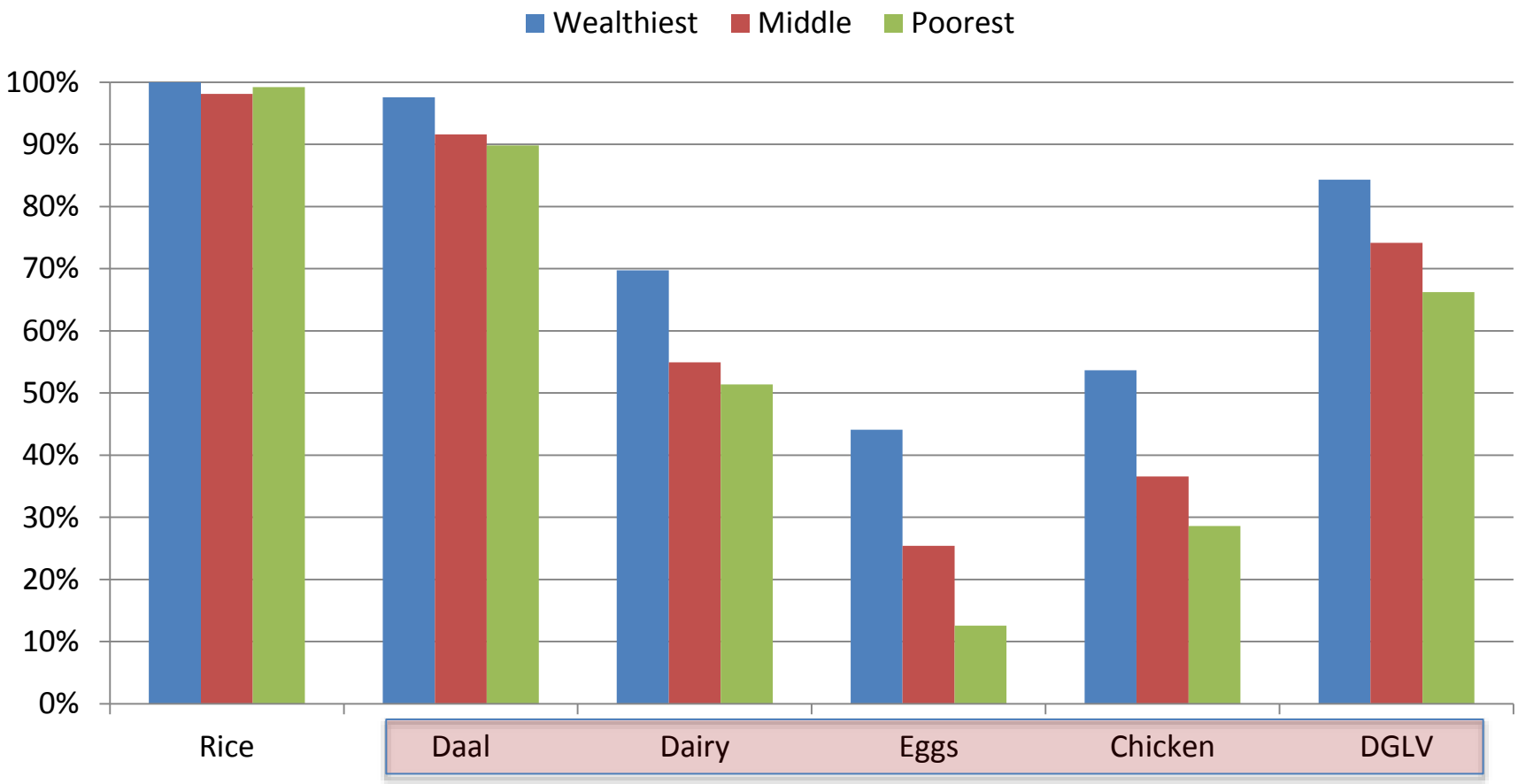
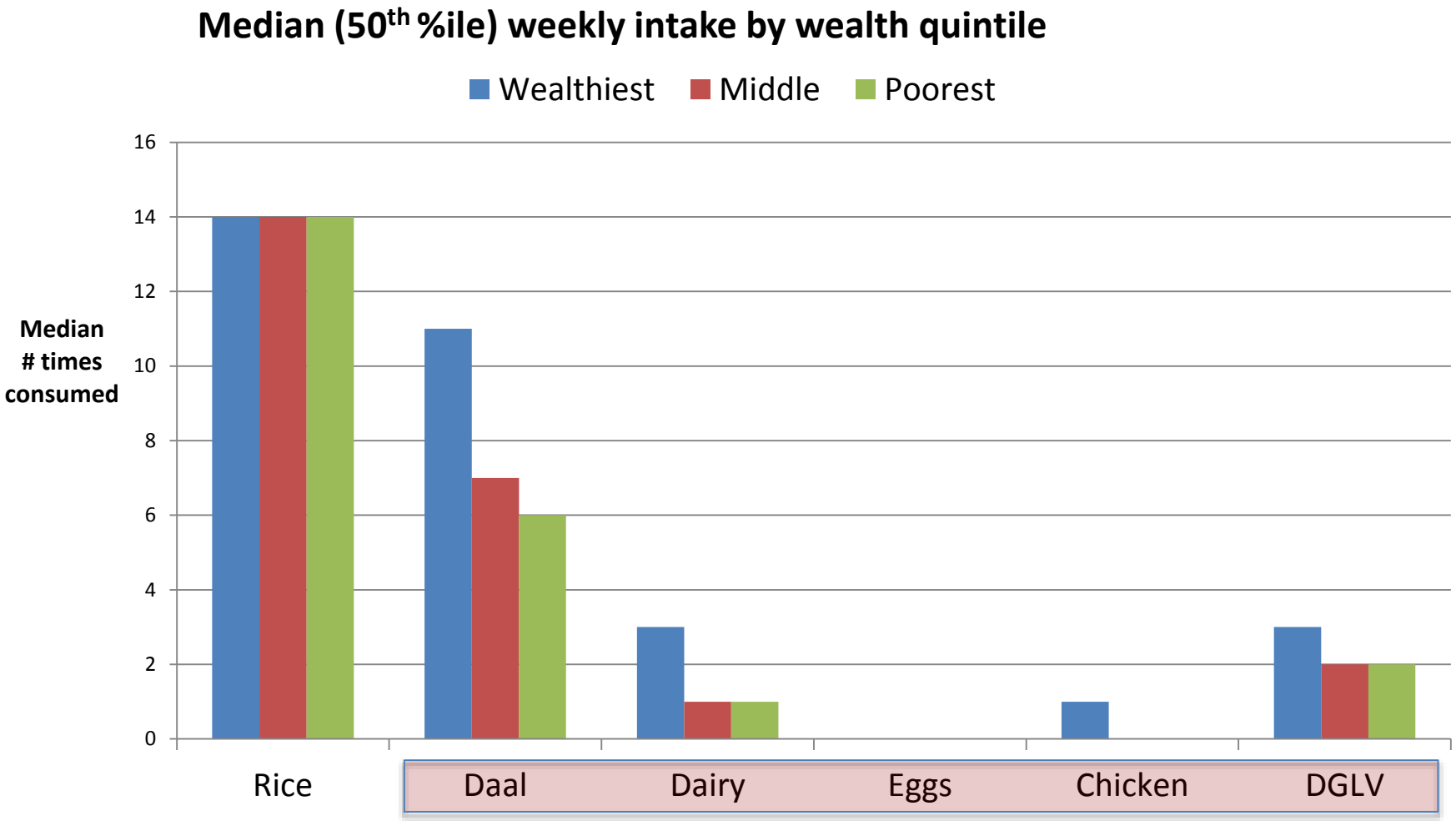
Women's Dietary Intakes of Nutritious Foods Decrease with Lower SES

Pecent consuming any food items in previous week by wealth quintile



Animal Source Food Intake by Women



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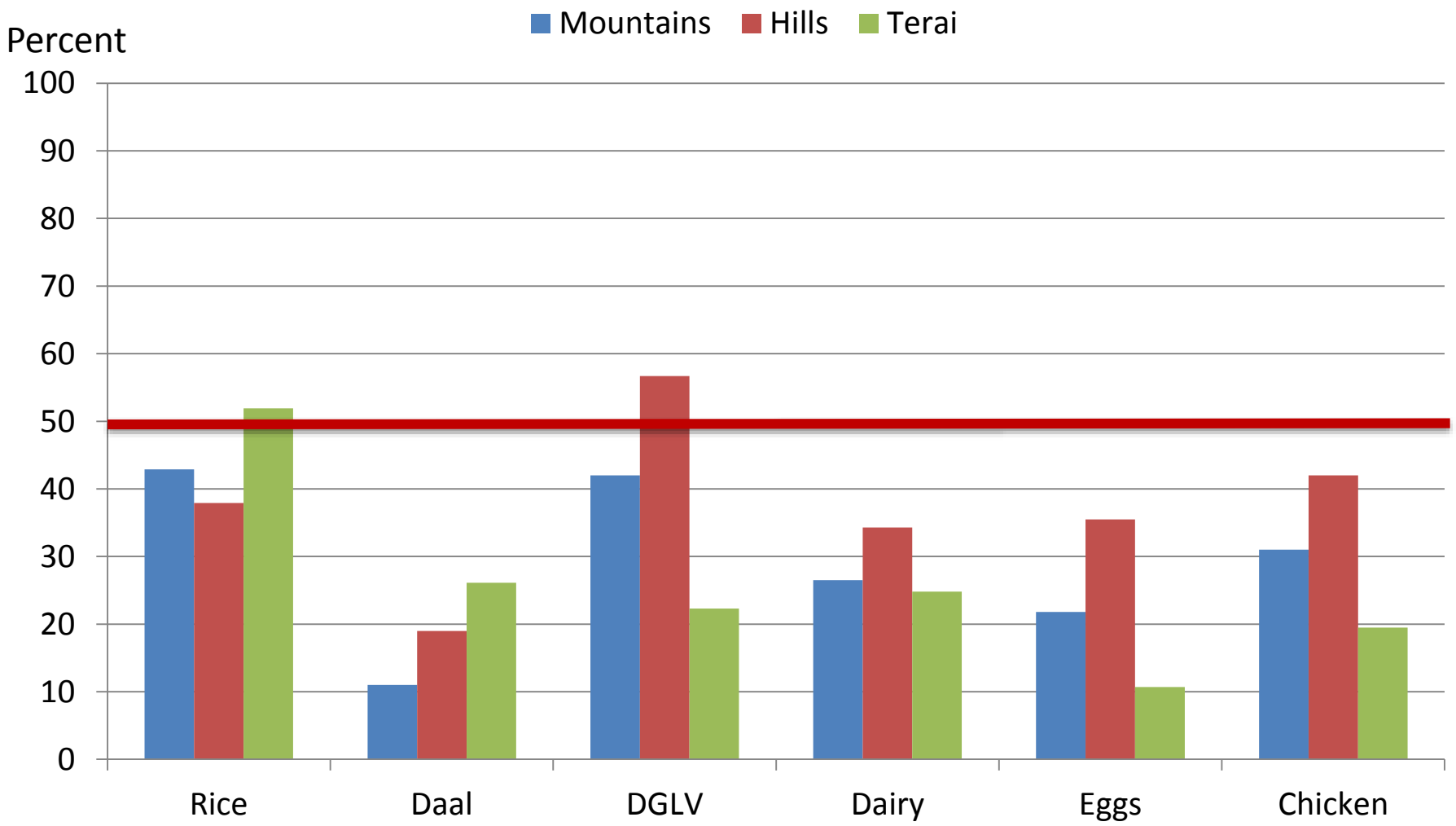
Percent of Households Producing …



Foods Grown or Raised in a Household

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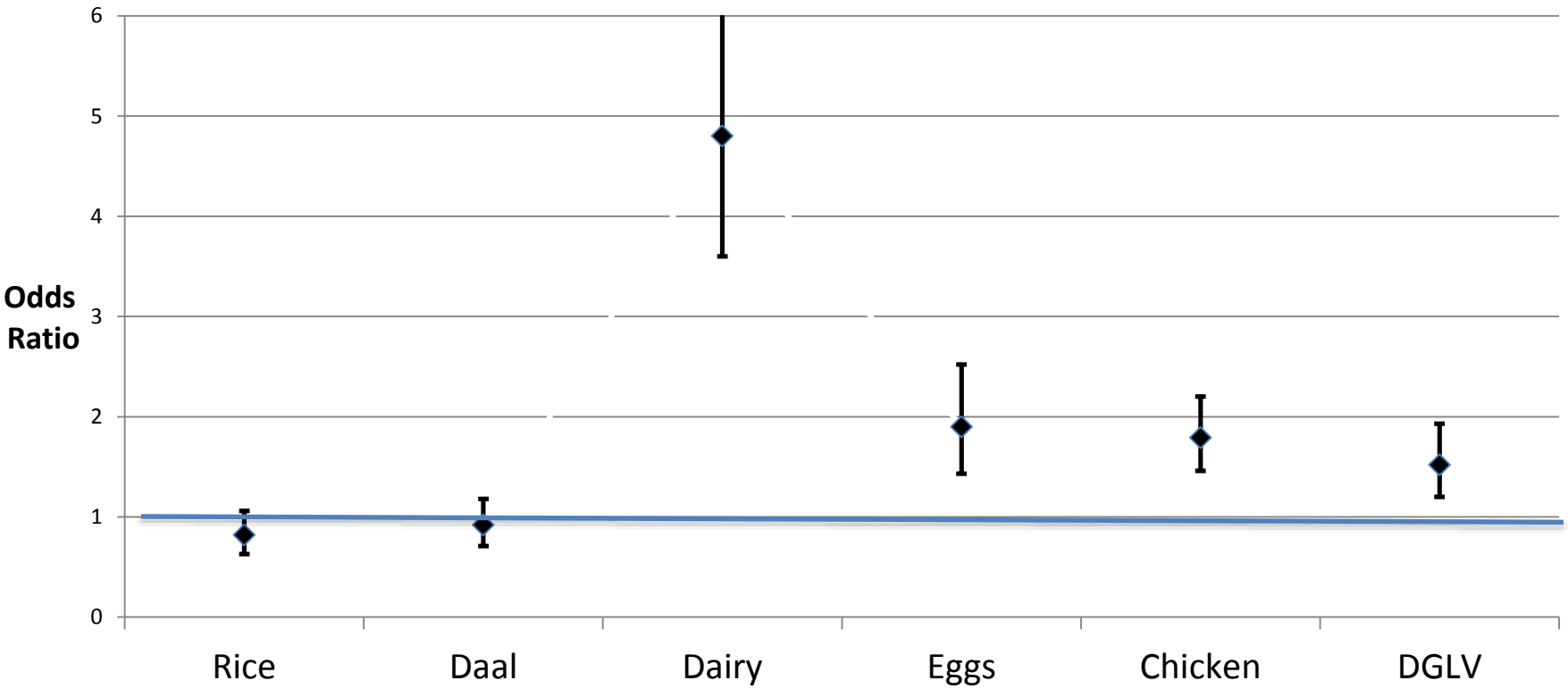
Nutritious Foods: If They Produce, They Eat More of Them

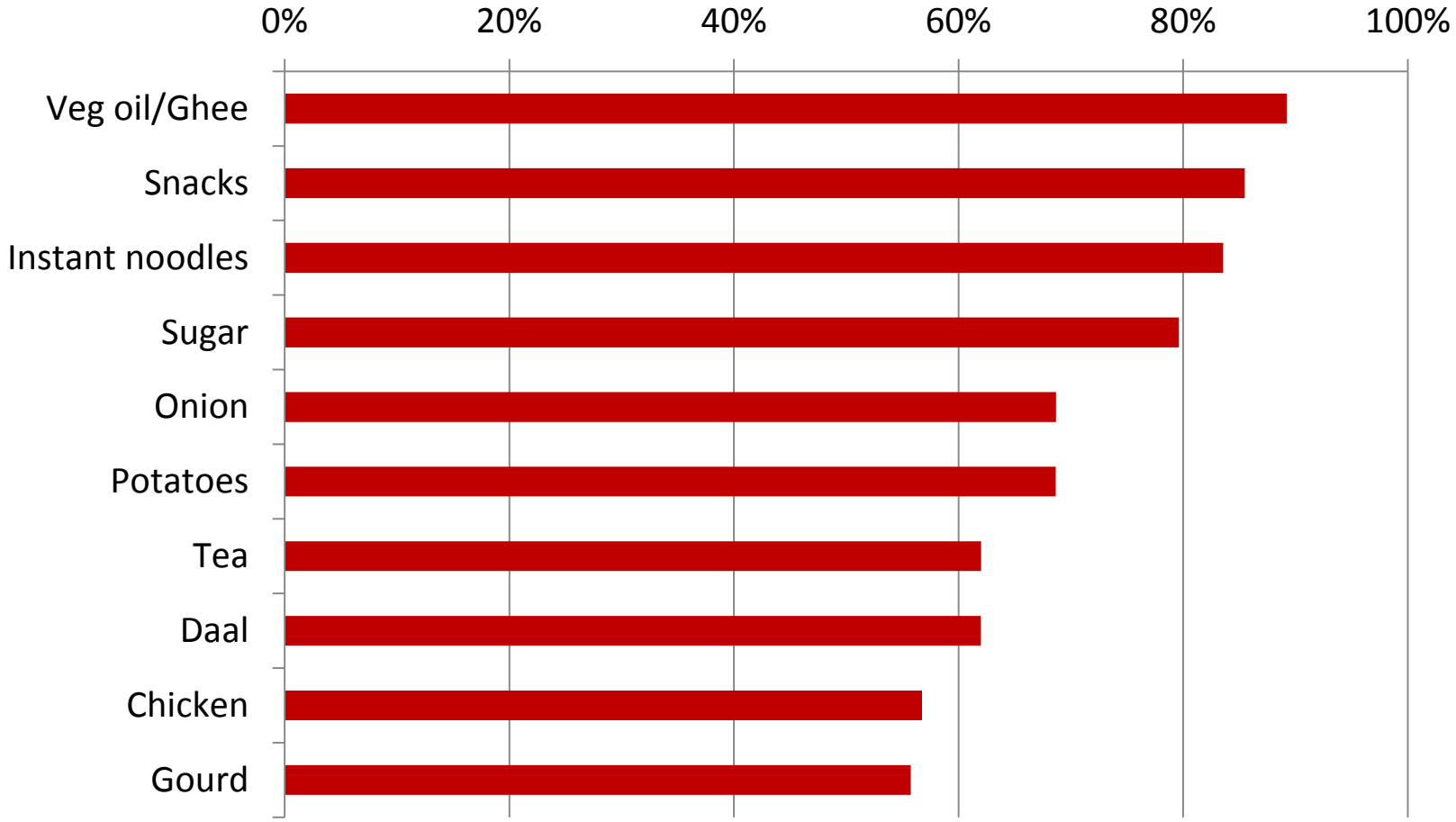
Odds ratio* (95% CI) of consuming above weekly median intake among producer vs non-producer households



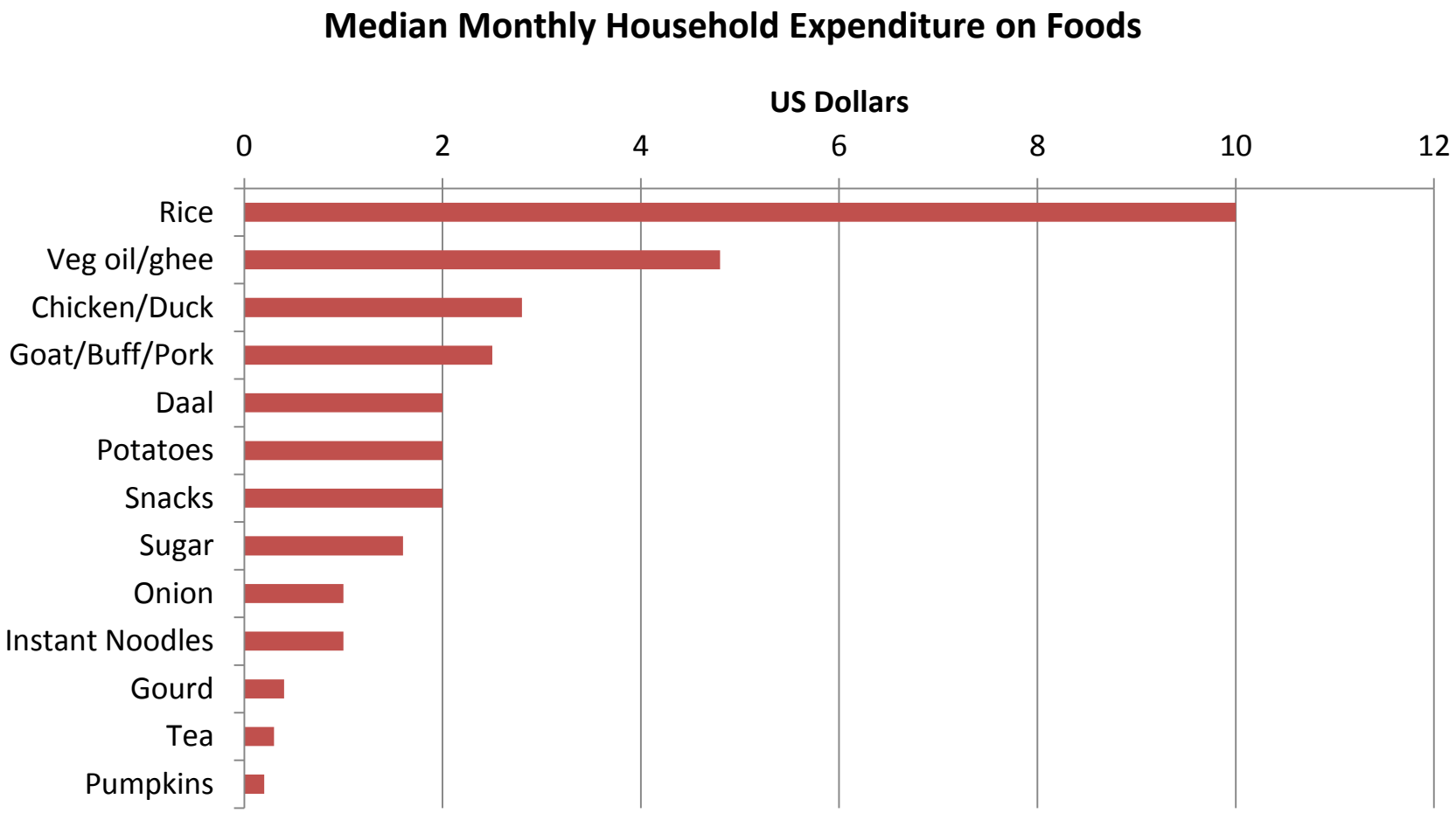
*Adjusted for market price, agro-ecological zone, wealth quintile & clustering

HHs Purchasing Foods in Past Month

N=4286



Money Spent on Foods in Market in Past Month



Key Messages

- Rural Nepal remains a country impoverished and undernourished, especially in the Terai
- Animal foods are costly, and prices are higher in the mountains
- With greater poverty, households spend less money and a larger share goes toward food
- With less money to spend, poorer households
  - Buy animal foods, daal and DGLV less often,
  - Fewer women are ever eating these nutritious foods, and
  - Those that do, eat them less often

However…

- 20-40% of rural households produce (raise or grow) nutritious foods sometime throughout the year, and
- If they do – women are more likely to increase their intakes of these foods

But also …

- The nutrition transition is happening:
  - Edible oils/ghee, snacks, noodles and sugar are the most common foods purchased at the market, and
  - Are among the top 10 foods for which households spend their food dollars (rupees)

Policy Implications

- In rural Nepal…
  - Producing nutritious foods at home leads to more consumption (if they grow them, they'll eat them)
  - Income generation remains a key goal for encouraging the purchase and consumption of nutritious foods

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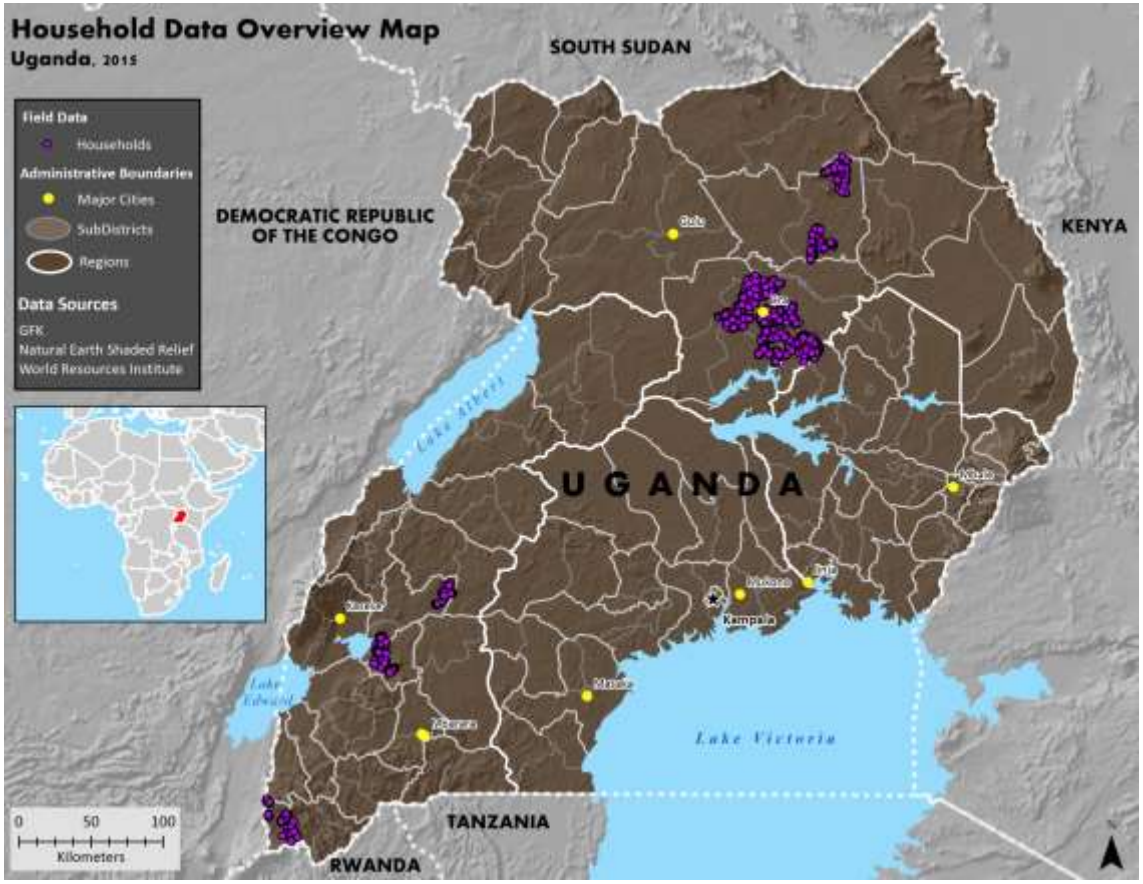
LIVESTOCK PRODUCTION, MALARIA AND ANEMIA LINKAGES

Findings from Uganda Panel Studies

BACKGROUND

- Livestock production (ownership) is essential for good nutrition (and possibly good health) outcomes
- **Directly** →households consume livestock products (e.g. milk and meat)
- **Indirectly** → sale of livestock and products (milk, meat, skins, manure) can improve incomes, employment
- A few recent studies have shown a considerable link between livestock ownership and consumption of animal source foods (ASF) but modest impacts on nutrition outcomes
- However, most of the studies mention one key point: **DATA LIMITATIONS**
  - *a gap that can be filled by the Feed the Future Nutrition Innovation Lab!*

DATA AND METHODS



- Panel dataset from 6 districts in Uganda
  —2 SW and 4 Northern Uganda
- 3,630 and 3,360 households in 2012 and 2014, respectively

Unlike other studies, we collected blood samples to test for Malaria and Hemoglobin on a large sample of children and a female caregiver!

FURTHER MULTIVARIATE ANALYSIS…

After accounting for observed and unobserved heterogeneity, we can robustly conclude that livestock ownership increases malaria prevalence by 12-14%.

Variables	Pooled probit (PP)	PP with control function	Correlated Random Effects (CRE)	CRE with control function
HH owns cows, yes=1	0.13** (0.052)	0.12** (0.05)	0.14*** (0.05)	0.13** (0.06)
…	…	…	…	…
Constant	0.66 (0.71)	0.65 (0.71)	0.14 (0.92)	0.08 (0.93)
N=7,200 children clustered in 3,013 households for 2012-2014.				

Dependent variable: *Child has malaria =1; = 0 otherwise.* ***Other X at:*** *individual child level; individual household head and caregiver attributes, household and locational attributes; farming practices.* ***Significance levels:*** **p<0.1; **p<0.05; ***p<0.01.* ***Figures in parentheses*** *are standard errors*

Possible Hypotheses For The Association?

1. Household that rear livestock have a specific activity pattern that exposes them to mosquito bites

   → *wake up early and enter houses late while tending to livestock*

2. Cattle hooves/drinking containers are breeding grounds for mosquitoes

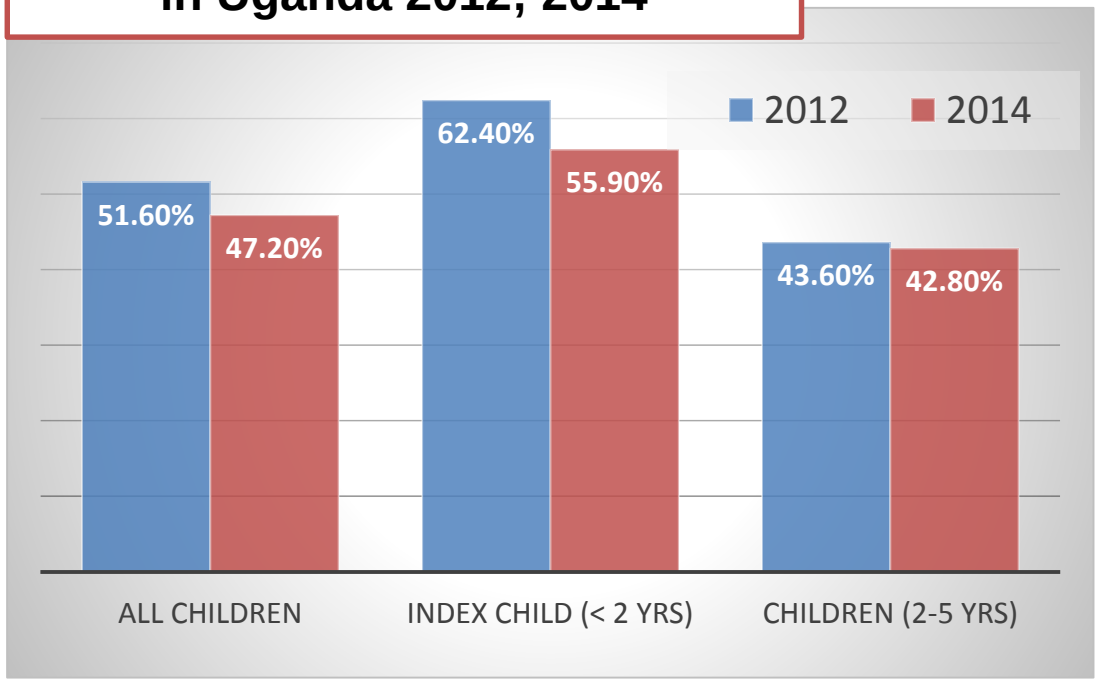
3. There are some mosquito species that thrive on both humans and cattle – zoophilic mosquitoes (**best bet!)**

➔*These are potential research areas that could inform future program targeting in as far malaria control is concerned*

TO WHAT EXTENT DOES MALARIA CAUSE ANEMIA?

Anemia prevalence rates are very high in Uganda – worse in children below 2 years!

Anemia prevalence for children in Uganda 2012; 2014



The linkage…

Consistently over the two panels, we observe that children (0-5 years) with Malaria have 23% more chances of being anemic!

FURTHER MULTIVARIATE ANALYSIS…

After accounting for observed and unobserved heterogeneity, we find less evidence that livestock ownership reduces anemia but consistently find that malaria increases anemia prevalence in children by about 74%

	Pooled probit (PP)	PP with control function	CRE	CRE with control function
Child tested positive for malaria, yes=1	0.76*** (0.04)	0.77*** (0.04)	0.74*** (0.04)	0.74*** (0.04)
HH owns cows, yes=1	-0.09*** (0.03)	-0.09** (0.04)	0.06 (0.50)	0.01 (0.44)
Other X, constant…				
N=7,200 children clustered in 3,013 households for 2012-2014.				

Dependent variable: *Child has malaria =1; = 0 otherwise.* ***Other X at:*** *individual child level; individual household head and caregiver attributes, household and locational attributes; farming practices.* ***Significance levels:*** **p<0.1; **p<0.05; ***p<0.01.* ***Figures in (.)*** *are Standard errors*

KEY MESSAGE:

- Livestock ownership can improve nutrition outcomes (yes – because other studies say so!) – although the effects are modest!
  - We do not know of any studies that rigorously analyze the association between livestock (cattle) ownership to anemia
- If we account for heterogeneous observable and unobservable factors, we find that livestock ownership does not necessarily reduce anemia but rather increases malaria (through zoophilic mosquitoes?), and;
  - ***Malaria increases the prevalence of child anemia by over 70%***

➔Interventions promoting livestock production would achieve better nutrition outcomes (e.g. reducing anemia) if other health confounders (e.g. control of mosquitoes) are seriously given consideration

Further research is required to understand these pathways well.

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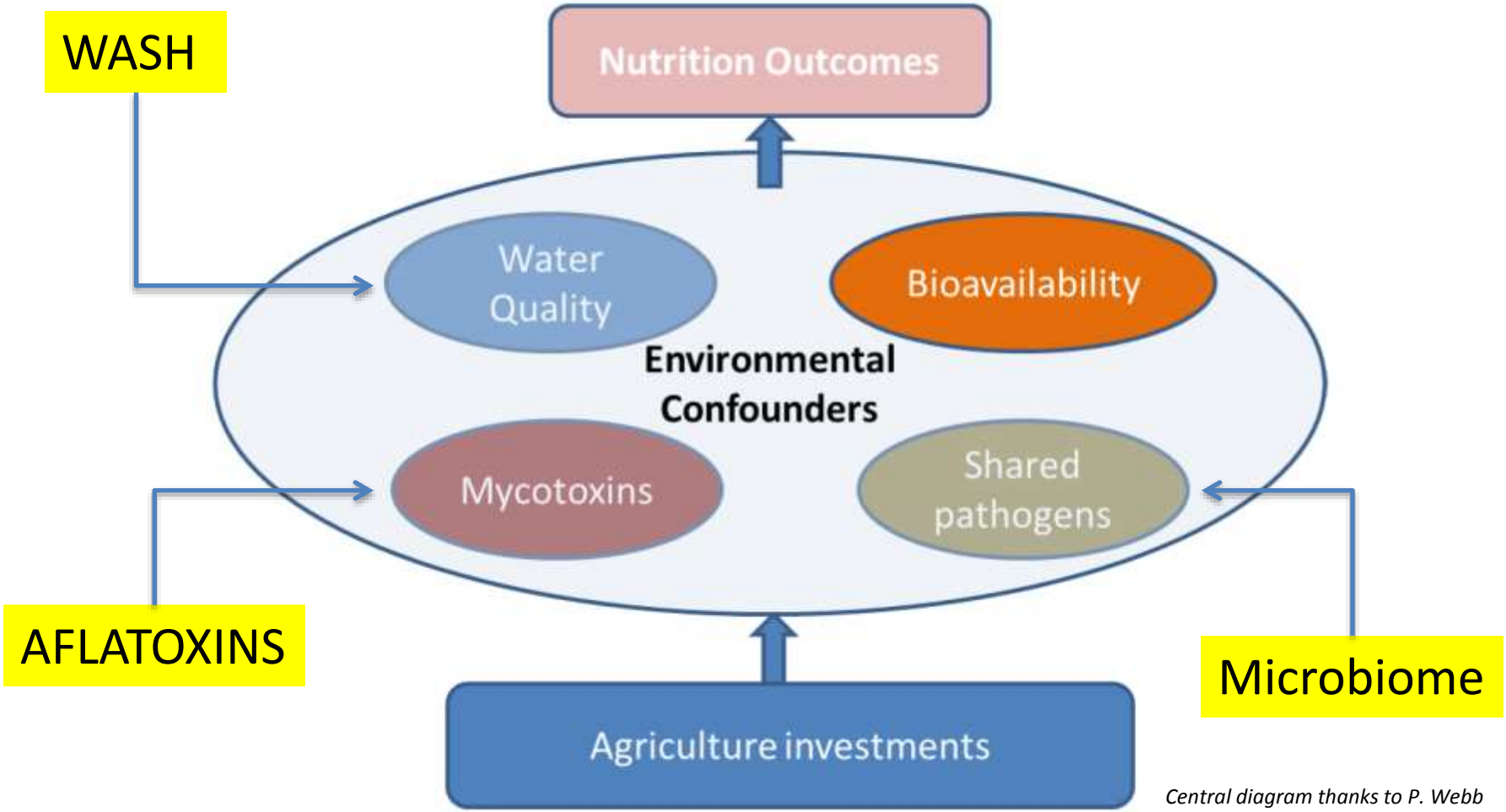
NEW DOMAINS FOR NUTRITION RESEARCH



Central diagram thanks to P. Webb

~20% of stunting can be addressed with food (Lancet 2013 series); other top-line concerns

ON THE IMMEDIATE HORIZON

1. Environmental Enteropathy (environmental enteric dysfxn, EED)

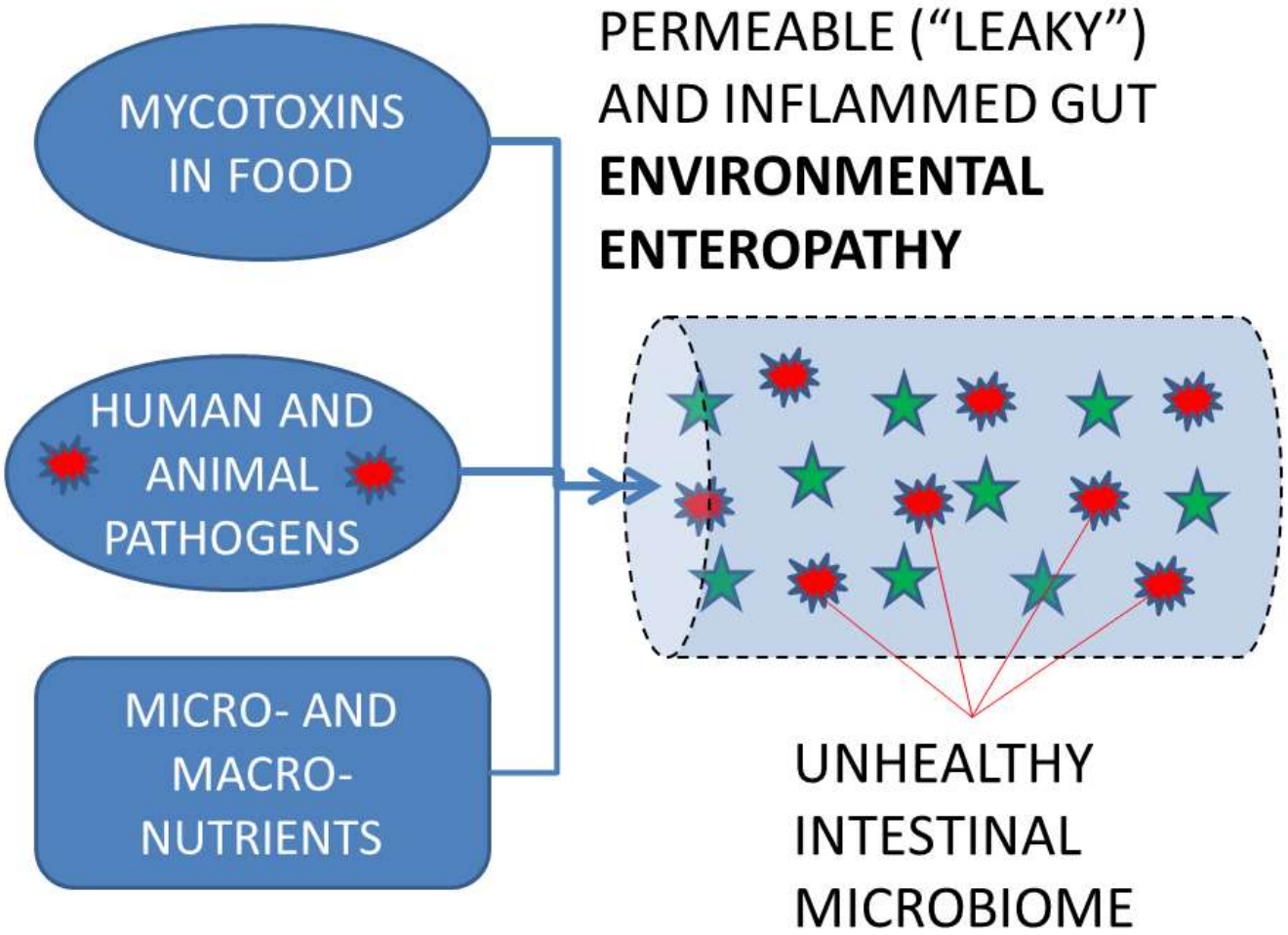
- Ubiquitous in environments without good sanitation and hygiene, EE increases caloric needs and subverts growth in children. *Providing clean water and sanitation (WASH) may reverse EE and improve nutrition.*

2. The Abnormal Gut Microbiomebv

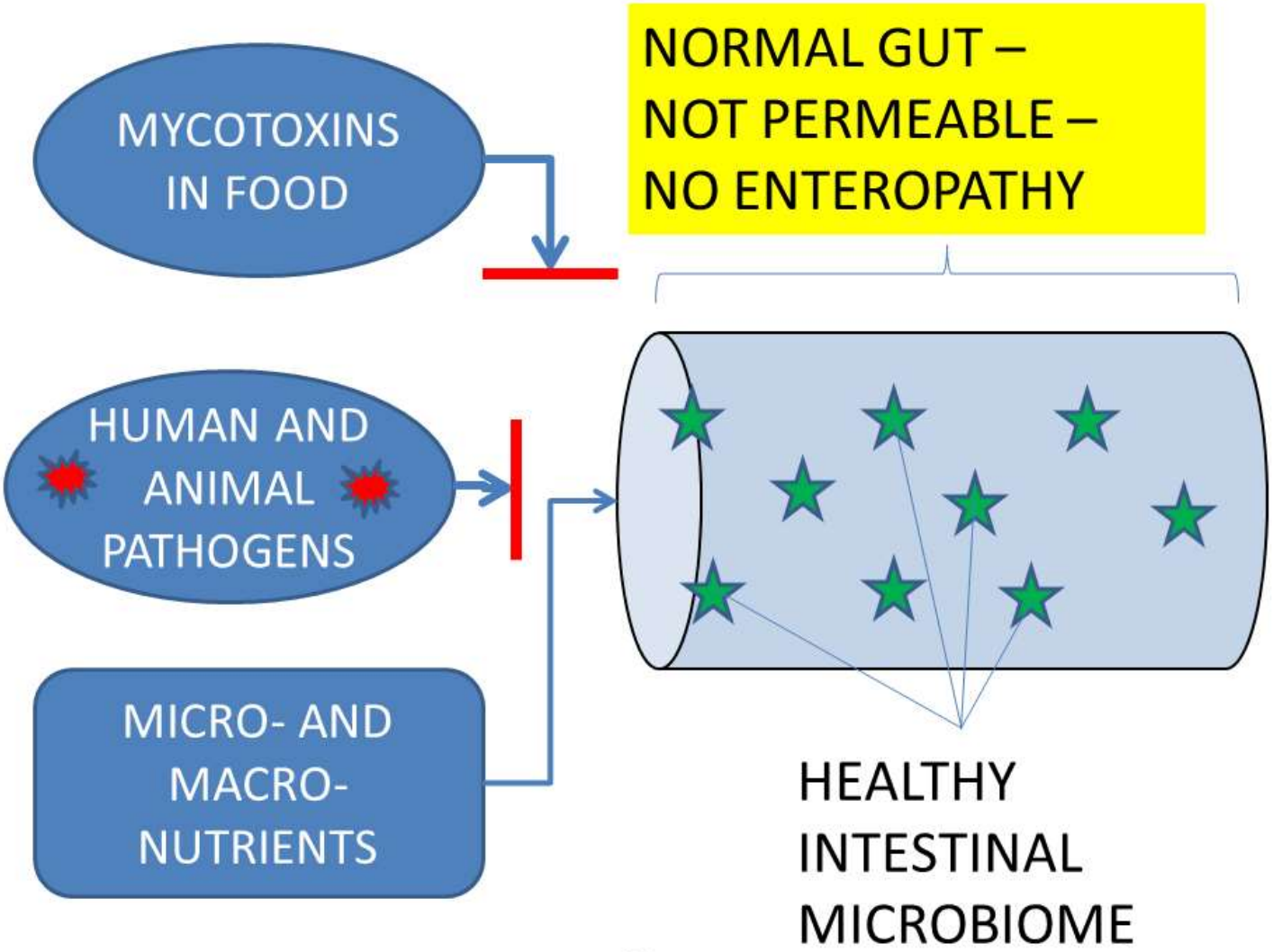
- Under-nourished children (and adults) have a spectrum of bacteria (the "microbiota") in their intestines which can actively contribute to under-nutrition. *What leads to this and what prevents this? If the colonization of their intestinal tracts early in life with an injurious group of bacteria can be prevented, will this improve nutrition? Will Probiotic / Prebiotic foods ameliorate EE and help normalize the microbiome?*

3. Aflatoxins

WHAT IS COMMON



WHAT THE GOAL MIGHT BE

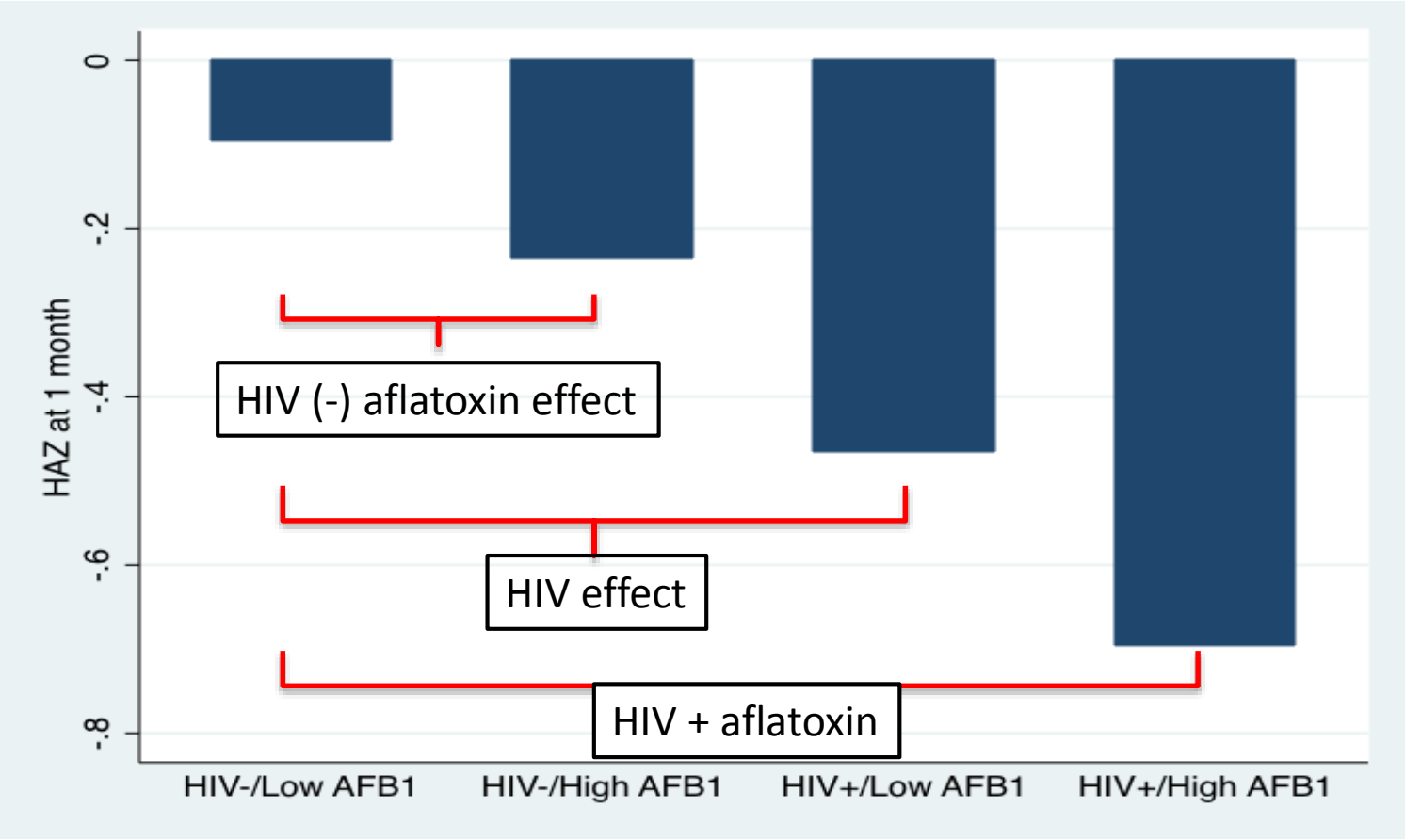


NOVEL AFLATOXIN FINDINGS

In a Gulu, Northern Uganda cohort, we have found:

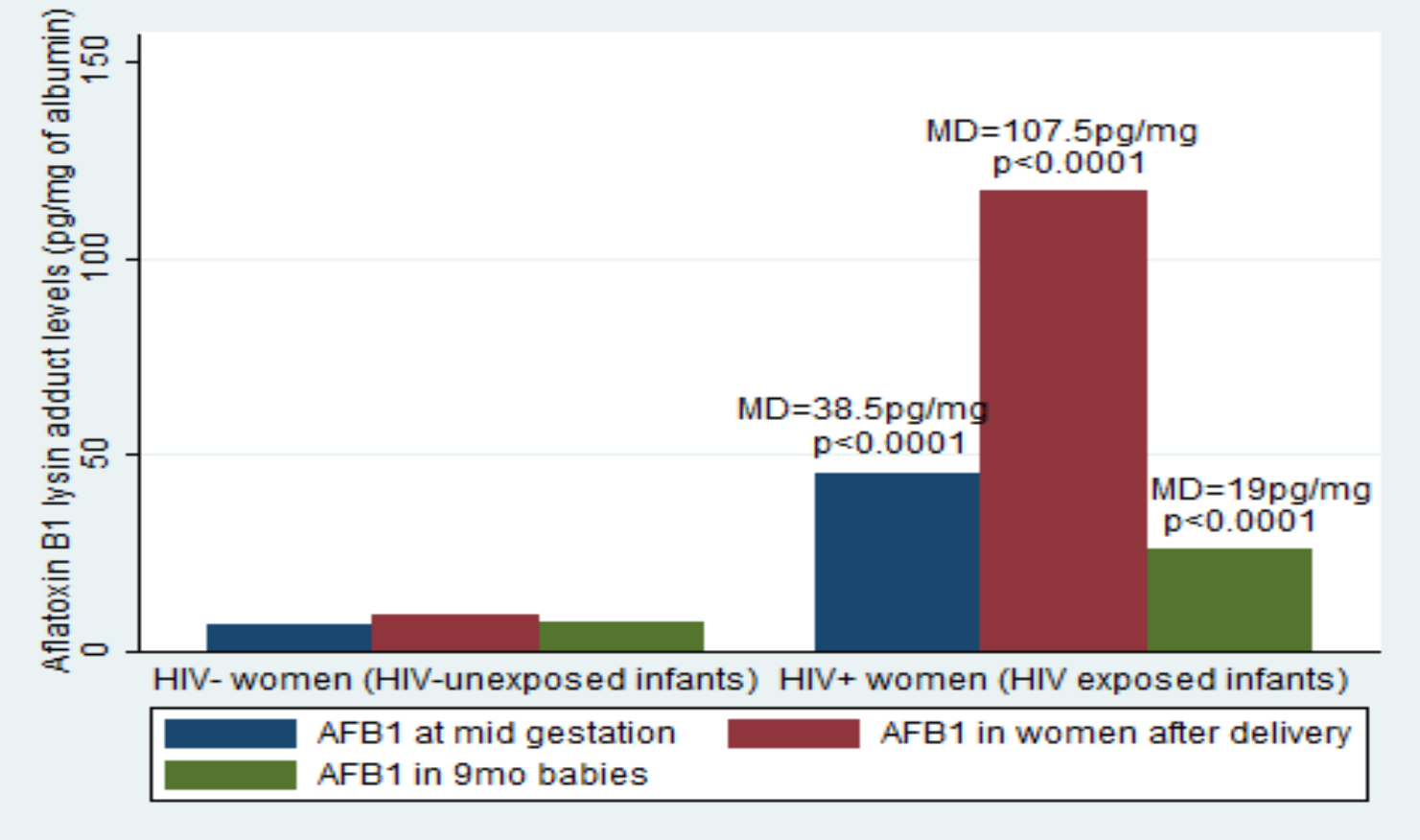
- Aflatoxin levels, measured at ~ 5 months gestation, predict **adversely affect subsequent weight gain in pregnancy** – *a key requirement for healthy, normal weight babies* ($p < 0.001$).
- **Higher aflatoxin levels are seen in women with HIV** despite being on anti-virals ($p < 0.0001$) – there may be an unexpected synergism between HIV and aflatoxins.
- **Maternal aflatoxin levels prospectively predict infant HAZ** (stunting) scores at 1, 3, 6, 9, and 12 months of age ($p < 0.002$)

Natamba et al; funding Nutrition Innovation Lab and USAID East Africa

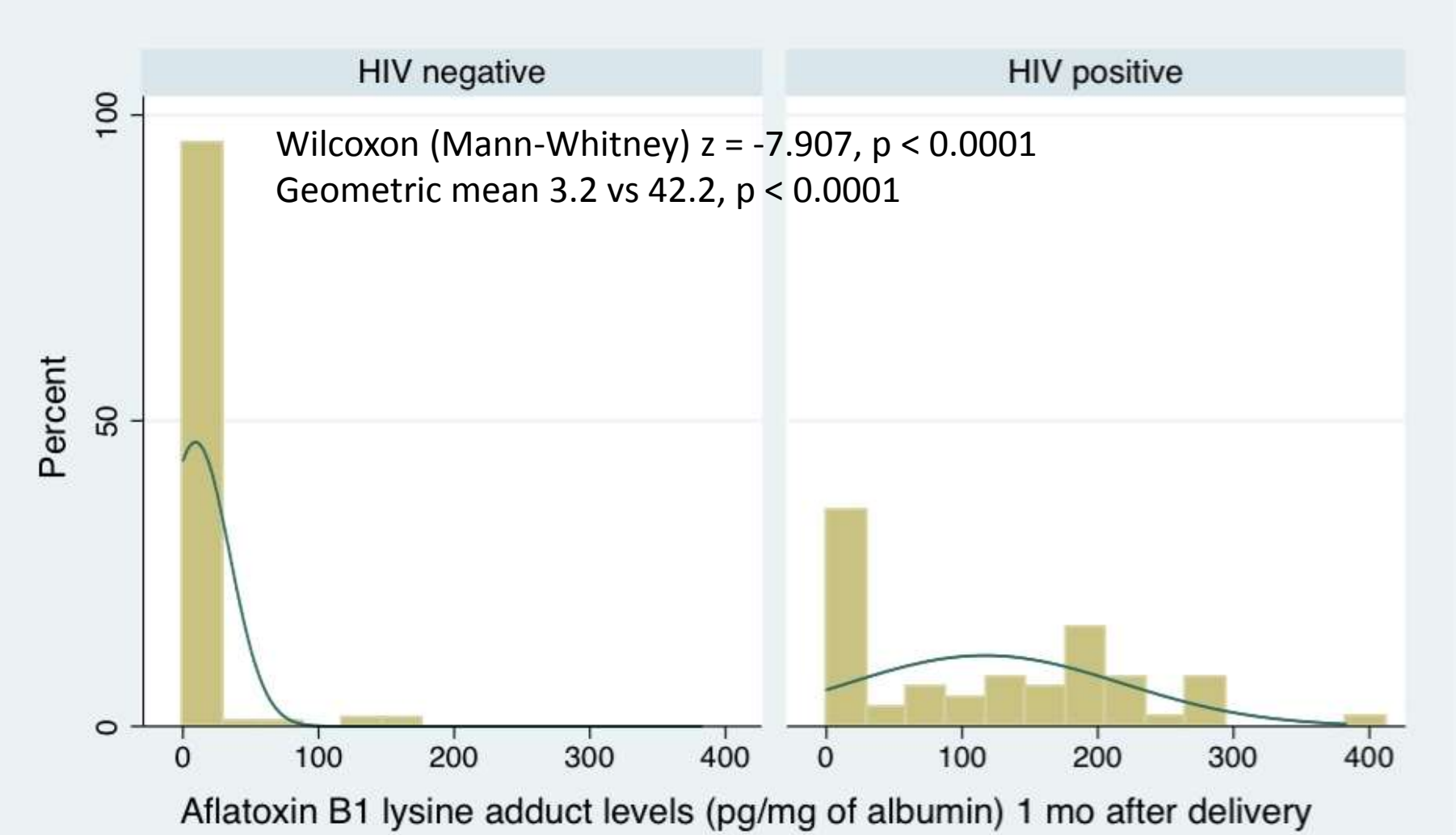


Natamba *et al*

AFLATOXIN LEVELS HIGHER IN HIV (+) WOMEN AND THEIR INFANTS

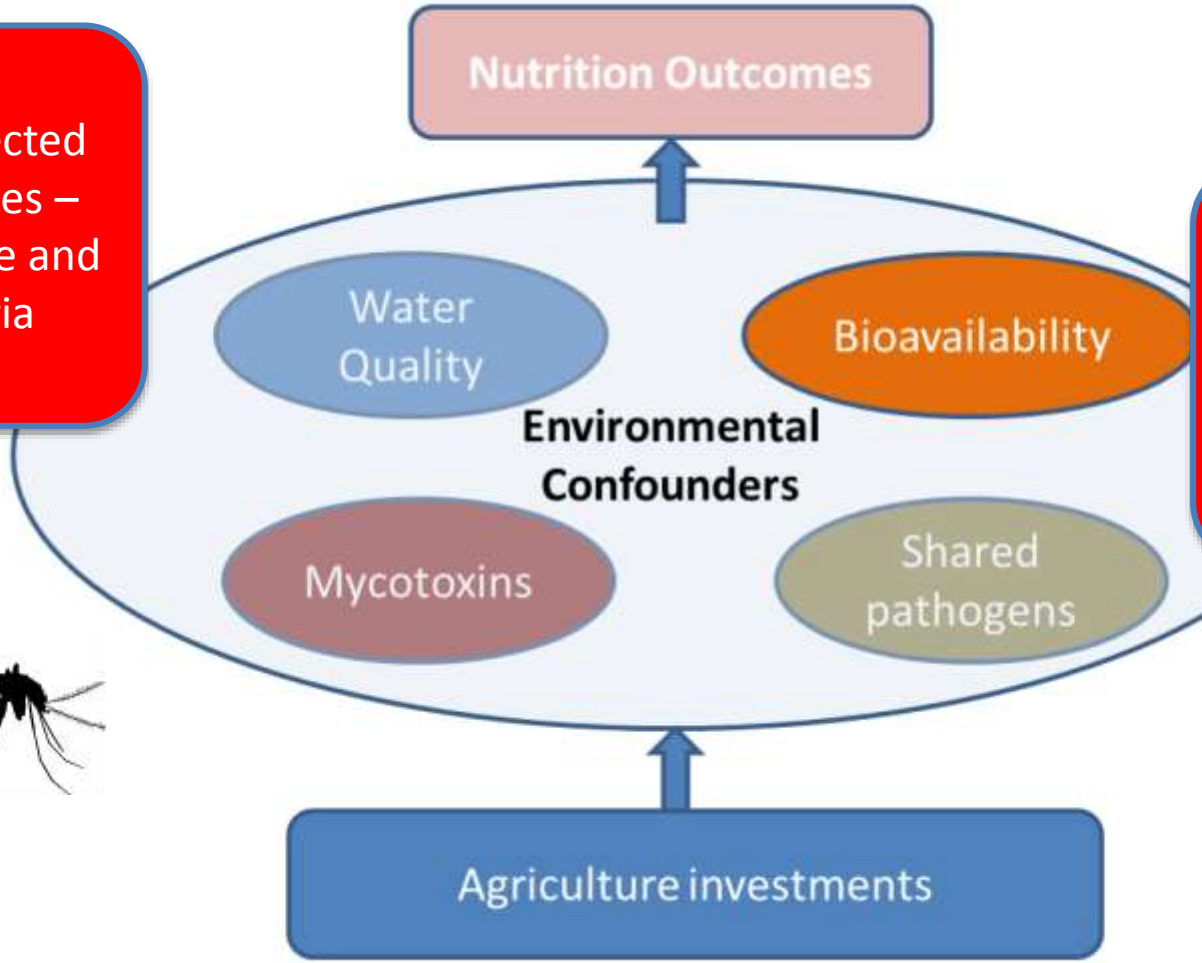


Natamba *et al*



N = 137, 66
Natamba *et al*

Unsuspected Influences – e.g. Cattle and Malaria



Unsuspected Influences – HIV and Aflatoxin Interaction

EMERGING DOMAINS

- **HOUSEHOLD AND INDIVIDUAL RESILIENCE**
  Shocks (Nepal: earthquakes) adversely affect nutrition – what programs & policies promote resilience?

- **WATER QUALITY**
  Microbial -> predicts enteropathy? A lever for action
  Heavy metals – arsenic, lead, cadmium implicated in stunting

- **COGNITIVE DEVELOPMENT**
  Historically focused on deficiencies of iron, iodine
  Little known about dietary patterns and cognition in Feed the Future countries, modern context

NEW DOMAINS

We 'Expect the Unexpected'

- Will pursue novel findings (cattle & malaria, aflatoxins in pregnancy / HIV, resilience in shocks) as they arise.
- Pursue opportunities to work collaboratively with others

- Provide nutrition expertise to enhance the work of other Innovation Labs

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