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Aflatoxins and Maternal and Child Nutrition:

Findings from Nepal, Mozambique, Uganda, and Timor-Leste

Patrick Webb, PhD; Jacqueline Lauer, PhD; Katherine Heneveld, MSc; Shibani Ghosh, PhD

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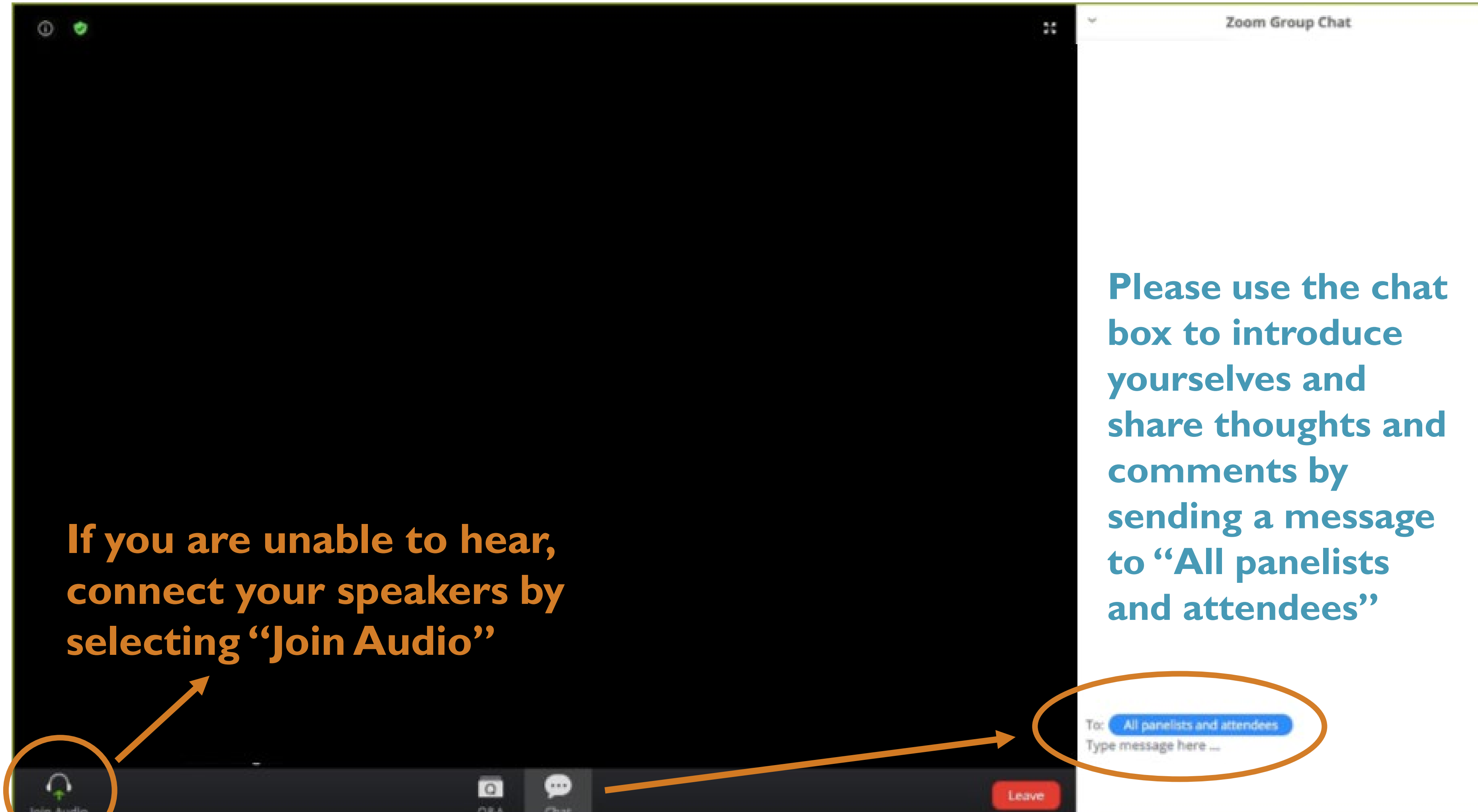

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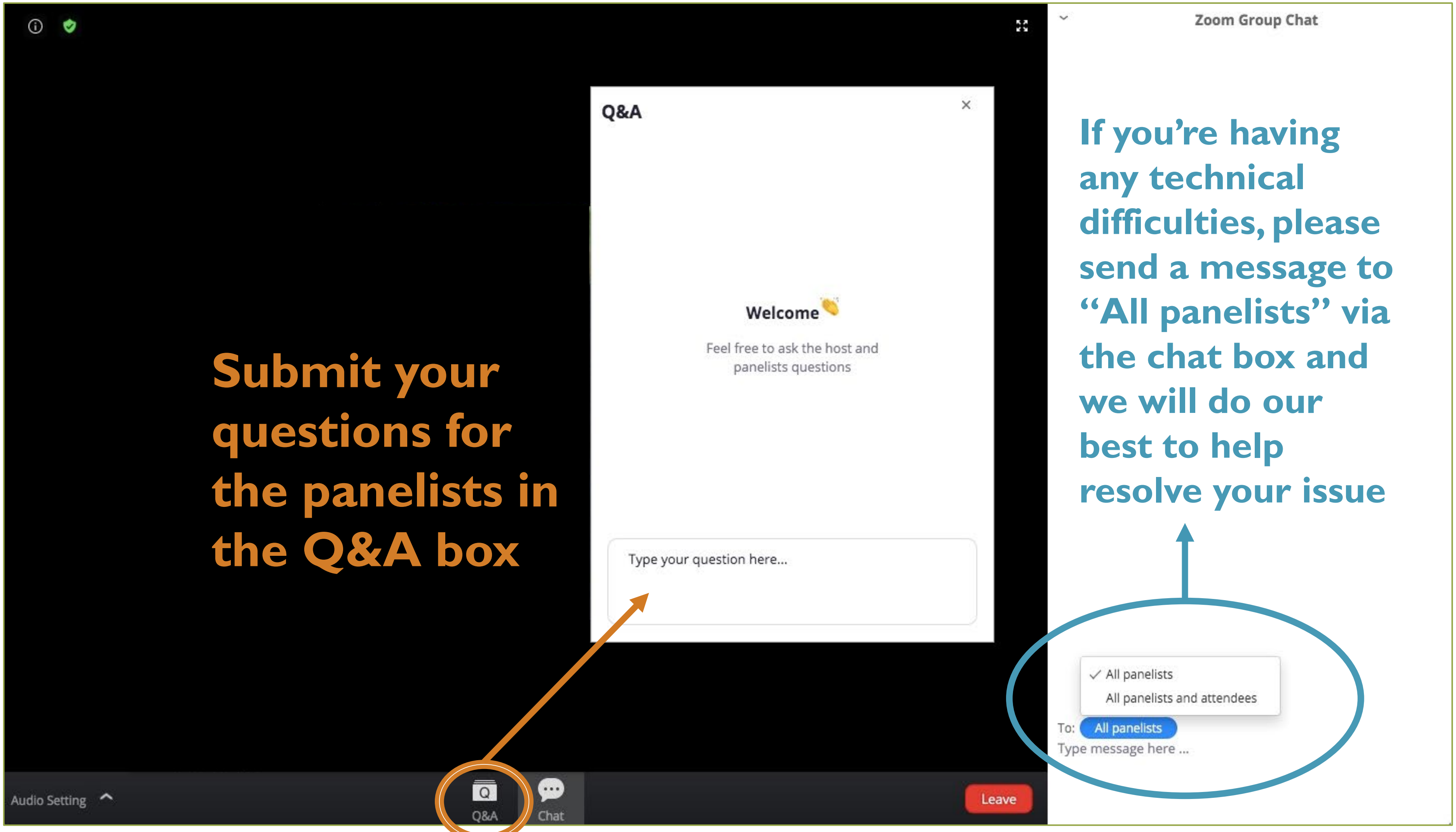
Q&A AND CHAT



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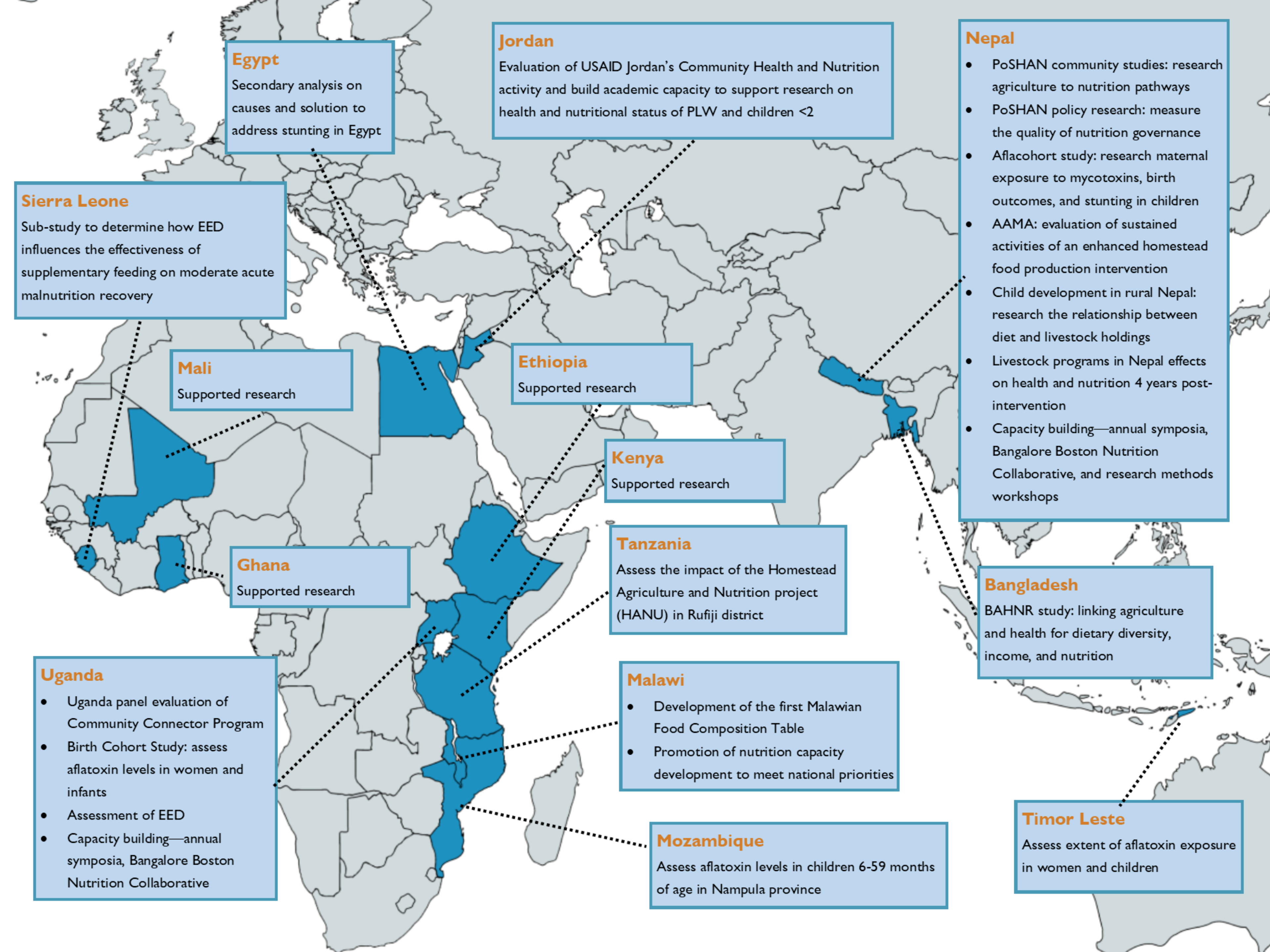

Egypt
Secondary analysis on causes and solution to address stunting in Egypt
Jordan
Evaluation of USAID Jordan's Community Health and Nutrition activity and build academic capacity to support research on health and nutritional status of PLW and children <2
Nepal
• PoSHAN community studies: research agriculture to nutrition pathways
• PoSHAN policy research: measure the quality of nutrition governance
• Aflacohort study: research maternal exposure to mycotoxins, birth outcomes, and stunting in children
• AAMA: evaluation of sustained activities of an enhanced homestead food production intervention
• Child development in rural Nepal: research the relationship between diet and livestock holdings
• Livestock programs in Nepal effects on health and nutrition 4 years post-intervention
• Capacity building—annual symposia, Bangalore Boston Nutrition Collaborative, and research methods workshops
Sierra Leone
Sub-study to determine how EED influences the effectiveness of supplementary feeding on moderate acute malnutrition recovery
Mali
Supported research
Ethiopia
Supported research
Kenya
Supported research
Tanzania
Assess the impact of the Homestead Agriculture and Nutrition project (HANU) in Rufiji district
Ghana
Supported research
Bangladesh
BAHNR study: linking agriculture and health for dietary diversity, income, and nutrition
Uganda
• Uganda panel evaluation of Community Connector Program
• Birth Cohort Study: assess aflatoxin levels in women and infants
• Assessment of EED
• Capacity building—annual symposia, Bangalore Boston Nutrition Collaborative
Malawi
• Development of the first Malawian Food Composition Table
• Promotion of nutrition capacity development to meet national priorities
Timor Leste
Assess extent of aflatoxin exposure in women and children
Mozambique
Assess aflatoxin levels in children 6-59 months of age in Nampula province

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Gulu Regional Referral & Teaching Hospital

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FTF Innovation Lab for the Reduction of Post Harvest Loss at Kansas State University
USAID Bureau of Food Security
USAID Nepal, East Africa Regional Mission, Mozambique

Ministry of Health, Timor-Leste
UNICEF, Timor-Leste
University of Indonesia

Research Theme: Neglected Biological Mechanisms

To understand mycotoxin links to growth retardation: several studies to explore links among diets, mycotoxins and nutrition

- Gulu Cohort: HIV, Food Security in pregnancy (N. *Uganda*)
- Birth Cohort Uganda (N. and SW *Uganda*)
- Alfatoxin in pregnancy and birth outcomes (Kampala, *Uganda*)
- Aflatoxin Study (Nampula province, N. *Mozambique*)
- AflaCohort Study (Banke district, *Nepal*)
- National maternal/child nutrition survey (*Timor Leste*)

MYCOTOXINS

- Metabolites of fungi: cancer, growth faltering, neural tube defects, renal diseases and immune modulation/suppression.
- Aflatoxin B1 (AFB1), fumonisin (FUM), deoxynivalenol (DON) and ochratoxin (OTA).
- Widely found in maize, groundnuts, wheat, oats, rice, barley, milk, chilies and spices, infant formula and baby foods

MYCOTOXINS AND CHILD GROWTH

- Observational studies showed association between in utero and infant exposure to aflatoxin B1 and poor child growth.

- Midline results from a randomized control trial in Kenya showed aflatoxins might affect growth at younger ages; but effects disappears at the endline (Hoffmann 2018).

- But prospective evidence of impacts on birth outcome, linear growth effects, interactions with other diseases limited.

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INNOVATION LAB FOR NUTRITION
WEBINAR SERIES

WEDNESDAY, AUGUST 12TH
9:00AM - 10:30AM (ET)

Aflatoxins and Maternal and Child Nutrition:
Findings from Nepal, Mozambique, Uganda, and Timor-Leste


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Maternal Aflatoxin Exposure and Pregnancy Outcomes in Uganda

Jacqueline M. Lauer, PhD, MPH
Clinical Assistant Professor
Boston University

August 2020

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Disclosures

I have no disclosures in relation to this presentation.

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AFLATOXINS IN UGANDA

- Tropical climate (between 40°N and 40°S) that favors growth of the aflatoxin producing Aspergillus spp.

- In Uganda, aflatoxins have been studied in maize, peanuts, cassava, millet, and sorghum-all showing very high levels across agricultural zones.

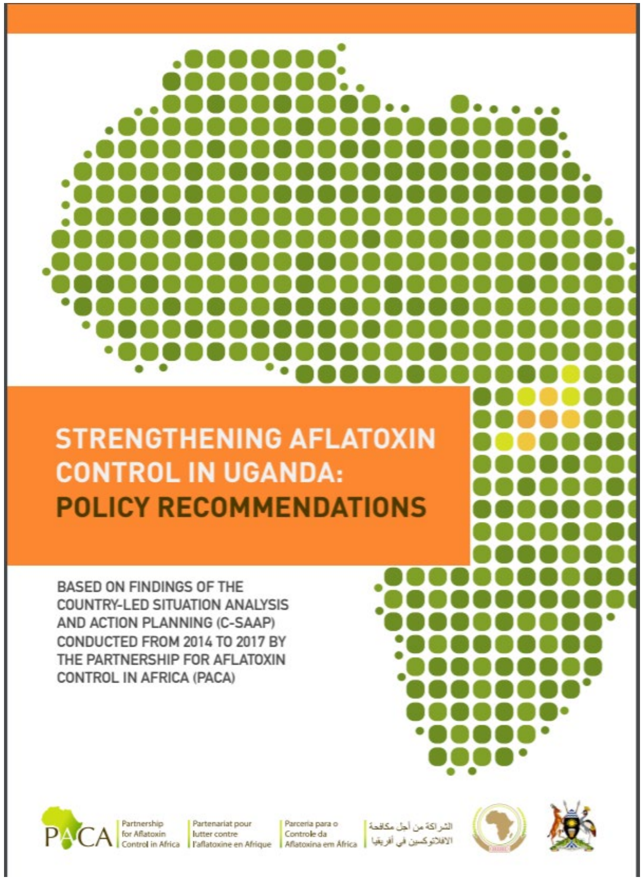


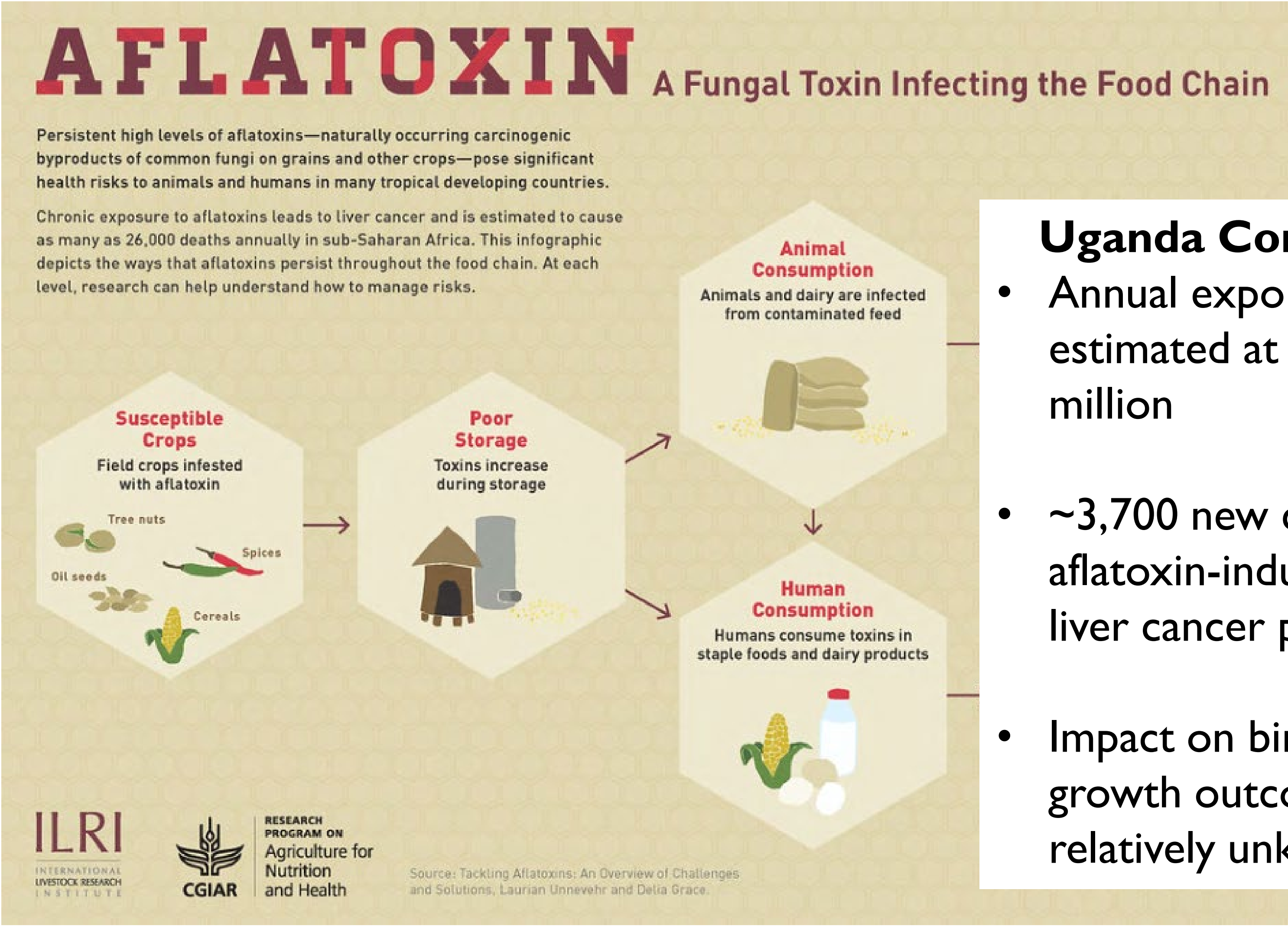
Table 5
Aflatoxin levels in sorghum in agro-ecological zones in Uganda.

Agro-ecological zone	District	% samples > limit of detection	Total aflatoxin levels (ppb)		% samples		
			Range[a]	Mean[b]	> 4 ppb[c]	> 10 ppb[d]	> 20 ppb[e]
Kioga plains	Soroti	100	98.25–265.5	170.1	100	100	100
	Tororo	90	4.0–215	61.14	85	70	65
Northern eastern	Gulu	90	5.5–119.5	70.5	90	90	85
Savannah	Amuria	100	28.5–472	11.5	100	100	100
Grasslands	Lira	100	27.5–227	102.27	100	100	100

Source: PACA [34]. Unpublished data

[a] The range was calculated for samples with aflatoxin levels above Limit of detection.
[b] The mean was calculated for samples with aflatoxin levels above Limit of detection.
[c] EU; European Union regulatory limit.
[d] UNBS/EAC; UNBS, Uganda National Bureau of Standards / East African Community regulatory limit.
[e] FDA/WHO; FDA, US Food and Drug Administration / World Health Organisation regulatory limit.

Lukwago FB, Mukisa IM, Atukwase A, Kaaya AN, Tumwebaze S. Mycotoxins contamination in foods consumed in Uganda: A 12-year review (2006–18). Scientific African. 2019 May 1;3:e00054.



Uganda Context

- Annual export loss estimated at US$ 38 million
- ~3,700 new cases of aflatoxin-induced liver cancer per year
- Impact on birth and growth outcomes is relatively unknown

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Maternal & Child Nutrition
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Maternal aflatoxin exposure during pregnancy and adverse birth outcomes in Uganda

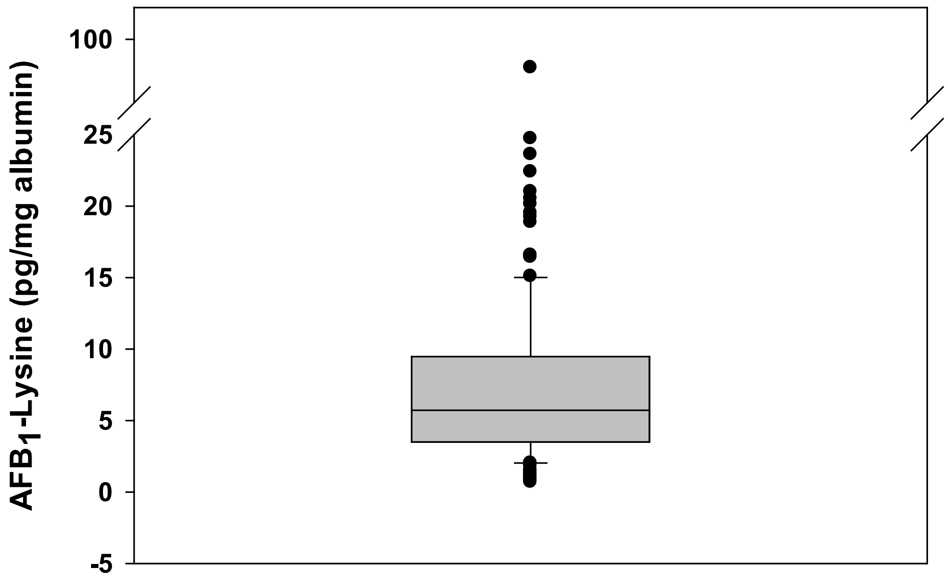
Jacqueline M. Lauer, Christopher P. Duggan, Lynne M. Ausman, Jeffrey K. Griffiths, Patrick Webb, Jia-Sheng Wang, Kathy S. Xue, Edgar Agaba, Nathan Nshakira, Shibani Ghosh

VISIT SCHEDULE

Visit	Time	Location	Description
#1: Enrollment visit (n=254)	After first prenatal visit (9-27 weeks gestation)	MHC IV	• Ultrasound scan • Hb test/blood pressure tests • Venous blood draw • Anthropometry (height, weight, MUAC) • Questionnaire
#2: L:M test (n=247)	< 1 week after enrollment visit	Participants' residence	• Solution containing 5 grams of lactulose and 2 grams of mannitol • 4-hour timed urine collection
#3: Follow-up visit (n=236)	3 weeks prior to participants' EDD	Participants' residence	• Anthropometry (weight, MUAC) • Questionnaire • Water quality test
#4: Delivery visit (n=232 total, 220 born alive)	Within 48 hours of delivery	Participants' residence or health facility	• Infant anthropometry (length, weight, head circumference)

MATERNAL AFB1 LEVELS

AFB1-Lysine (pg/mg albumin)	
Mean	8.55
Standard Deviation	11.09
Median	5.71
q1	3.49
q3	9.47
Geometric Mean	5.77
95% CI	5.19
	6.40
Minimum	0.71
Maximum	95.60



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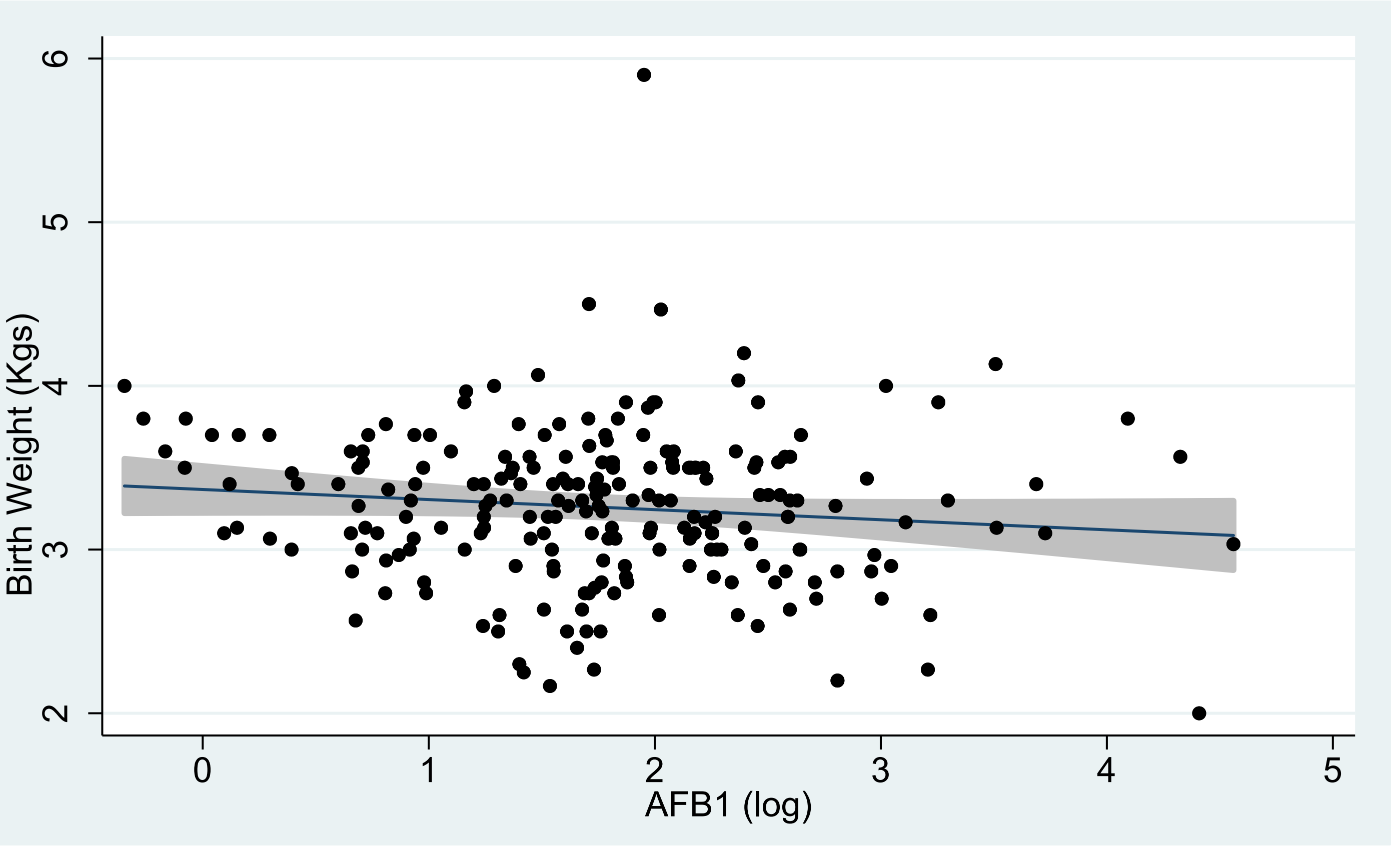
MATERNAL AFB1 AND INFANT BIRTH WEIGHT



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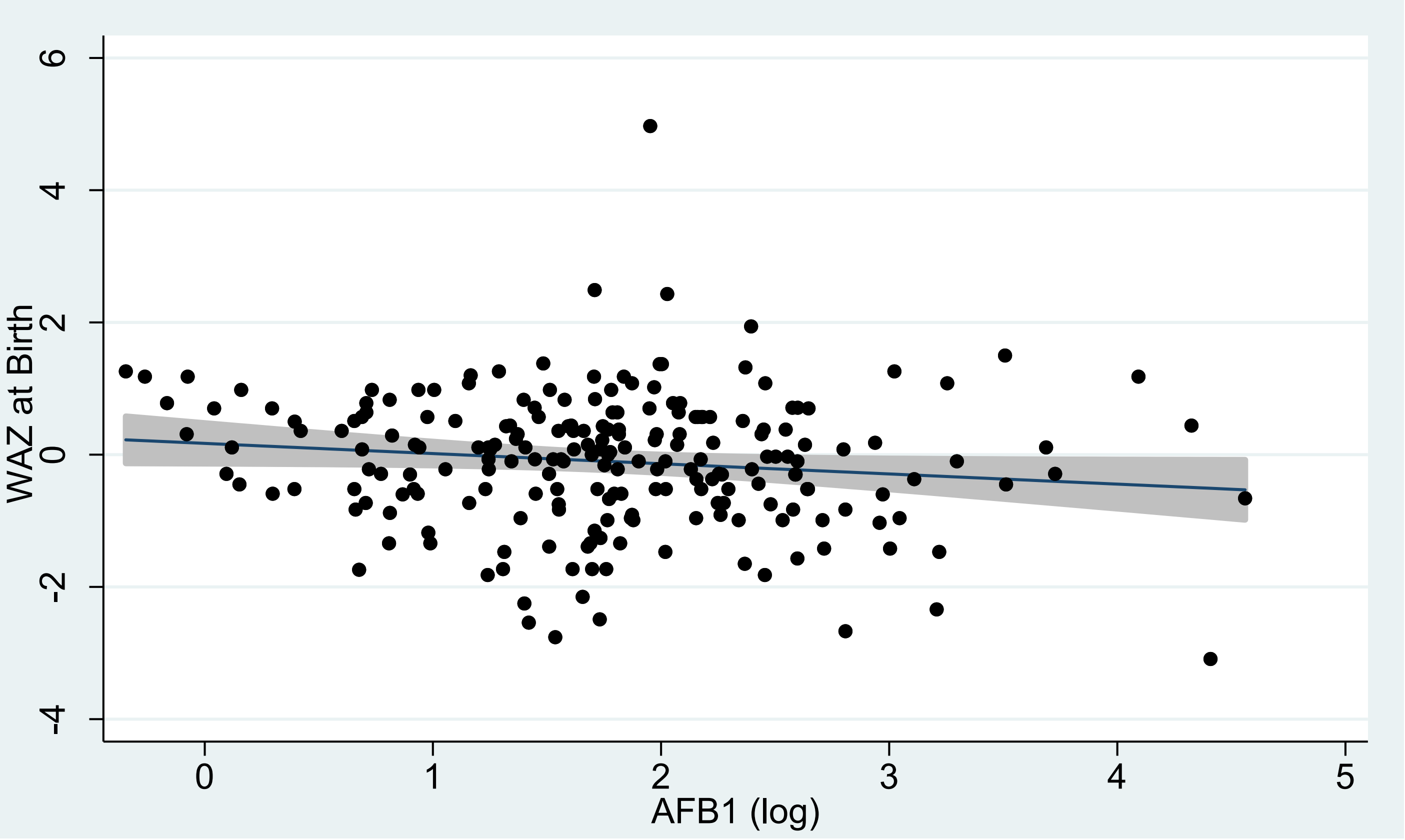
MATERNAL AFB1 AND INFANT WAZ AT BIRTH



	Unadjusted model	Adjusted model[a]
Weight, kg	−0.07 (−0.14, −0.002) *p* = 0.045	−0.07 (−0.13, −0.003) *p* = 0.040
Length, cm	−0.09 (−0.41, 0.24) *p* = 0.598	−0.10 (−0.42, 0.22) *p* = 0.532
Weight-for-age *z*-score	−0.16 (−0.32, −0.006) *p* = 0.041	−0.16 (−0.30, −0.01) *p* = 0.037
Weight-for-length *z*-score	−0.15 (−0.40, 0.10) *p* = 0.238	−0.15 (−0.40, 0.11) *p* = 0.267
Length-for-age *z*-score	−0.06 (−0.23, 0.11) *p* = 0.444	−0.07 (−0.24, 0.10) *p* = 0.406
Head circumference, cm	−0.24 (−0.48, −0.005) *p* = 0.045	−0.26 (−0.49, −0.02) *p* = 0.035
Head circumference-for-age *z*-score	−0.22 (−0.42, −0.02) *p* = 0.030	−0.23 (−0.43, −0.03) *p* = 0.023
Gestational age at birth, weeks	−0.11 (−0.44, 0.22) *p* = 0.526	−0.07 (−0.41, 0.26) *p* = 0.663

a Adjusted linear regression model controls for maternal age, weight, pulse pressure, and years of education in all models. Infant gestational age at birth was controlled for in all models except for when an outcome variable.

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A European Journal
TMIH
Tropical Medicine & International Health

Original Article | Open Access

Aflatoxin exposure in pregnant women of mixed status of human immunodeficiency virus infection and rate of gestational weight gain: a Ugandan cohort study

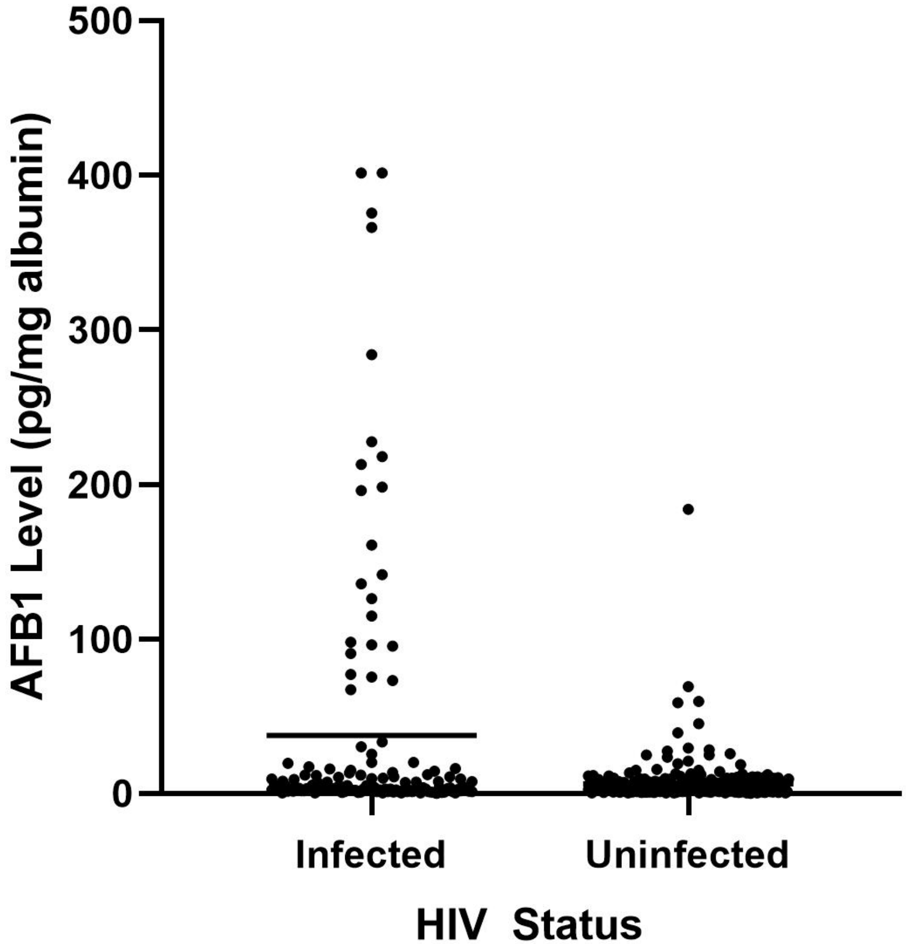
Jacqueline M. Lauer, Barnabas K. Natamba, Shibani Ghosh, Patrick Webb, Jia-Sheng Wang, Jeffrey K. Griffiths

DATA

Data for this study were collected from 2012 to 2013 as part of the *Prenatal Nutrition and Psychosocial Health Outcomes study* (i.e., PreNAPs).

- Observational, longitudinal cohort study designed to explore relationships among food access, nutritional and psychosocial exposures, and several physical and mental health outcomes in a sample of 403 HIV-infected (n = 133) and HIV-uninfected (n = 270) pregnant women in Gulu, northern Uganda (https://clinicaltrials.gov/ct2/show/NCT02922829)

Aflatoxin (AFB1) Levels by HIV Status



AFB1 AND GWG

		†,‡
Constant (β_0), starting weight	59.0 ± 0.6 kg	58.5 ± 0.7 kg
Effect of the time variable (gestational age; β_1), the rate of GWG	428.5 ± 24.9 g per week (<0.001)[*]	442.4 ± 24.6 g per week (<0.001)[*]
Effect of the quadratic term of the time variable (gestational age squared; β_2)	4.1 ± 0.7 g per week^2 (<0.001)[*]	4.1 ± 0.7 g per week^2 (<0.001)[*]
Effect of the AFB1 exposure (β_3) on starting weight	0.2 ± 0.3 kg (NS)	0.4 ± 0.3 kg (NS)
Effect of exposure on the effect of the time variable (β_4), differences in the rate of GWG	(−)20.4 ± 7.1 g per week (0.004)[*]	(−)16.2 ± 7.4 g per week (0.028)[*]
Effect of exposure on the quadratic term of time variable (β_5)	Not modelled	Not modelled

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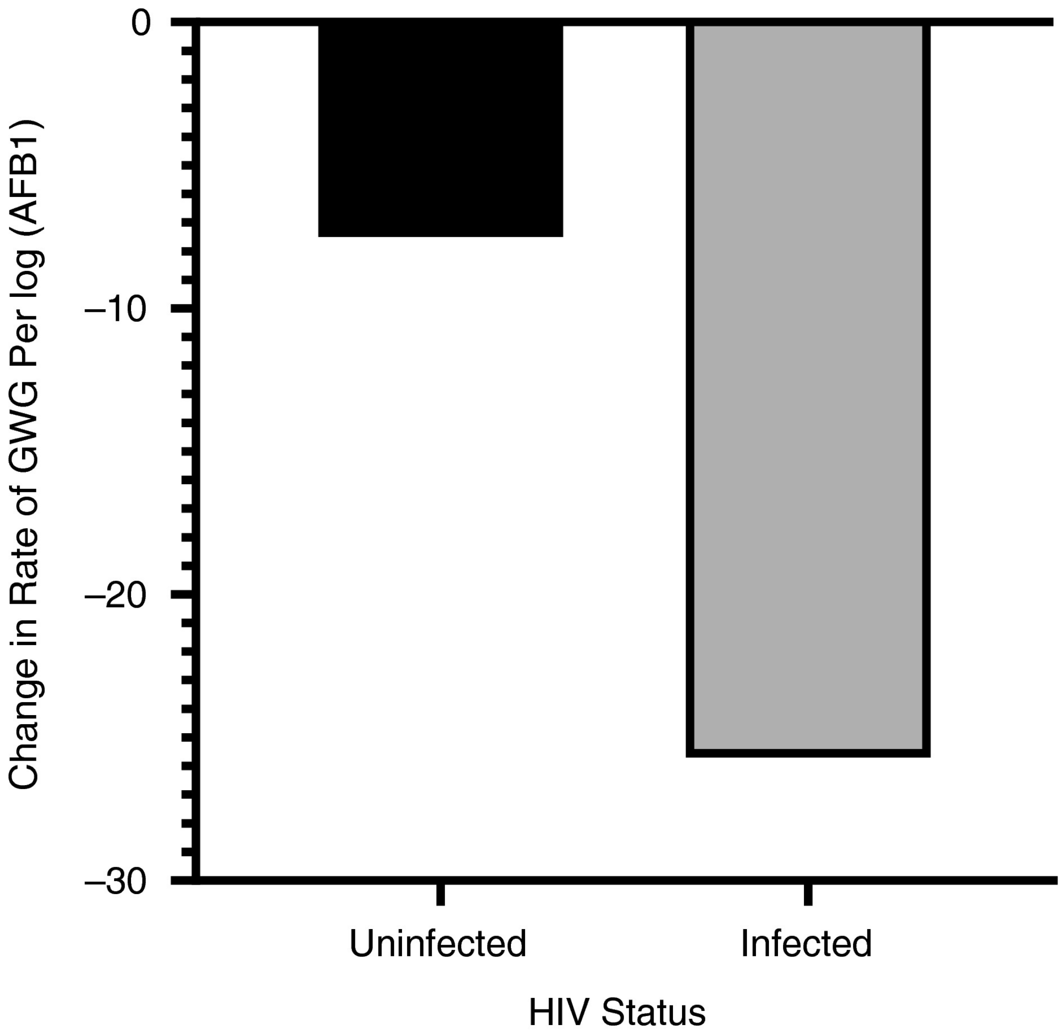
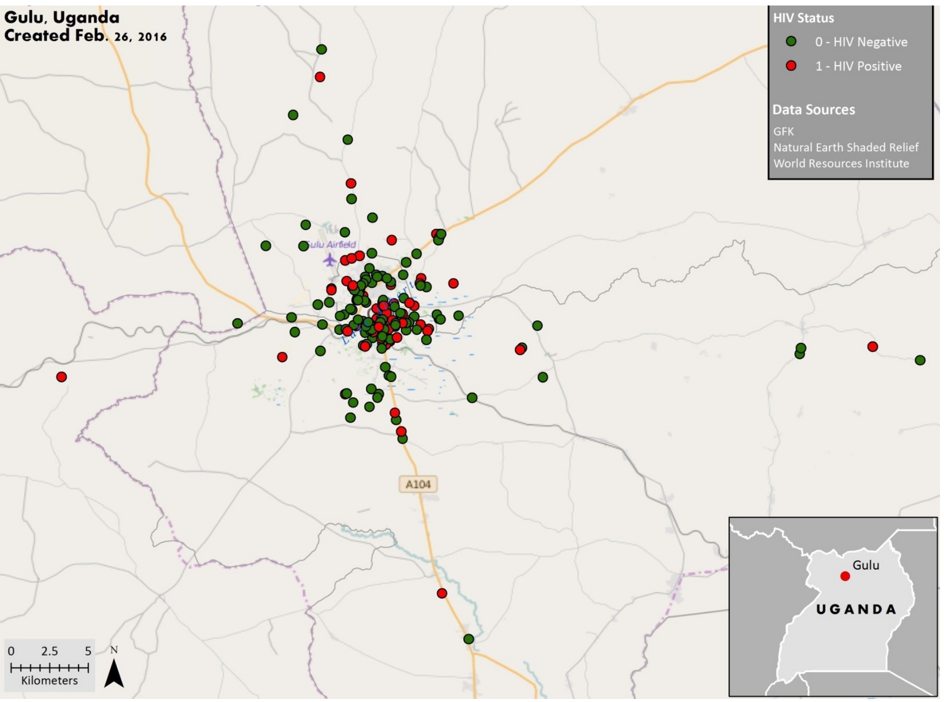
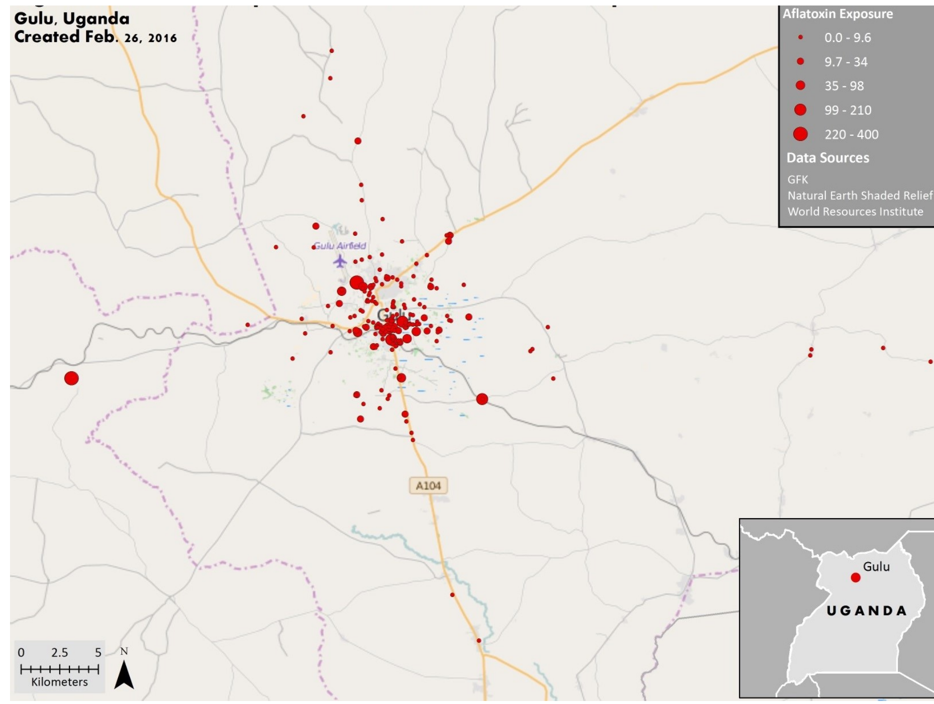
AFB1 Levels and Rate of Gestational Weight Gain



GIS ANALYSES





CONCLUSIONS

- Maternal aflatoxin exposure during pregnancy appears to have a small but significant effect on pregnancy and birth outcomes in Uganda, including GWG and infant WAZ/weight at birth.

- Maternal HIV infection-even seemingly well controlled-appears to exacerbate these effects, though unclear as to why.
  - Synergistic relationship between HIV and aflatoxin exposure with regard to immune suppression?
  - HIV's ability to impair liver function resulting in a decreased ability to detoxify toxic metabolites, including aflatoxins?

- Future studies: larger sample sizes, additional aflatoxins and fumonisins (AFB2, AFG1, AFM1, etc), HIV viral load data

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Assessing the relationship of serum aflatoxin levels and stunting in children 6-59 months of age in 10 districts of Nampula Province, Mozambique

Katherine Heneveld, MSc

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AFLATOXIN IN MOZAMBIQUE

- Previous assessment of crops and soil levels in Nampula province has shown aflatoxin contamination[1]
- Assessment of groundnuts sold in markets in Maputo found high levels of aflatoxin[2]
- Population highly dependent on commonly contaminated crops[1], such as maize, groundnuts, and cassava
- Little is known about infant and young child exposure to aflatoxins in Mozambique

[1] Probst, C., Bandyopadhyay, R., Cotty, P.J., 2014. Diversity of aflatoxin-producing fungi and their impact on food safety in sub-Saharan Africa. Int. J. Food Microbiol. 174, 113–122.
[2] Hlashwayo, D.F., n.d. Aflatoxin B1 contamination in raw peanuts sold in Maputo City, Mozambique and associated factors 10.

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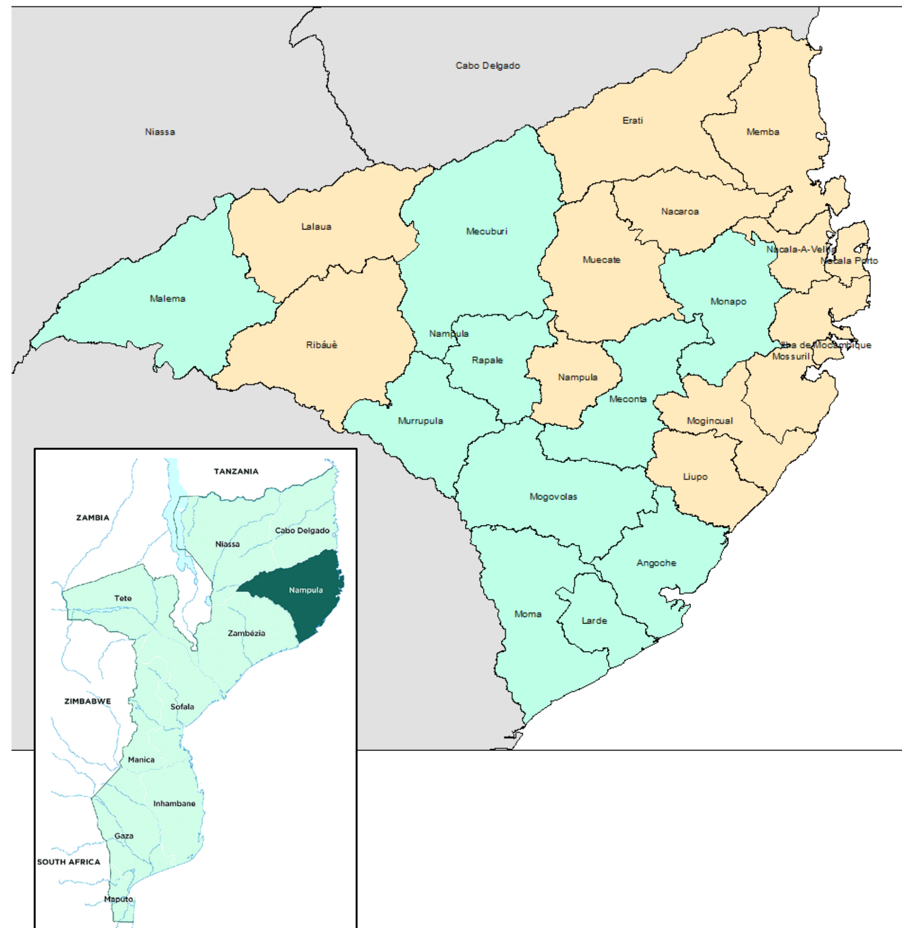
STUDY METHODS

- Cross-sectional, two groups (under 2 and 2-5 year olds)
- Sample size: 720 per age group (plus 25% attrition)
- Located in 10 Feed the Future Zone of Influence districts of Nampula (green districts in map)
- Sampling strategy:
  - Population proportional by district, random selection 2017 census INE enumeration areas
  - Random selection of households within EAs
- Representative of children 6-59 months of age in the 10 districts



DATA COLLECTION

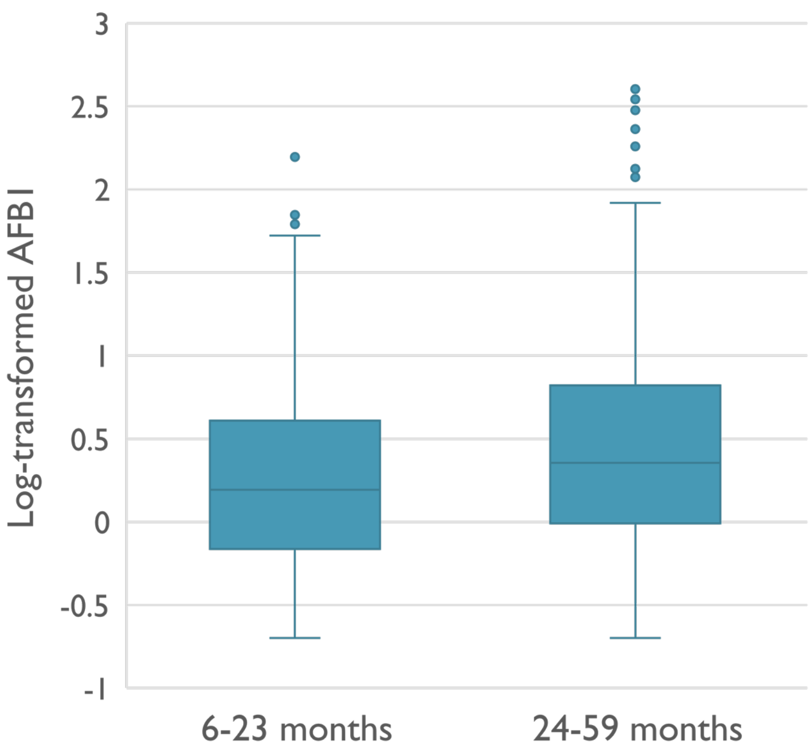
At the household:

- Caregiver questionnaire: diet recall, child morbidity, WASH practices, breastfeeding and complementary feeding practices
- Household head questionnaire: agricultural practices, socio-economic indicators

At the health clinic:

- Anthropometry measurements: weight, length/height, MUAC, head circumference, and knee-heel length
- Finger prick for anemia and malaria assessment
- Venous blood draw for aflatoxin assessment

AFLATOXIN BY AGE GROUP

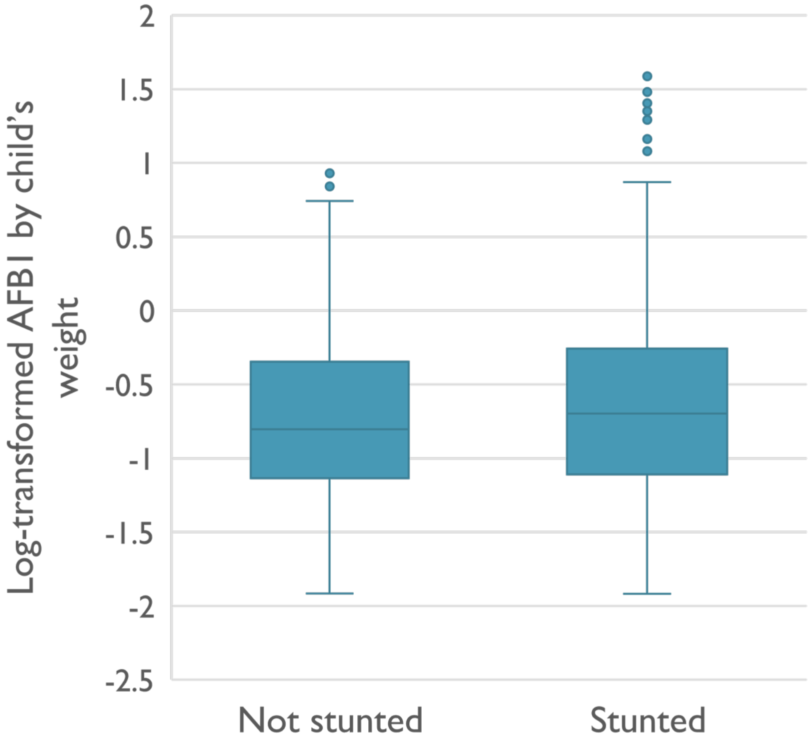


Age group	N	Mean ± SE	p-value
Children 6-23 months	311	0.24 ± 0.04	0.026
Children 24-59 months	583	0.37 ± 0.05	

AFLATOXIN AND STUNTING

A child was **60% more likely to be stunted** with every unit increase in logged aflatoxin level standardized by child's weight.

Logistic regression model adjusted for clustering, anemia, WHZ, age, age^2, sex, and detectable AFB1.



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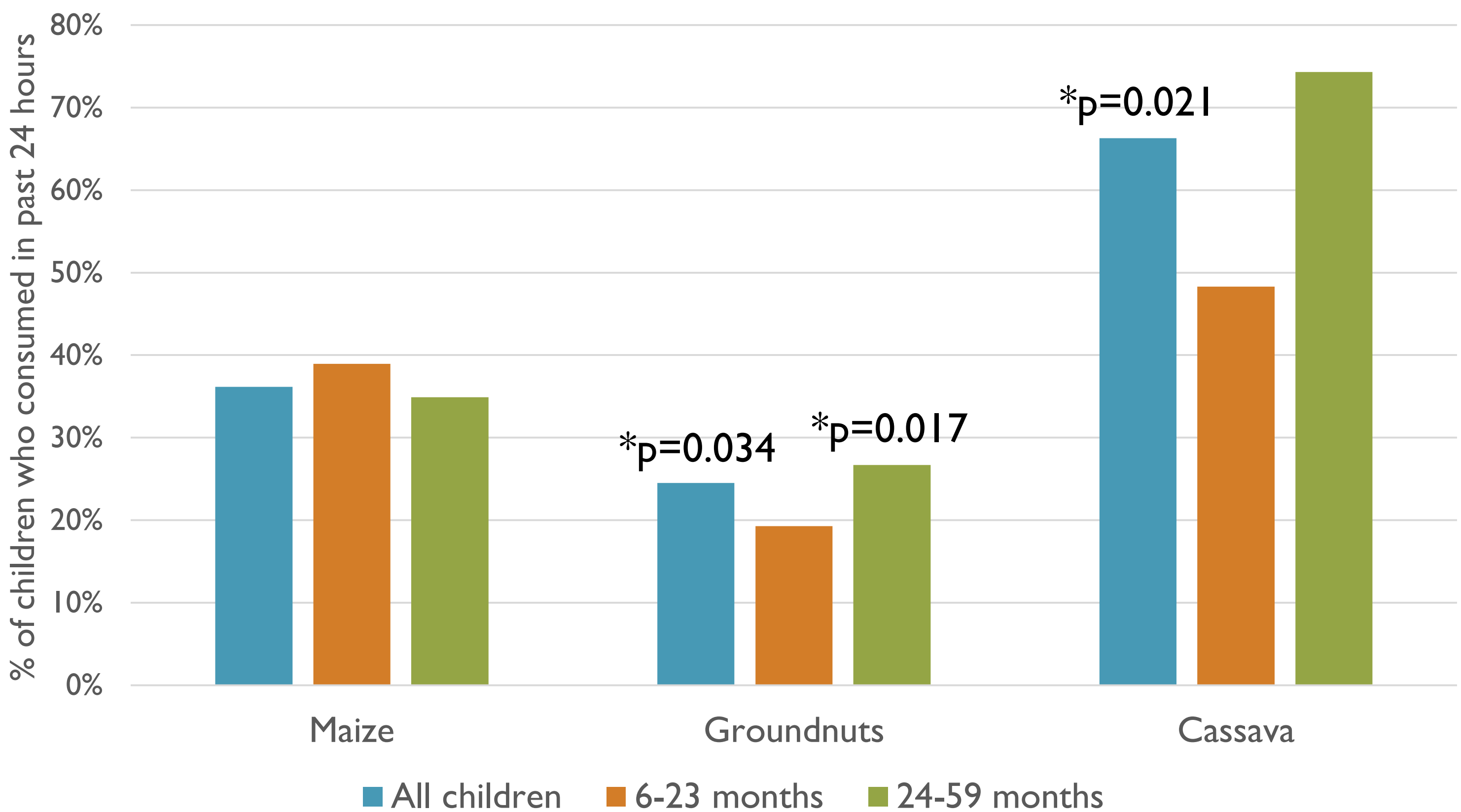
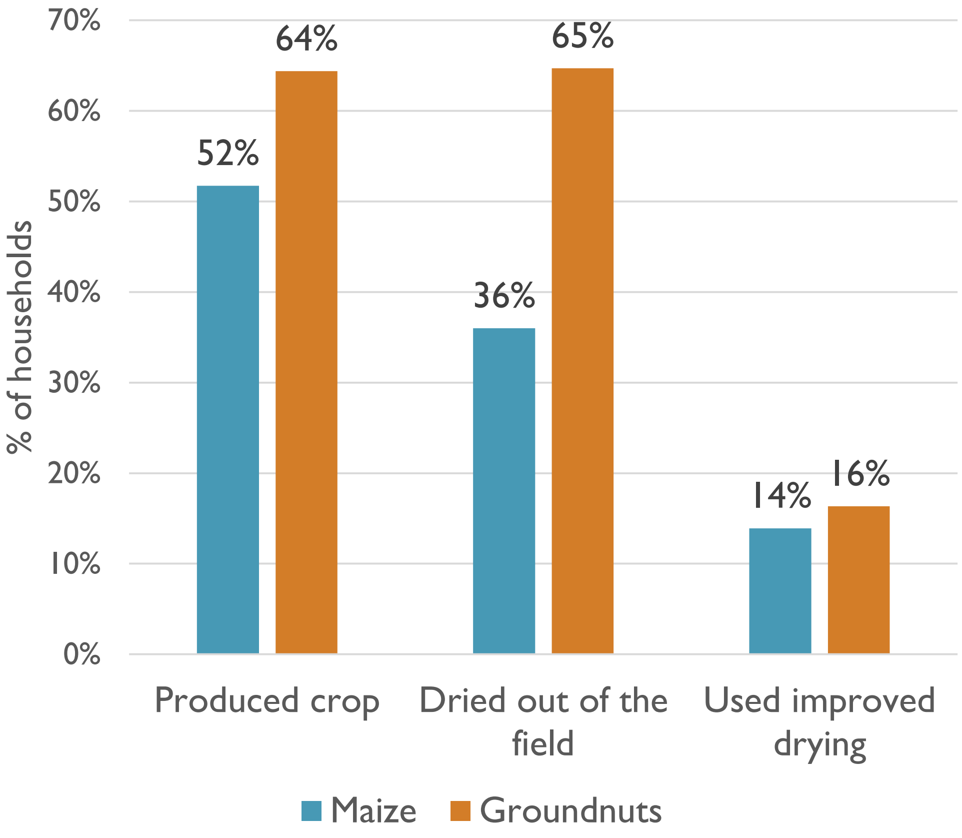
CONSUMING AFLATOXIN-PRONE FOODS



OLS model adjusted for clustering, WHZ, age, meeting minimum dietary diversity, wealth, and detectable AFB1.

AGRICULTURAL PRACTICES

- **Drying location**
  - In the field only
  - Outside of the field (includes those that also dried in the field)
- **Drying method**
  - **Improved methods**: with fans, on platforms or plastic sheets, hung under roof or in kitchen
  - **Unimproved methods**: drying only in the field, spreading directly on dirt, cement, or brick floor, or on roof



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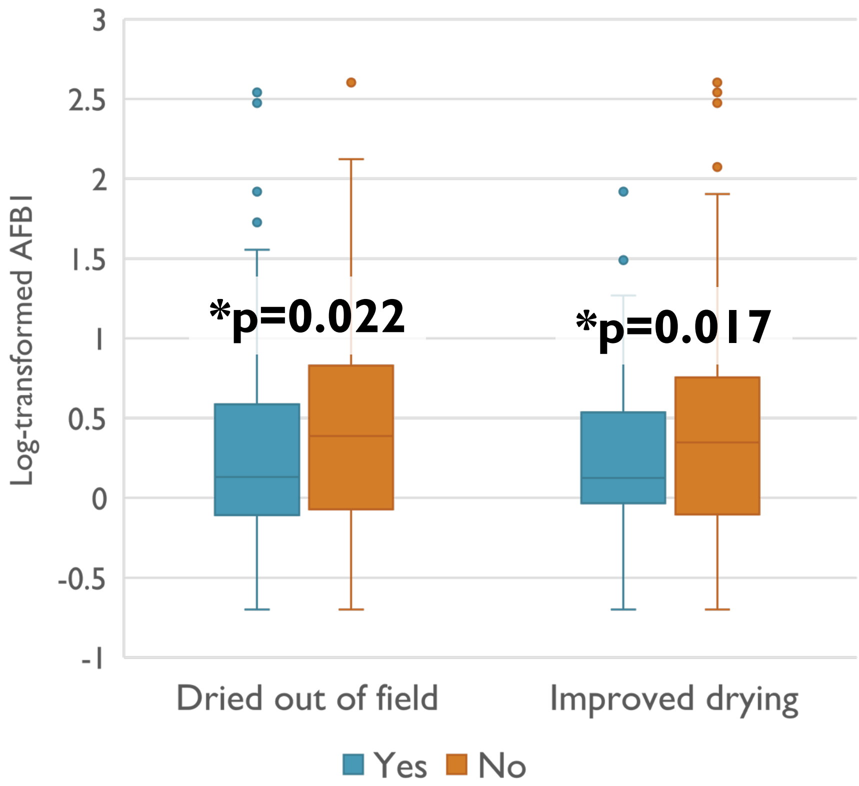
AFLATOXIN LEVELS AND AGRICULTURAL PRACTICES: MAIZE

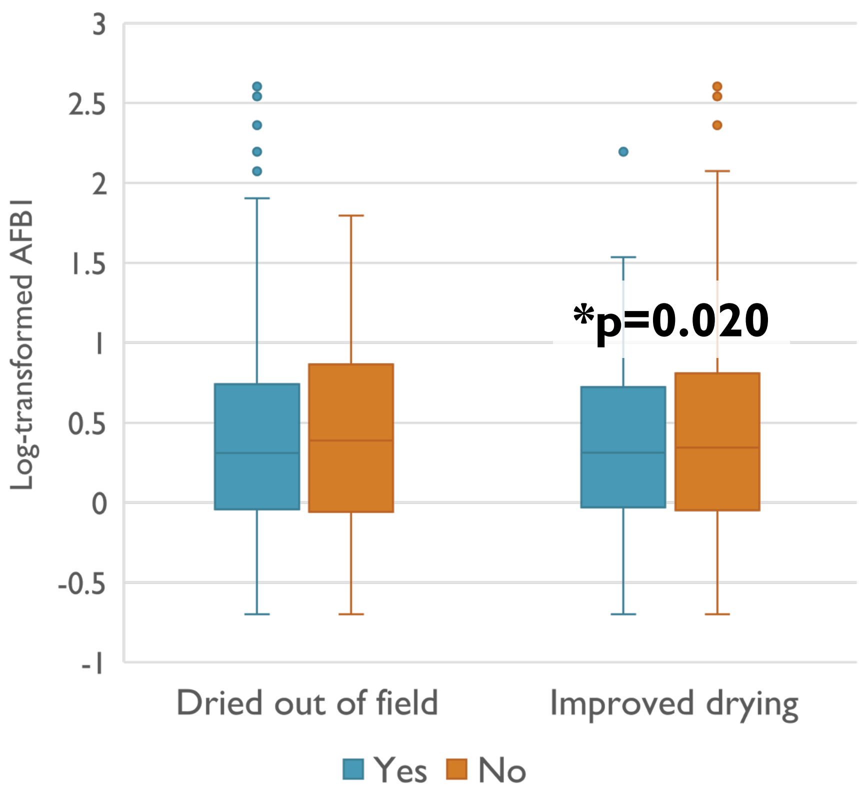


In maize-producing households, **lower aflatoxin levels were associated with**:

- Drying maize outside of the field (0.59 pg/mg albumin, p=0.022)
- Using improved drying methods (0.55 pg/mg albumin, p=0.017)

OLS models adjusted for clustering, age, household head's education level, and inter-cropping.

AFLATOXIN LEVELS AND AGRICULTURAL PRACTICES: GROUNDNUTS



Children in groundnut-producing households with **improved drying methods had lower aflatoxin levels** (0.64 pg/mg albumin, p=0.020) compared to those in households with unimproved methods

OLS models adjusted for clustering, age, household head's education level, and inter-cropping.

CONCLUSIONS

- Detectable levels of aflatoxin in 90% of the children in the study
- High levels of anemia, malaria, and stunting
- Association between stunting and aflatoxin
  - Stronger relationship in older children
  - Complex relationship (age and body weight)
- Dietary consumption of groundnuts and cassava linked to aflatoxin
- Households with improved agricultural practices on maize and groundnuts linked to lower aflatoxin levels

FUTURE RESEARCH

- Several initiatives targeting aflatoxin in different crops in Mozambique (particularly groundnut)
- The potential of cassava being a source of contamination
- Study focused on rural areas – better understanding of exposure in urban areas is needed
- What is the relationship between aflatoxin exposure and linear growth in Mozambique?

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Serum aflatoxin, length and length for age Z-score in Nepal and Timor Leste

Shibani Ghosh, PhD and Johanna Andrews Trevino, PhD

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BACKGROUND

- Stunting rates are still high in Nepal and Timor Leste – 36% (2016) and 51% (2013) respectively (https://data.worldbank.org)
- In Nepal, aflatoxin contamination has been found
  - 1/3 of food samples collected contaminated with aflatoxin.
  - The highest contamination in peanut butter and vegetable oil (42.5%) (Koirala 2005)
- Detection of aflatoxin in placenta and in offspring at 2 years of age in Nepal (*Groopman et al. 2014 Food and Chemical Toxicology 74*)
- No association between aflatoxin-stunting relationship in older children in peri-urban Nepal (*Mitchell et al. 2016, Journal of Exposure Science and Environmental Epi, 1-6*)

BACKGROUND

- Only one study has examined aflatoxin contamination and exposure in Timor Leste *(Almeida et al 2019, Scientific Reports)*
  - Assessed locally produced maize and groundnuts found about 11% of maize and 12% of groundnut samples had aflatoxin levels higher than EU cutoffs
  - Utilized aflatoxin data from the Timor Leste national survey which found 80% detection rate

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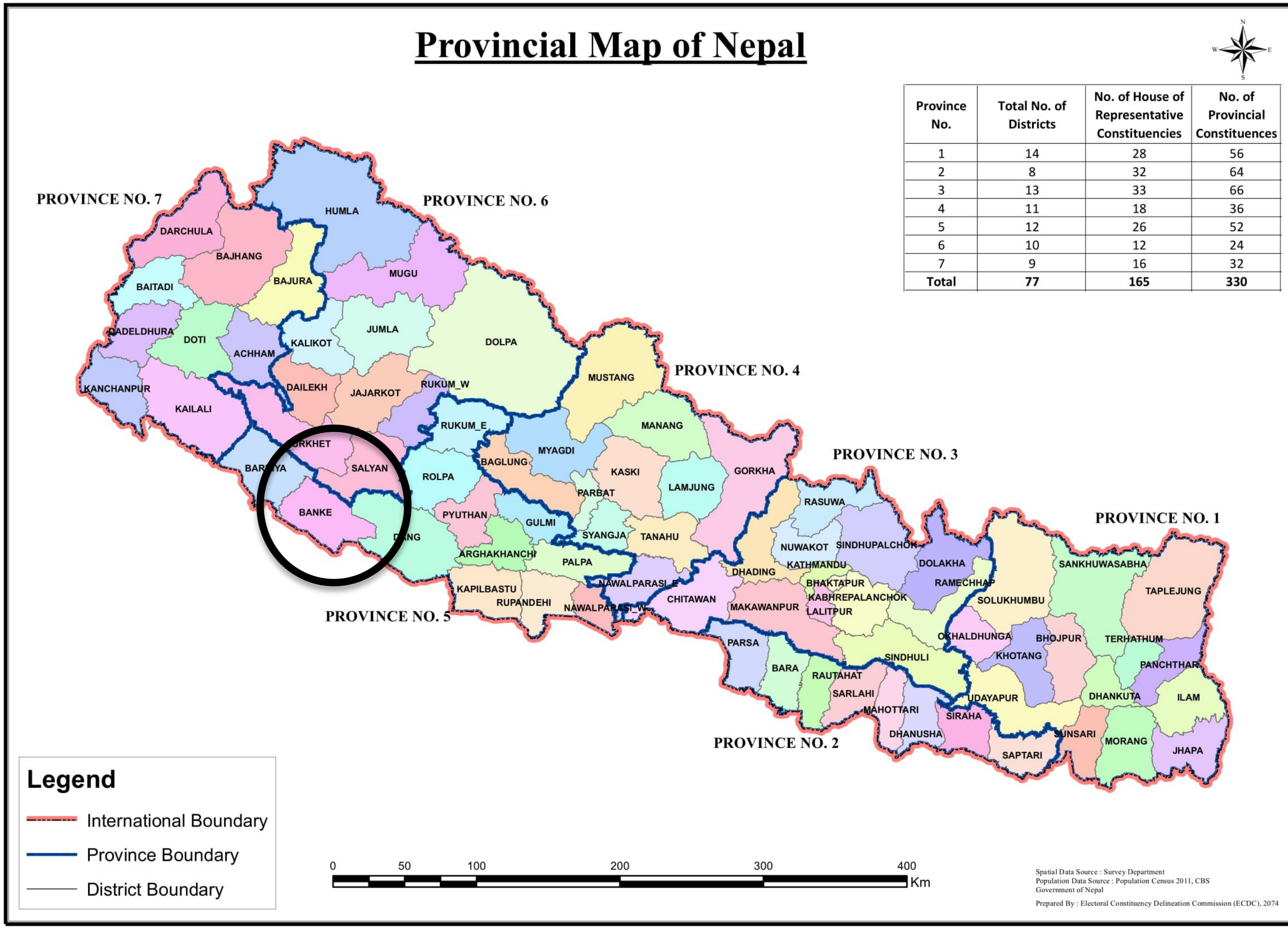
AFLACOHORT STUDY

- Observational Birth Cohort Study
- Location: Banke District of Nepal
- n=1,675 mother-infant dyads



Province No.	Total No. of Districts	No. of House of Representative Constituencies	No. of Provincial Constituencies
1	14	28	56
2	8	32	64
3	13	33	66
4	11	18	36
5	12	26	52
6	10	12	24
7	9	16	32
Total	77	165	330

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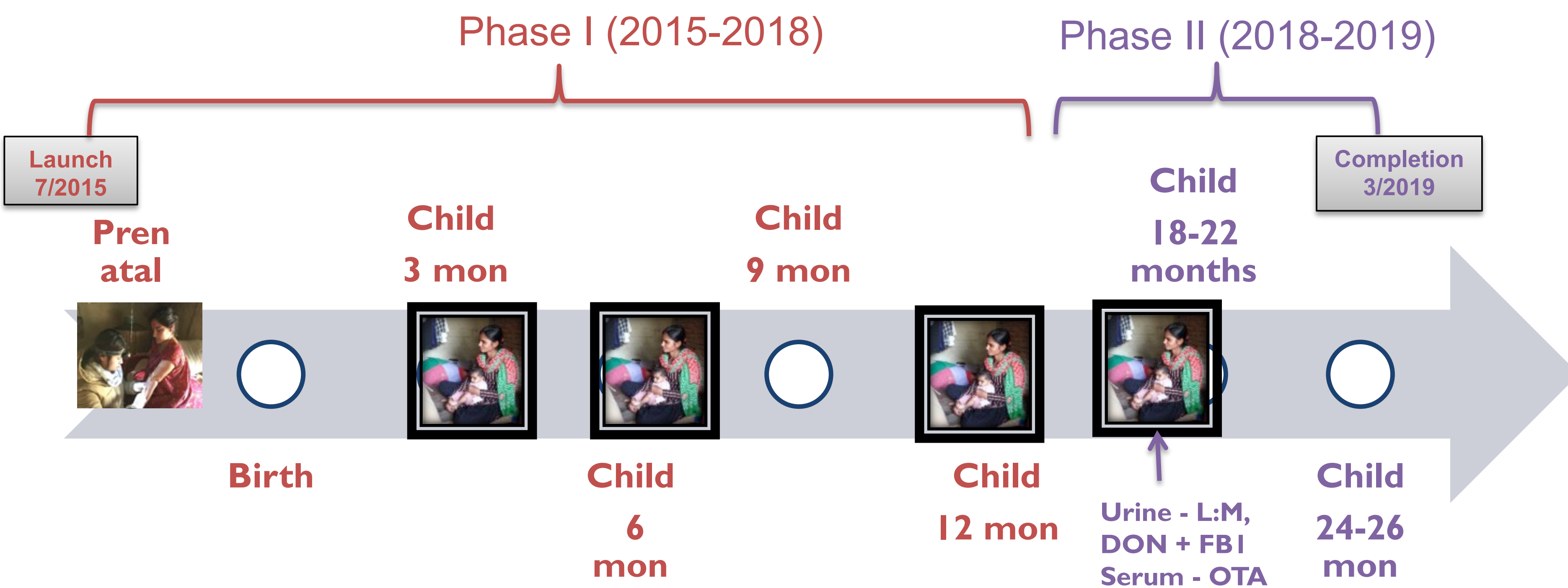
AflaCohort Study (2015-2019)



n=1675 mother-infant dyads;

L:M: lactulose:mannitol; DON: Deoxynivalenol; FB1: Fumonisin B1; OTA: Ochratoxin A

SERUM AFLATOXIN B1 CONCENTRATIONS

	n	Detectable AFB1-lys adduct (%)	Mean ± SD AFB1-lys adduct (pg/mg alb)*	Geometric mean (CI) AFB1-lys adduct (pg/mg alb)*	Min	Max
Pregnancy	1652	94.3	3.4 ± 8.5	1.5 (1.5,1.6)	0.4	147.3
Child 3 months	1363	80.5	1.0 ± 1.1	0.8 (0.8, 0.9)	0.4	24.7
Child 6 months	1294	75.3	1.2 ± 2.1	0.9 (0.8, 0.9)	0.4	41.6
Child 12 months	1329	81.1	2.0 ± 4.6	1.1 (1.0,1.1)	0.4	84.6
Child 18-22 months	699	85.1	2.4 ± 7.9	1.3 (1.2,1.4)	0.4	128.1

* Detectable only; alb: albumin; mg: milligrams; min: minimum; mo: months; n: samples size; pg: picograms

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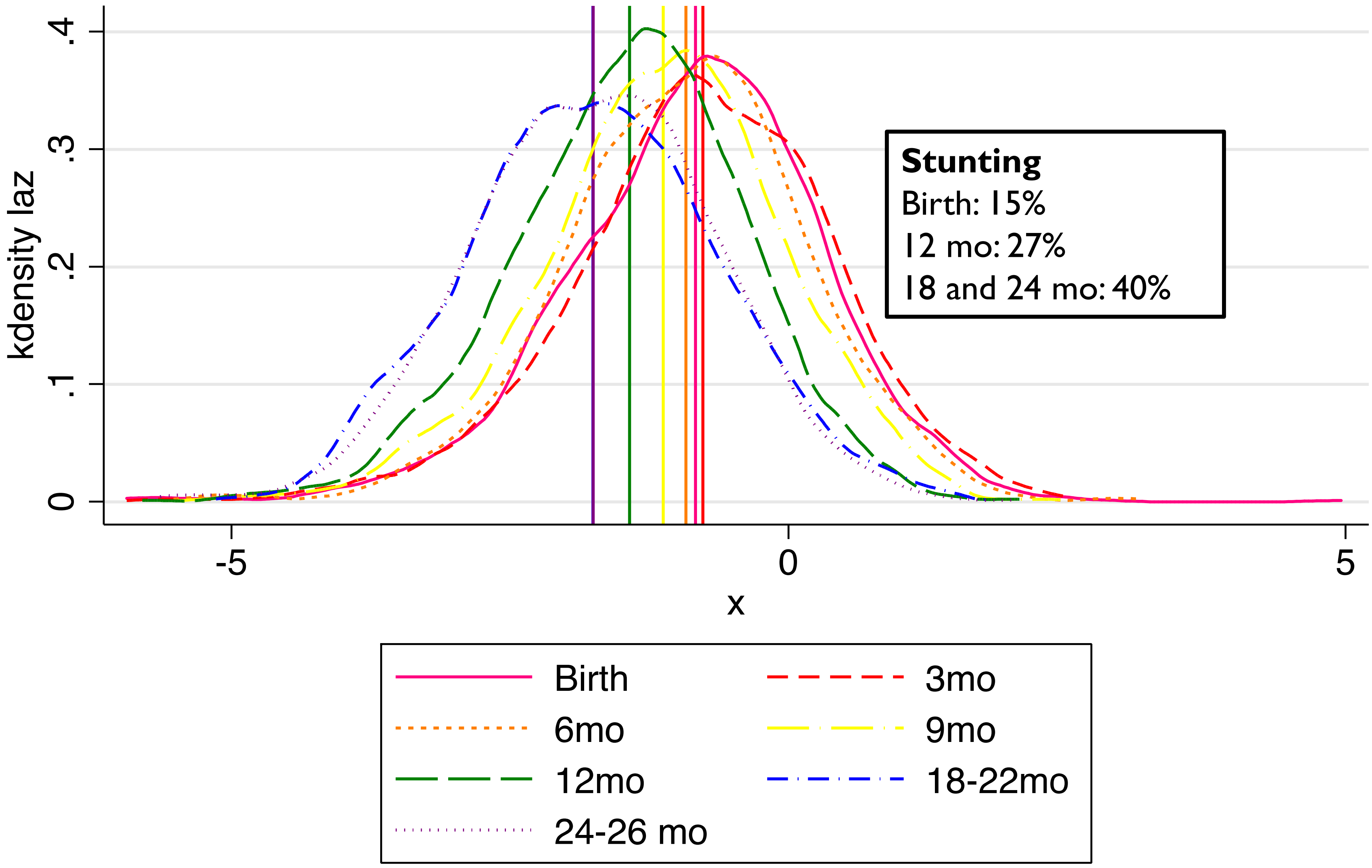

GESTATIONAL AFB1 AND BIRTH OUTCOMES

Variable	Adjusted Model [1]
Low birth weight [2]	1.10 (0.97-1.27)
Small-for-gestational-age [3]	1.13 (1.00-1.27)*
Stunting at birth [4]	0.99 (0.85-1.16)
Preterm birth [5]	0.98 (0.83-1.15)

Values are odds ratio (95% confidence interval); [1] Adjusted logistic regression models controlled for maternal education, hemoglobin, stature, parity, MUAC, diet, ANC visits, tobacco use, wealth index, VDC, trimester, and birth month; [2] n=1444, Adjusted Pseudo R2 = 0.1455; [3] n=1348, Adjusted Pseudo R2 = 0.0832; [4] n=1443, Adjusted Pseudo R2 = 0.1084; [5] n=1529, Adjusted Pseudo R2 = 0.1313

Relatively low maternal aflatoxin exposure is associated with small-for-gestational-age but not with other birth outcomes in a prospective birth cohort study of Nepali infants

Andrews-Trevino et al. (2019) Journal of Nutrition

AFB1 AND GROWTH (3 MONTHS - 22 MONTHS)

	Length (cm) β	LAZ β	Stunting Odds Ratio
(Ln) aflatoxin B1-lysine adduct [1]	-0.19 -0.29, -0.09)**	-0.05 -0.09, -0.02)**	1.34 (1.02, 1.77)*
(Ln) aflatoxin B1-lysine adduct/kg weight [2]	-0.26 -0.33, -0.18)**	-0.08 -0.11, -0.05)**	1.27 (1.02, 1.59)*

Child-level fixed effects models, children ages 3-22 months; cm: centimeter; LAZ: length-for-age z-score; Ln: natural log; [1] Adjusted for age, season of measurement, detectable AFB1 concentrations [2] Adjusted for age, weight-for-length z-score, season of measurement, detectable AFB1 concentrations

*p<0.05, ** p<0.01, *** p<0.001

Significant negative association between AFB1 concentrations, length, LAZ and odds of stunting

Andrews-Trevino et al. (2020) "Aflatoxin exposure and child nutrition: measuring anthropometric and long-bone growth over time in Nepal" – Submitted to AJCN

AFB1 AND GROWTH (3 MONTHS - 22 MONTHS)

	WAZ	WLZ
(Ln) aflatoxin B1-lysine adduct [1]	-0.038*** (-0.071, -0.005)	-0.013 (-0.055, 0.031)

Child-level fixed effects models, children ages 3-22 months; WAZ: weight-for-age z-score; WLZ: weight-for-length z-score; Ln: natural log;

[1] Adjusted for age, season of measurement, detectable AFB1 concentrations
*p<0.05, ** p<0.01, *** p<0.001

Andrews-Trevino et al. (2020) "Aflatoxin exposure and child nutrition: measuring anthropometric and long-bone growth over time in Nepal" – Submitted to AJCN

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DIET AND AFB1-LYSINE ADDUCTS IN PREGNANT WOMEN

	OLS	Q10	Q30	Q50	Q70	Q90
Maize consumption [b]	0.549 (0.281)	0.091 (0.054)	0.094 (0.041)	0.112* (0.051)	0.109* (0.048)	0.147 (0.111)
Groundnut consumption [b]	0.730*** (0.121)	0.037 (0.027)	0.058*** (0.016)	0.085** (0.026)	0.133*** (0.026)	0.133*** (0.030)
Milk consumption [c]	0.906 (0.799)	0.630** (0.221)	0.194 (0.108)	0.230* (0.106)	0.173 (0.128)	0.066 (0.244)
Dietary diversity score	-0.229 (0.149)	0.064* (0.029)	0.004 (0.020)	0.008 (0.018)	-0.012 (0.026)	-0.057 (0.053)
Winter	2.339*** (0.430)	0.313** (0.091)	0.460*** (0.059)	0.552*** (0.066)	0.623*** (0.085)	1.101*** (0.130)
Model Adjusted R^2	0.0639	0.0539	0.0698	0.0801	0.1010	0.1367

Diet-associated aflatoxin exposure in these women driven by groundnut and maize consumption.

Dietary diversity score showed no significant association with average maternal aflatoxin exposure.

Andrews-Trevino et al. (2019) "Dietary determinants of aflatoxin B1-lysine adducts in pregnant women consuming a rice-dominated diet in Nepal" – European Journal of Clinical Nutrition

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SOURCES OF AFLATOXIN-PRONE FOODS

	n	%	AFB1 (pg/mg)[a]	Adjusted β
MAIZE				
Did not consume	280	17.0	3.2 (7.4)	-
In-kind only	568	34.6	2.4 (5.4)	REF
Home production only	396	24.1	**4.1 (11.2)**	**0.24****
Market only	389	23.7	**3.5 (8.8)**	**0.22****
Home production and market	11	0.7	3.3 (4.9)	0.10
GROUNDNUTS				
Did not consume	45	2.7	2.3 (4.0)	-
In-kind only	59	3.6	2.5 (4.6)	REF
Home production only	25	1.5	**1.6 (3.3)**	**-0.35**
Market only	**1505**	91.4	**3.3 (8.6)**	**0.03**
Home production and market	12	0.7	**2.3 (2.1)**	**0.13**
CHILIES				
Did not consume	4	0.2	0.7 (0.3)	-
In-kind only	**23**	**1.4**	**6.9 (16.3)**	REF
Home production only	37	2.3	3.2 (6.4)	-0.59
Market only	**1524**	**92.6**	**3.1 (7.3)**	**-0.50**
Home production and market	58	3.5	5.7 (19.9)	-0.42

Receiving in-kind food and a high reliance on market-purchased food limits consumers' information on the quality and safety of the food consumed.

Andrews-Trevino et al. Relationship of Postharvest practices and serum aflatoxin levels in pregnant women in the mid-western Terai region of Nepal

SOURCES OF AFLATOXIN-PRONE FOODS

A very small percentage of households relied on self-production of aflatoxin-prone foods; off-farm food acquisition was common

Corn

- 17% did not consume
- 24% market
- 35% in-kind
- 24% home-produced
- <1% market & home-produced

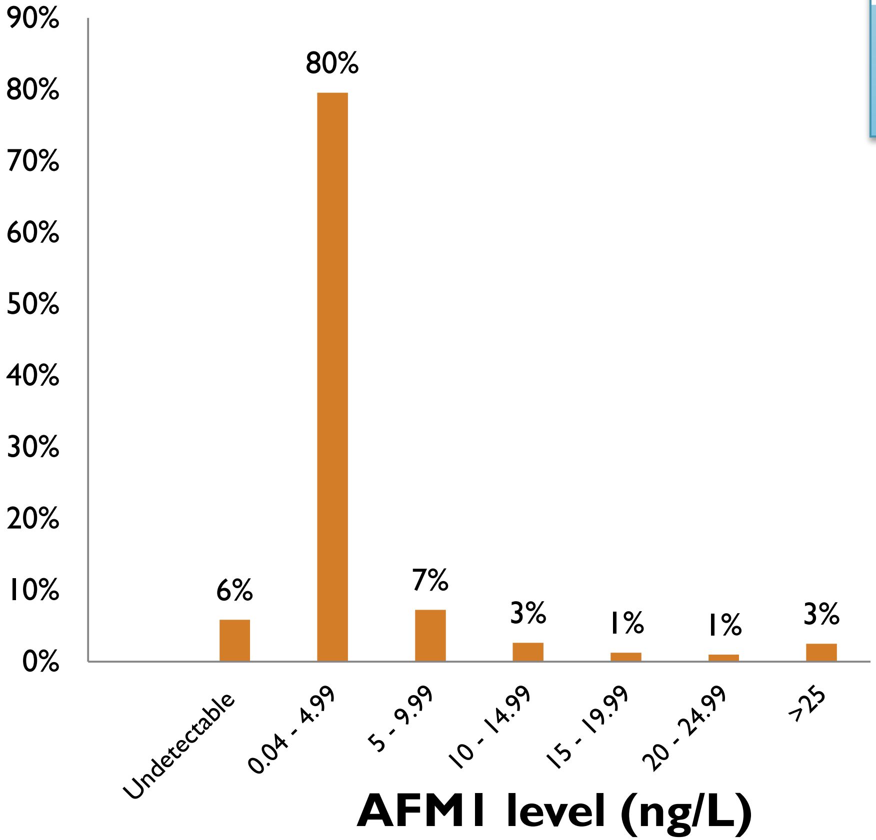
Peanuts

- 3% did not consume
- 91% market
- 4% in-kind
- <2% home-produced
- <1% market & home-produced

Chilies

- <1% did not consume
- 93% market
- 1% in-kind
- 2% home-produced
- 4% market & home-produced

AFM1 IN BREAST MILK



Mean ± SD	4.46 ± 18.8 ng/L
Geometric Mean (95% CI)	0.78 ng/L (0.71, 0.86)

- Yogurt, milk, hydrogenated oil and ripe pumpkin were positively associated with AFM1 concentrations
- Legumes were negatively associated with AFM1 concentrations
- Significantly higher AFM1 concentrations in winter compared to spring months

Pokharel et al- Draft Manuscript

DIETARY DETERMINANTS OF SERUM AFB1 IN THE CHILD AT 12 MONTHS

Diet at 9 months, serum aflatoxin at 12 months

Positive Association

- Large fish
- Infant formula
- Groundnut
- Cauliflower

Diet at 12 months, serum aflatoxin at 12 months

Positive Association

- Large fish
- Groundnut

Negative Association

- Banana
- Mango

Models (OLS and Quantile regression) adjusted for: mother's age, mother's education, wealth index, seasonality and VDCs; Clustered standard errors used for VDC clusters in all the models

Lamichhane et al – Draft manuscript

MYCOTOXIN EXPOSURE, CHILD 18-22 MO

	n	Detectable (%)	Min	Max	Average mean (SD)	Geometric mean (CI)
Aflatoxin B1, (pg/mg albumin)	699	595 (85)	0.40	128.1	2.4 (7.88)	1.3 (1.2, 1.4)
Ochratoxin A, ng/mL	699	699 (100)	0.02	44.5	0.48 (1.82)	0.31 (0.29, 0.33)
Fumonisin B1, pg/mg creatinine	683	683 (100)	6.57	132,373	2,594 (9,756.7)	192.1 (163.7, 225.3)
DON ng/mg creatinine	685	596 (87)	0.04	129.9	0.78 (5.42)	0.31 (0.28, 0.33)

TIMOR-LESTE AFLATOXIN SURVEY

- TLFNS: Timor-Leste Food and Nutrition Survey: Quantitative national level household survey (2014)
- Children 6 - 59 months and non-pregnant mothers were included in the biochemical study
- Anthropometric measurements were converted to z-scores using the 2006 WHO growth reference
- AFB1-lysine adduct data
  - Log-transformed for statistical analyses
  - Undetectable serum AFB1 values were set to half the LOD (i.e. 0.1 pg/mg AFB1-lysine adduct)
  - Dummy variable created for detectable versus undetectable

SERUM AFB1 CONCENTRATIONS - CHILD

	n	Detectable (%)	Mean ± SD (pg/mg alb)*	Geometric mean (CI) (pg/mg alb)*	Min	Max
Serum AFB1-lys adduct	513	83.2	1.4 ± 3.5	0.6 (0.6, 0.7)	0.2	37.0

* Detectable only; alb: albumin; mg: milligrams; min: minimum; n: samples size; pg: picograms

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AFB1 AND GROWTH

Variable	LAZ	Stunting
(Ln) aflatoxin B1-lysine adduct [1]	-0.13* (-0.22, 0.03)	1.58 (0.94, 2.64)
(Ln) aflatoxin B1-lysine adduct/kg weight [2]	-0.26** (-0.36, -0.16)	1.92* (1.18, 3.10)
Weighted multivariable linear and logistic regressions; LAZ: length-for-age z-score; Ln: natural log; [1] Adjusted for age, aldeia, wealth quintile, detectable AFB1 concentrations [2] Adjusted for age, WLZ, aldeia, wealth quintile, detectable AFB1 concentrations		

Significant negative association between AFB1 concentrations adjusted for weight and LAZ

Higher AFB1 concentrations adjusted for weight associated with increased odds of stunting

CONCLUSIONS

- Levels of aflatoxin are low in both Nepali and Timor-Leste populations (compared to Sub-Saharan Africa
- Levels get higher as children get older and exposure is ubiquitous with no difference by SE status, education or location
- Existing weight status and its relationship with aflatoxin- better understanding of the role of body composition
- Low levels of exposure in pregnancy increases the risk of small for gestational age
- There is a longitudinal relationship between aflatoxin exposure in early life and linear growth (negative) and stunting (positive)
- Aflatoxin exposure reflects consumption of various aflatoxin-prone foods from multiple sources (self-production vs. market purchases) (Nepal)

FUTURE RESEARCH

- Entry points for intervention - context specific intervention studies to reduce aflatoxin contamination in the food system and their effects on nutritional status and health of vulnerable populations
- Understand relationship of of co-exposure with other mycotoxins and child growth
- Assess the role of body composition (weight as a proxy for fat versus lean mass?)
- Test associations between aflatoxin, other mycotoxins, inflammation and environmental enteric dysfunction (EED)
- Relationship between aflatoxin exposure and cognitive function
- Assess the long-term effects of low levels of chronic exposure to aflatoxins

ONGOING WORK

- Relationship between EED, mycotoxins and cognitive development (Nepal)
- Aflatoxins at birth (in mothers) and birth outcomes (Uganda)
- Longitudinal analysis of growth in Ugandan infants, inflammation and aflatoxin exposure (Uganda)
- Correlation of aflatoxin in food with biomarkers in blood and growth outcomes
- Relationship between agricultural practices and food aflatoxin exposure

In collaboration with FTF Innovation Lab for Reduction of Post Harvest Loss

POLICY IMPLICATIONS

- Chronic exposure to different mycotoxins in pregnancy and early life: public health implications
- Agricultural, post harvest interventions and policies targeting aflatoxin may want to consider the health effects in vulnerable populations such as infants and young children
- Little is known about what happens with chronic low-level exposure to a single or multiple mycotoxins
- All regulatory focused research utilizes acute exposure as a metric for setting cutoffs

POLICY IMPLICATIONS

- Understand and contextualize aflatoxin exposure through different foods at the household and in markets (e.g. cassava, chilies)
- The role of markets and addressing gaps in a ensuring a clean, safe and nutritious food supply is critical

  Poor handling and storage practices of commodities outside the household need to be understood and documented

- Going beyond aflatoxin mitigation of maize and groundnuts on and off farm
- Emphasizes the need for enhancing multi-sectoral collaboration and a food systems approach towards aflatoxin mitigation in order to improve health and well being, economy, productivity and self reliance

Q&A

THANK YOU

- August 19th 9:00am-10:30am EDT, "**WASH, Environmental Enteric Dysfunction and Nutritional Status of Infants and Young Children**."
- To register for any of these events, you can visit **NutritionInnovationLab.org** or **AdvancingNutrition.org**.
- Recordings and slides for each webinar will also be posted on our websites.

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