



FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

A photograph of a rural landscape. In the foreground, there is a field of young green plants in reddish-brown soil. Behind the field, there are several traditional huts with thatched roofs and walls made of mud or clay. A line of green trees separates the huts from the background. In the background, there are large, steep, rocky mountains under a blue sky with white clouds.

Innovation Lab for Nutrition Annual Report October 1st, 2018 - September 30th, 2019

Building the evidence base for policies
that leverage agriculture for nutrition

Award
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Feed the Future Innovation Lab for Nutrition

U.S. Government Partners



Feed the Future Innovation Lab for Nutrition's Global and Local Partners



**Feed the Future Innovation Lab for Nutrition
Annual Report
Fiscal Year 2019 (Year 9)**

Management Entity Information

Tufts University's Friedman School of Nutrition Science and Policy is the Management Entity (ME) for the Feed the Future Innovation Lab for Nutrition (hereafter called the Nutrition Innovation Lab). The Nutrition Innovation Lab's core activities are funded under cooperative agreement AID-OAA-L-1000006 from the United States Agency for International Development (USAID). Additional work is funded through USAID mission Associate Awards or Buy-Ins and with funding from other donors.

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Map of Focus Countries



Country Index

-  Priority Countries: Bangladesh, Malawi, Nepal, Uganda, Mozambique
-  Countries with Supported Research: Egypt, Ethiopia, Ghana, Kenya, Mali, Tanzania, Timor Leste, Sierra Leone

List of partners

US Consortium Partners

Johns Hopkins University
Harvard T.H. Chan School of Public Health
Boston Children's Hospital
Purdue University
Tuskegee University
Cornell University

Other US Partners

Baylor College of Medicine
Georgia State University
Feed the Future Innovation Lab for Peanut Productivity and Mycotoxins (University of Georgia)
Feed the Future Innovation Lab for Horticulture Innovation Lab (University of California, Davis)
Feed the Future Innovation Lab for Livestock Systems, (University of Florida)
Feed the Future Innovation Lab for Post-Harvest Loss (Kansas State University)
Feed the Future Innovation Lab for Soybean (University of Illinois)

Nepal-Based Partners

Family Welfare Division, Ministry of Health and Population
National Planning Commission
Tribhuvan University/Institute of Medicine (IOM)
Patan Academy of Health Sciences (PAHS)
Nepali Technical Assistance Group (NTAG)
Helen Keller International (HKI/Nepal)
Save the Children/Nepal
Center for Molecular Dynamics Nepal (CMDN)
National Agricultural Research Council (NARC)
Heifer/Nepal
Valley Research Group (VaRG)

Uganda-Based Partners

Makerere University
International Food Policy Research Institute, Uganda (IFPRI-Uganda)
Mukono Hospital
Gulu University
National Agricultural Research Organization (NARO)

Bangladesh-Based Partners

WorldFish (Bangladesh)
Dhaka University (Bangladesh)
Bangladesh Agriculture University
Helen Keller International (HKI/Bangladesh)
CSISA-Cereal Systems Initiative of South Asia (CIMMYT/Bangladesh)

Malawi-Based Partners

Lilongwe University of Agriculture and Natural Resources (LUANAR)
University of Malawi, College of Medicine (COM)
South African Medical Research Council (SAMRC)
Food and Nutrition Technical Assistance (FANTA)

Ministry of Health (MoH)
University of Cape Town (UCT)

Mozambique-Based Partners

Institute of Public Health (Ministry of Health)
University of Lúrio (UniLúrio), Nampula
ANSA (Association for Food and Nutrition Security)
Institute of Statistics (INE)

Egypt-Based Partners

El Zanaty & Associates
GOTHI, Viral Hepatitis Research Laboratory (VHRL)

Ethiopia-Based Partners Addis

Continental Institute of Public Health (ACIPH)

Tanzania-Based Partners

Ifkara Health Institute
Sokoine University

Ghana-Based Partners

University of Ghana- Legon

Other International Partners

Leverhulme Centre for Integrative Research on Agriculture and Health-
University of London (LCIRAH) (UK)
London School of Hygiene and Tropical Medicine (UK)
University of Reading (UK)
UNICEF
Save the Children (SAVE)
Heifer International
Helen Keller International
University of Indonesia-Jakarta
St. John's Research Institute (Bangalore, India)

Acronyms

AAEA	Agricultural & Applied Economics Association
ANSA	Association for Food and Nutrition Security (Mozambique)
AAMA	Action Against Malnutrition through Agriculture
BBNC	Bangalore Boston Nutrition Collaborative
BIFAD	Bureau for International Food, Agriculture and Development
CSISA	Cereal Systems Initiative of South Asia
CIMMYT	International Maize and Wheat Improvement Center
EED	Environmental Enteric Dysfunction
FTF	Feed the Future
GAIN	Global Alliance for Improved Nutrition
HKI	Helen Keller International
IFPRI	International Food Policy Research Institute
INGO	International Non-Governmental Organization
IOM	Institute of Medicine (Nepal)
JHBSP	Johns Hopkins Bloomberg School of Public Health
LCIRAH	Leverhulme Centre for Integrated Research on Agriculture and Health
LSHTM	London School of Hygiene and Tropical Medicine
LSIL	Livestock Systems Innovation Lab
NGO	Non-Governmental Organization (or private voluntary organization)
NASA	National Aeronautics and Space Agency
NTAG	Nepali Technical Assistance Group
PAHS	Patan Academy of Health Sciences (Nepal)
PHLIL	Innovation Lab for Post-Harvest Loss Reduction
PoSHAN	Policy and Science for Health, Agriculture and Nutrition
SDG2	Sustainable Development Goals 2
UNICEF	United Nations Organization for Children
Unilúrio	University of Lúrio (Mozambique)
UNSCN	United Nations Standing Committee on Nutrition
VaRG	Valley Research Group (Nepal)
KSU	Kansas State University

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I) Executive Summary

The Nutrition Innovation Lab pursues research on: i) how agriculture can be leveraged to achieve improved nutrition; ii) how multiple sectors of policy and program activity can be more effectively integrated to achieve improvements in maternal and child nutrition at scale; and, iii) what role is played by neglected biological mechanisms (such as exposure to dietary aflatoxins or to open defecation) in impairing nutrition. In FY2019, the Innovation Lab continued to emphasize activities that were innovative on both the research and capacity-building fronts. Partnerships continued with other Innovation Labs (e.g. the Feed the Future Innovation Lab for Livestock Systems, Feed the Future Innovation Lab for Post-Harvest Loss, and the Horticulture Innovation Lab) and with other USAID projects (e.g. CSISA in Bangladesh, World Fish in Bangladesh). The Management Entity (ME) leveraged support from UNICEF to successfully organize the 6th annual symposium in Nepal, elevating the evidence around agriculture, nutrition and health in Nepal to the highest policy level. In FY2019, Tufts and consortium partner researchers worked in Nepal, Uganda, Malawi, Mozambique, Bangladesh, Tanzania and Sierra Leone.

Through FY2019, the Nutrition Innovation Lab (hereafter, Nutrition Lab) continued analyzing data and finalizing manuscripts from field studies conducted in sub-Saharan Africa and South Asia. The Nutrition Lab successfully completed all data collection within its studies on mycotoxins and nutrition outcomes in Mozambique and Nepal (the Aflacohort birth cohort study supported by USAID Nepal). A report on the USAID Community Connector was finalized and shared with USAID Uganda. The final report is being shared with USAID BFS along with this report. The Nutrition Lab also supported analytical work on biomarkers of environmental enteric dysfunction (EED) using the Ugandan birth cohort samples as well as supported work on the characterization of EED biomarkers and the microbiome characterization complementing the support of USAID Food Aid Quality review in Sierra Leone. The ME decided to support this work since a) it is implemented by one of the Nutrition Lab's Nepali collaborators (Akriti Singh), and b) leverages an ongoing study supported by USAID's Office of Food AID Quality Review in Sierra Leone. Support continued on analysis of secondary data on homestead agriculture and nutrition in Tanzania.

Many impactful presentations were made, and high-quality peer reviewed papers were published. Abstracts were submitted to international meetings, including the annual meeting of the American Society of Nutrition (Nutrition 2019) in D.C, USA, the first Annual National Symposium in Kampala, Uganda, and the 6th Annual National Symposium in Kathmandu, Nepal. The second advanced research methods workshop was successfully held in Nepal in April 2019 and the first cohort of students graduated from the Malawi Dietetics program. Academic and technical support for the MPH program at Tribhuvan University Institute of Medicine continued in Nepal.

Findings from the Nutrition Lab work were shared at the local level with in-country stakeholders and policy makers through research dissemination events in Uganda (2 districts in Southwest Uganda) and Bangladesh (3 divisions – Dhaka, Barisal and Khulna). Two high-level policy consultation workshops on mycotoxin contamination and mitigation strategies were held in Nepal in collaboration with the Post-Harvest Loss Reduction Innovation Lab.

One of the highlights of this year was the Nutrition Lab's Annual Partners Meeting, that was held under the theme, "Supporting Program Design through Research on Agriculture to Nutrition Linkages", at the Friedman School of Nutrition Science and Policy at Tufts University in Boston. The meeting brought together 65 partners, advisors, collaborators, and implementing partners from five countries (Bangladesh, Malawi, Mozambique, Nepal, Uganda), nine US-based universities (Harvard, Johns Hopkins,

Kansas State University, Purdue, Tufts, Tuskegee, UC Davis, University of Georgia, Cornell University) along with representatives from the United States Agency for International Development (USAID) in D.C. and Nepal.

A total of 110 presentations were made during FY2019, of which 65 were peer-reviewed oral or poster presentations at conferences, 45 invited presentations, and 14 presentations at the Second National Workshop on Study Design held in Nepal. A total of 21 papers were published in FY2019 in a range of impactful scientific journals. Two papers are in press, 15 papers are under peer review, 4 papers are ready for submission and nine papers and reports are in progress.

Nineteen individuals (7 post-doctoral, 6 doctoral and 6 master's – 3 men, 16 women) were supported for graduate-level studies in FY2019. A total of 1249 individuals (714 men and 535 women) received short term training. In Nepal, 654 individuals received short-term skills training (310 men and 344 women), while in Uganda, 395 individuals received various forms of skills training (256 men and 139 women). In Bangladesh, 142 individuals (27 women and 115 men) were trained while in India- 3 men and 1 woman were trained at the BBNC course. In Mozambique, 58 individuals (25 women and 33 men) were trained.

II) Program Activities and Highlights

The Nutrition Innovation Lab's research generates programmatically relevant findings aimed at donors, governments, operational agencies and academic partners. In FY2019, the Nutrition Lab continued its focus on innovative activities with the realm of research and capacity building.

The Nutrition Innovation Lab successfully invested in implementation research to deepen the empirical global understanding of the pathways and linkages between agriculture and nutrition, including research on policy governance and multisector programming. The Nutrition Innovation Lab is one of the first to demonstrate that dietary diversity, including animal source foods (mainly milk) and vegetable/fruit consumption, over young childhood may be an important predictor of child development in rural agrarian settings in Nepal and Uganda. The Nutrition Innovation Lab generated critical policy and programmatic relevant findings on infrastructure (roads and transportation, for examples) development as a driver of economic growth as well as short- and long-term nutrition outcomes for children under five years of age.

The Nutrition Innovation Lab invested in research to look at critical aspects of nutrition programming and policy to ensure effective implementation of evidence-based interventions. For example, an innovative method to measure quality of nutrition governance was proposed by the Nutrition Lab from its work on policy process in Nepal. A new method to measure nutritional resilience was developed using the panel data. An evaluation of a USAID Community Connector program in Uganda demonstrated a possibility that multisectoral nutrition-sensitive programming may have potential to improve nutrition and health status of rural agrarian households. Research in Bangladesh has shown that although sustainable diets, reduction of food security and improved nutrition security are achievable goals, they may be offset by poor purchasing practices and availability of ultra-processed foods and that more evidence is warranted to understand if this is due to poor market linkages or households deriving income from nutrition sensitive agriculture, aquaculture and horticulture. Similarly, our work in developing the first food composition table in Malawi has established a precedent for regional collaboration on food composition that will be used in measuring food system performance.

The Nutrition Innovation Lab made significant contributions in elucidating food safety and neglected pathways, such as mycotoxins and environmental enteric dysfunction (EED), and its effect on child nutrition and health outcomes. For example, flagship cohort studies in Nepal and Uganda have suggested an association between maternal aflatoxin exposure during pregnancy and low birth weight and smaller head circumference. Similarly, research on water quality, EED and growth suggest that programs seeking to improve nutrition should also address poor WASH conditions simultaneously.

Specific Research in FY2019 by Theme included:

1. **Agriculture-to-nutrition pathways** (including research on policy governance, multisector programming, analyses of secondary data relating to climate and prices, resilience, and assessment of household engagement in agriculture-based livelihoods). This work includes analyses of a nested set of studies, such as the multi-year PoSHAN community studies panel and policy survey analyses, the Uganda longitudinal birth cohort study and panel surveys and the randomized controlled trial in Banke district implemented by Heifer. The Nutrition Lab continued its support to the evaluation of a homestead agriculture and nutrition project in Tanzania led by Harvard T.H. Chan School of Public Health.
2. **Neglected biological mechanisms:** This work includes analyses of a set of studies on mycotoxins, EED and human health, such as the Nepal Aflacohort study, the Mozambique Aflatoxin study, the Uganda birth cohort study and a sub-study in Sierra Leone on EED and microbiome characterization. Data collection and analysis of biological samples (blood and urine) were completed for the Aflacohort study and the Mozambique aflatoxin study, and processing of serum samples was completed for the Uganda birth cohort study. Publications in FY2019 include a paper from the Aflacohort study on low maternal aflatoxin and small-for-gestational age in Nepalese infants, three papers on assessment of extent of EED (environmental enteric dysfunction) in the Uganda birth cohort infants. An analysis of the relationship of EED and aflatoxin exposure in pregnancy and their effect on birth outcomes in Uganda is ongoing. Activities to foster dissemination and policy dialogue on mycotoxin mitigation for health, nutrition and agricultural productivity and prosperity in South Asia was initiated. The Nutrition Lab continued its support to a sub-study in Sierra Leone that aims to determine how the presence and severity of EED influence the effectiveness of supplementary feeding on Moderate Acute Malnutrition (MAM) recovery using intestinal inflammatory markers, adding to Nutrition Innovation Lab's overall assessment of the extent of EED and body composition. The main study considers the cognitive and body composition effects associated with the treatment of severe acute malnutrition. The ME decided to support this work since a) it is implemented by one of the Nutrition Lab's Nepali collaborators (Akriti Singh), and b) leverages an ongoing study supported by USAID's Office of Food for Peace.
3. **Resilience to environmental climate/seismic shocks and price volatility:** Since FY2017, several analyses have sought to understand resilience to shocks particularly within the context of post-earthquake Nepal. The analyses examine resilience in dietary patterns over time, as well as recovery from wasting linked to agricultural commercialization. Analyses from Ugandan data are emphasizing the importance of understanding the relationship of rainfall, climate and disease relative to child weight gain. Two papers were published in FY2019 on resilience post-earthquake in Nepal. New analysis aimed at developing a novel method to measure resilience using multi-year panel data and applying the method to survey data on maternal and child diets from Nepal and Bangladesh was undertaken in this fiscal year and is being written up in a publication.

Capacity building activities in FY2019 included:

- i) Long term training (support for post-doctoral fellowships, Ph.D. research support or graduate study)
- ii) Short term training (training courses, organization of symposia and seminars and learning labs to build technical capacity of partners, support attendance of the Boston Bangalore Nutrition Collaborative (BBNC). The Nutrition Lab has been planning three separate symposia in this fiscal year. The 7th Annual Scientific Symposium in Nepal, a Scientific Symposium and technology exhibition in Bangladesh and the 2nd Annual Symposium in Uganda that will take place in the next fiscal year (FY2020).

iii) Long-term training

Trainee Number	Sex	University	Degree	Major	Program End Date (year)	Degree Granted (yes/no)	Home Country
Africa							
1	F	Harvard T.H. Chan	Doctoral	Nutrition	2019	No	Zimbabwe
2	F	Tufts University	Doctoral	Food Policy and Applied Nutrition	2018	Yes	USA
3	M	IFPRI	Post-doctoral	Agricultural Economics	2020	Yes	Uganda
Asia							
4	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal
5	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal
6	F	Tufts University	Doctoral	Food Policy and Applied Nutrition	2020	No	Nepal
7	F	Purdue University	Doctoral	Nutrition	2020	No	USA
8	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal
9	F	Johns Hopkins	Doctoral	Intl Health	2018	Yes	USA
10	F	Tufts University	Post-doctoral	Food Policy and Applied Nutrition	2018	Yes	USA
11	F	Tufts University	Post-doctoral	Nutrition	2019	Yes	USA
12	F	Johns Hopkins	MPH/Post-doctoral	Intl Health	2017	Yes	Nepal
13	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal
14	F	University of Tokyo	Doctoral	Nutrition	2020	No	Bangladesh
15	F	Tufts University	Post-doctoral	Finance, Economics	2020	Yes	USA
16	F	Johns Hopkins	Doctoral	Intl Health	2019	No	Singapore
17	M	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal

18	M	Purdue University	Post-doctoral	Nutrition	2020	No	USA
19	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal

iv) Short-term training

Country of Training	Brief Purpose of Training	Sector Trained	Number Trained		
			M	F	Total
Africa					
Mozambique	Household Enumeration	Civil	24	18	42
Mozambique	Survey Anthropometrics	Civil	5	3	8
Mozambique	Phlebotomy	Civil	4	4	8
Uganda	1 st Annual Scientific Symposium	Civil, Government, and Private	229	125	354
Uganda	Kamwenge and Kitagwenda district dissemination	Civil, Government, and Private	26	13	39
Asia					
Bangladesh	Chloe Andrews	Civil	0	1	1
Bangladesh	Refresher training for beneficiary farmers	Civil, Government, and Private	8	2	10
Bangladesh	Dhaka Dissemination	Civil, Government, and Private	29	13	42
Bangladesh	Barisal Dissemination	Civil, Government, and Private	35	7	42
Bangladesh	Khulna Dissemination	Civil, Government, and Private	43	4	47
India	BBNC 1/7/2019	Civil	3	1	4
Nepal	6 th annual symposium	Civil, Government, and Private	221	217	438
Nepal	Mycotoxins and Post-Harvest Control Measures in LMICs	Civil, Government and Private	15	20	35
Nepal	Assessing Quality of Registered Dietetics Program in Nepal	Civil	17	35	52
Nepal	Data Analysis Workshop	Civil	2	2	4
Nepal	IOM student Internship	Civil	0	1	1
Nepal	Food Sample collection and market and health center mapping survey	Civil	2	4	6
Nepal	USAID Family Planning Statutory and Policy Requirements Training	Civil	1	0	1
Nepal	Second Annual Workshop 2019	Civil	7	13	20
Nepal	Lecture at a dietetics school (CAFODAT)	Civil	20	10	30
United States					
USA	Annual Partners meeting	Civil, Government, and Private	28	37	65

Developing partnerships and collaborations continued to be a key emphasis in FY 2019 and the Nutrition Innovation Lab continued its partnerships and collaborations with other Innovation Labs (e.g.

the Feed the Future Innovation Lab for Horticulture, Aquaculture and Fisheries, Peanut and Mycotoxins, Livestock Systems, Post-Harvest Loss Reduction, and Soybean). The Innovation Lab also leveraged in country relationships in Nepal and successfully hosted two high-level policy consultation workshops on mycotoxins and its mitigation strategies and interacted extensively with the Livestock Systems Innovation Lab to support organization of LSIL Partners Meeting in Nepal. A significant policy emphasis and high-level attendance is expected at the upcoming symposia in Bangladesh, Nepal and Uganda.

III) Key Accomplishments (FY2019)

The Nutrition Innovation Lab was designed explicitly to be policy and programmatically-relevant. While its main outputs come in the form of peer-reviewed science, the focus of research streams and the kinds of findings produced are tailored to the needs of USG and its development partners in focus low-income countries of sub-Saharan Africa and South Asia, and to the governments of those countries. This year's research outputs have continued to inform and guide these multiple audiences as they decide on policies or operational investments aimed at tackling nutrition, health, and dietary inadequacy via food-based interventions implemented at scale.

Among other things, our new publications have shown, i) how important it is for child nutrition to ensure water quality within the home, not just at the source outside the household – yes, protecting against environmental enteropathy is critical to preventing wasting; ii) the value of bundled packages of interventions to enhance both on-farm production diversity and diet diversity of mothers and children – yes, multisector programming works; iii) that access to markets is a hugely significant driver to diet diversity, making investments in tertiary rural roads and functional markets a priority investment supporting nutrition outcomes – yes, families distant from markets continue to need support to diversify their own production as a means of ensuring diet quality; iv) aflatoxins in the food supply are independently and statistically significantly linked to impaired birth outcomes – yes, confirmed for the first time in the literature through prospective birth cohorts; v) birthweight and subsequent infant feeding practices are crucial determinants of later child growth across Asia – yes, programming needs to include impactful behavior change activities around Infant and Young Child Feeding, but much more attention is needed to promoting healthy pregnancies to support good birth events; vi) engagement in agriculture represent a successful coping strategy in the context of major natural disasters – yes, agricultural investments can represent good value as a pro-resilience strategy; and vii) new agricultural inputs and technologies such as hermetic bags, solar dryers, or floating gardens (used for growing herbs and spices) can all 'work' in a technical sense, but their uptake and economic viability varies by location (proximity to markets) and depending on the foods grown/processed/stored (price variability, input costs and demand).

Research Accomplishments

Agriculture-to-nutrition pathways:

- Analysis and write-up of papers using the POSHAN Community and policy process studies continued this year. Analyses and write up of the pattern of linear growth and risk factors of stunting and wasting in the Terai region is advancing. The second and third panel survey data have been released to USAID DDL and are being reviewed by USAID. Development of a newly designed nutrition governance indicator to quantify the quality of governance in nutrition was completed and the resulting manuscript has been submitted to a peer review journal. A fifth round of data collection for the POSHAN policy process studies have been planned at the start of FY2020. The data will add to the prior findings on nutrition governance in Nepal and provide significant insights on the impact on governance with the new federal administrative structure in the country.

- Reports from the regional dissemination events in Bangladesh are being finalized for the aquaculture-horticulture for nutrition project in Bangladesh. A Bangladeshi PhD student in Japan (whose study costs are covered by a separate source and not from the Nutrition Lab) is using the data to answer critical research questions on assessing diet quality among households exposed to USAID programming. She will present her results at the Bangladesh symposium in December 2019.
- A randomized controlled trial (RCT) that examined the role of nutrition sensitive interventions in improving infant and young child growth and development was completed in Banke, Nepal. Data analysis and manuscript write up are underway.
- Writing of a draft report and manuscript of the findings of a qualitative survey to evaluate sustainability of a home garden, poultry, and nutrition education intervention in three program districts of western Nepal is under preparation.
- New analyses using nationally representative data from Uganda examined the relationship of yields, rainfall, disease and child growth. A paper was published in *Agricultural Economics*.
- Research continues on evaluating the implementation of a homestead agriculture and nutrition project in Tanzania.
- Analyses examining the affordability of nutritious diets in Asia and Africa is ongoing.
- Two peer reviewed papers examining the relationship of micronutrient deficiencies, cognition and maternal schooling were published.

Neglected Biological Mechanisms:

The Nutrition Innovation Lab made significant contributions in the past year to the global evidence base around pregnant women's exposure to aflatoxin and its subsequent effect on children after birth. Evidence from Nepal, Uganda and Mozambique has shown a widespread exposure to aflatoxins in pregnant women and a relationship between aflatoxin exposure during pregnancy and low birth weight in newborns. The findings also show a strong association between consumption of maize and groundnuts and maternal aflatoxin levels in the blood.

Mozambique

- Data collection on aflatoxin exposure in children under five in Nampula province, Mozambique was successfully completed.
- Maternal and infant samples from Mozambique have been analyzed for aflatoxin – 90% of the samples had detectable aflatoxin.
- After completing data cleaning and management, an analysis workshop is planned for the start of FY2020.

Uganda

- Maternal and infant samples from Uganda have been analyzed for aflatoxin and data analysis is underway. 100% of the samples had detectable aflatoxin.
- Maternal and infant samples from Uganda are also being analyzed for environmental enteric dysfunction (EED) and micronutrient biomarkers.

Nepal

- Data collection for the Aflacohort study in Banke district in Nepal for additional time points (18 and 24 months) to examine EED, and additional analyses on other mycotoxins such as fumonisins and DON was completed. Analysis are underway and four manuscripts were submitted and are under review. Findings will be presented during the dissemination event in December 2019.

- In collaboration with the Feed the Future Innovation Lab for Post-Harvest Loss Reduction (PHLIL), the Feed the Future Innovation Lab for Nutrition (NIL) collected food samples and data from a sub-sample of 173 study participants in Banke, Nepal for aflatoxin testing in food. A joint analysis examining the food and exposure to aflatoxin is ongoing.
- A paper on the relationship between gestational aflatoxin exposure and birth outcomes from the Aflacohort study was published in the Journal of Nutrition.
- The research and evidence generated around mycotoxins are powerful tools for national and regional policymakers and stakeholders to frame and integrate specific policies targeting their mitigation. To facilitate a multi-sectoral policy engagement process in Nepal, the Nutrition Innovation Lab has partnered with other Feed the Future Innovation Labs (Post-Harvest Loss Reduction and Livestock Systems), development partners, health and agriculture sectors of the government of Nepal since 2017 through a series of high-level consultation and strategic workshops and capacity building activities.
- The two workshops so far have been instrumental in bridging multi-sectoral partnerships between different government ministries (health, agriculture, livestock, and National Planning Commission) and initiating policy dialogues around mycotoxin as a food safety and public health concern in Nepal. The workshops have resulted strong political commitment and willingness to collaborate from the key stakeholders to examine food safety policies, regulatory frameworks, and strategies around mycotoxins and its mitigation.

Sierra Leone

- This small study is co-sponsored by Nutrition Innovation Lab as part of a larger body of research undertaken by Tufts for the Food Aid Quality Review (FAQR). The study protocol was approved by the Sierra Leone Ethics and Scientific Review Committee and the Tufts University Health Sciences Institutional Review Board. The main study considers the cognitive and body composition effects associated with the treatment of moderate acute malnutrition. The Nutrition Lab supported sub-study aims to determine how the presence and severity of EED influence the effectiveness of supplementary feeding on Moderate Acute Malnutrition (MAM) recovery using intestine inflammation markers, thus, adding to Nutrition Innovation Lab's overall assessment of the extent of EED and body composition.
- A total of 601 individuals were enrolled in the EED sub-study, with urine samples collected from 422 participants and stool samples collected from 475 participants at enrollment, after 4-hour wait period for the L:M test. Stool samples were also collected from 277 subjects after four weeks of treatment.
- All lab analyses were completed in FY2019. Statistical analyses on characterizing the microbiome and assessing environmental enteric dysfunction (using fecal markers) in moderately malnourished children in Sierra Leone is ongoing. Findings have shown the prevalence of EED assessed using lactulose excreted (%L), myeloperoxidase (MPO), and neopterin (NEO) was high among children with MAM enrolled in a supplemental feeding program in the Pujehun district of Sierra Leone. Three EED scores based on 15 fecal host mRNA transcripts were used: GIS, GSS, and GDS. The EED protein score (EPS), Gut inflammation score (GIS), gut structure score (GSS), and gut defense score (GDS) did not correlate with %L. That said, a weak but significant correlation was found between EPS and GIS, suggesting that they are both markers of inflammation, which is characteristic of EED. Previous studies have found mixed results for the association between proteins comprising EPS and L:M ratio or %L. However, eight fecal host mRNA transcripts were able to identify the presence of EED and severe EED using %L with high sensitivity and specificity.

Dissemination of research findings:

- A total of 110 presentations were made during FY2019, of which 65 were peer reviewed oral or poster presentations at conferences, 45 invited presentations and 14 were from the advanced research methods workshop (Second National Workshop) held in Nepal. The total (aggregate) audience participating in these presentations was over 2,400 individuals.
- Twenty-one papers/reports and one PhD dissertations were published, two papers are in press, 19 under peer review, and nine manuscripts and reports are in progress.
- A regional dissemination of study findings was held in three divisions (Dhaka, Khulna and Barisal) of Bangladesh. Similarly, dissemination seminars were run in 2 districts of Southwestern Uganda.
- A partners meeting was held in Dhaka, Bangladesh in March 2019 to disseminate study findings to USAID mission colleagues and implementing partners in Bangladesh.
- An annual partners meeting was held in Boston USA in August 2019 bringing together all core and host country partners and collaborators. Research findings from different completed and ongoing studies of the Nutrition Lab were shared with implementing partners and USAID colleagues.
- In conjunction with the annual meeting, the Nutrition Innovation Lab also held a meeting of its technical advisory committee and the Board of Directors.

Capacity Building (Human and Institutional) Accomplishments

- One Ugandan male and two US female received support for post graduate studies
- Two Nepali (both male) and two Ugandan (one male one woman) candidates were supported to the BBNC (1 woman and 3 men).
- 1249 individuals received short-term training in Asia and Africa in FY2019. A total of 453 individuals in Africa (289 men, 164 women) and 796 in Asia (425 men and 371 women).
- Continued promotion of local partner engagement through the support of the IOM master's in public health nutrition (6 students).
- Worked closely with IOM faculty on the delivery of lectures, seminars and journal clubs for the 2018-19 academic year.
- 11 Nepali, 1 Bangladeshi, 5 Ugandan, 6 Malawian 1 Ethiopian, 2 Tanzanian and 5 Mozambican institutions gained enhanced capacity to engage with and undertake policy-relevant research linking agriculture to nutrition.
- Coordinated and facilitated lecture sessions for MPH students in Nepal on 1) Nutritional Assessment methods and 2) Electronic data collection methods in Ag-Nutrition research.

Fitting Evidence to Policy – Global and Regional efforts of Nutrition Lab to support evidence-based policy actions

- A key research theme of the Nutrition Innovation Lab is to elucidate little known neglected biological pathways in assessing the nutrition, health and agriculture linkages from food and feed to human health outcomes. An example of a research area is the assessment of aflatoxin exposure in vulnerable populations and associations with birth outcomes and growth. Another example is assessing the relationship of EED and aflatoxin biomarkers. Since 2014, the Lab has engaged extensively with in-country stakeholders including the government of Nepal, Uganda and Mozambique, academic institutions, non-government organizations as well as other USAID Feed the Future Innovation Labs (e.g. the Feed the Future Innovation Lab for the Reduction of Post-Harvest Loss, Feed the Future Innovation Lab for Peanut Research, Feed the Future Innovation Lab for Livestock Systems) in undertaking large-scale, complex research activities to generate evidence about nutrition and health risks from dietary aflatoxins in Nepal, Uganda and Mozambique.

- The Nutrition Lab has made significant contributions to the global evidence base about pregnant women's exposure to aflatoxin and its subsequent effect on children after birth (Nepal, Uganda and Mozambique). Early analysis in Nepal and Uganda has shown a widespread exposure to aflatoxins in pregnant women and a relationship between aflatoxin exposure during pregnancy and low birth weight in newborns. Findings also show a strong association between the consumption of maize and groundnuts and maternal aflatoxin levels in the blood.
- In addition, the research and evidence generated about aflatoxins, and the activities (national and regional dissemination, symposium, partners' meeting and consultation workshops, presentations, publications) have proven to be powerful tools for researchers, programmers, policymakers and government stakeholders to frame and facilitate discussions to integrate specific program and policies targeting aflatoxin detection and mitigation. The research and evidence generated about aflatoxins have been shared with over 400 representatives from the Government of Uganda ministries of health, agriculture, research and academic institutions, donor agencies (UNICEF, Gates Foundation, DFID), civil society, implementation partners and private sector partners in Uganda. Similarly, two mycotoxin policy workshops in Nepal brought together more than 200 representatives from ministries of health, agriculture, research and academic institutions, donor agencies, civil society groups, implementing partners and private sectors to deepen their knowledge about the impact of mycotoxins and food safety in human health, as well as innovative technologies that are cost-effective and have ability to mitigate mycotoxins at farm and household levels.
- The impacts of continued dissemination and policy engagement with the policymakers, across regions, have resulted in a strong political commitment, in the form of willingness to establish a national mycotoxin control committee by the Government of Nepal to facilitate collaborative partnerships among health and non-health sectors, identify evidence gaps and challenges in aflatoxin and food safety regulations and policies in Nepal and Uganda, and uptake learnings from collaborative partnerships from Sub-Saharan Africa (for example, Partnerships for Aflatoxin Control in Africa).
- The government of Nepal, and Uganda, along with its national partnerships have signaled their commitment to transform food safety policy landscape by using various policy forums conducted by the Nutrition Lab and its partners and have urged public and private sectors to join hands. In addition, a greater interest has been shown by stakeholders in Nepal to develop and implement national regulatory standards critical in safeguarding risk of contamination of food commodities at the farm and market level.

IV) Research Program Overview and Structure

The Nutrition Innovation Lab conducts and supports cutting-edge research on agriculture, diets and nutrition in developing countries. Such research has an applied focus (operations or “delivery science” research or field based research rather than “bench science”), it is country-owned (supporting research which includes national stakeholders and informs locally-defined priorities in food and nutrition) and it allocates resources to few grants at larger scale, rather than many small grants supporting studies of experimental or pilot activities. The research is pursued in ways which seek to enhance global and national understanding of how to overcome constraints in policy and program design and implementation, while also producing global public goods in the form of new scientific knowledge of relevant and diverse settings.

Following these principles, the Nutrition Lab is framed by the following over-arching research questions, namely: 1) How can investments in agriculture achieve measurable impacts in nutrition (and can

pathways to impact be empirically demonstrated)?; This includes how multisector programs and policies (and the enabling environment) can support nutrition-specific and nutrition-sensitive actions and how sustainable are these actions; 2) What role is played in nutrition by biological mechanisms which have been relatively overlooked or ignored in past research (including aflatoxins, water quality, chemical contamination, etc.)? and 3) What type of resilience (household and community) exists to environment, climate, seismic or price volatility shocks and what is the potential for recovery?

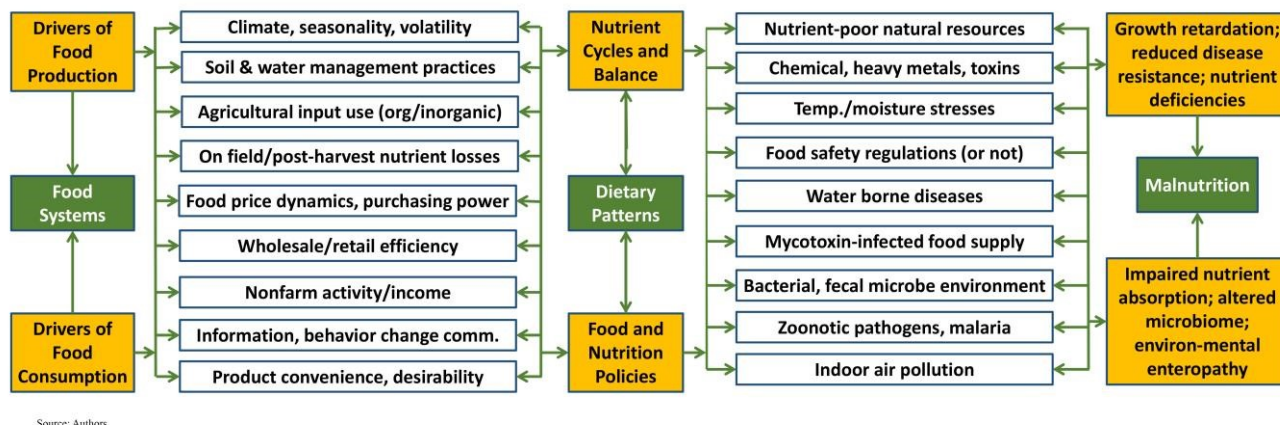
Tufts University's Friedman School of Nutrition Science and Policy serves as the Management Entity (ME). The Friedman School implements the program of work in partnership with US university partners including Tuskegee, Purdue, Johns Hopkins and Harvard TH Chan School of Public Health.

The Nutrition Lab partners with many other universities, Feed the Future Innovation Labs and research organizations, including the University of Georgia, University of Florida, University of California-Davis, International Food Policy Research Institute; European universities (University of Bergen, Norway, the London School of Hygiene and Tropical Medicine and the Leverhulme Centre for Integrative Research on Agriculture and Health in London); and host country institutions, such as the Nepal Agricultural Research Council (NARC), the Child Health Division of the Ministry of Health and Population of Nepal (CHD) and the National Planning Commission, the Nepal Valley Research Group (VaRG), the Nepali Technical Assistance Group (NTAG), Tribhuvan University (Institute of Medicine), Patan Academy of Health Sciences (PAHS), St. John's Research Institute in Bangalore, Makerere University, Gulu University, Institute of Public Health, Mozambique, University of Lurio, Nampula, Mozambique, ANSA, Mozambique, INE, Mozambique, University of Malawi, the Lilongwe University of Agriculture and Natural Resources, the Medical Council of Malawi, the Department of Nutrition and HIV/AIDS (Ministry of Health), Malawi, the South African Medical Research Council (SAMRC) and the Ugandan Office of the Prime Minister and Ministry of Health); as well as international non-governmental organizations like Heifer International, Heifer Nepal, Helen Keller International (Bangladesh, Nepal, FHI 360, FANTA, SPRING, Save the Children, CIMMYT, IITA and WorldFish.

V) Theory of Change and Impact Pathway(s)

The Nutrition Innovation Lab utilizes a framework that is a novel vision of the many factors involved in food systems dynamics (Figure 1). Within the context of research activities, this framework outlines the policy relevant activities that the Innovation Lab undertakes in host countries. The framework, which links economic, climatic, agronomic, and biologic cycles together as collective influences on maternal and child nutrition, will serve as the organizing structure for integrating all studies to be undertaken. The framework challenges simpler linear thinking on the pathways by which agriculture interacts with the broader food system to impact nutrition. Understanding the complicated interconnected factors within this framework requires enhanced research approaches such as those undertaken by the Nutrition Innovation Lab.

Figure 1: Framework for Research Linking Food Systems, Biological Mechanisms and Nutrition



To understand the linkages, and understand impact pathways, across this framework the Nutrition Innovation Lab pursues 3 streams of research, each of which addresses key elements of the conceptual framework. *First* is on better understanding **agriculture to nutrition pathways**. This research includes the Nutrition Lab’s innovative focus on policy implementation efficiency, measuring the capacity of implementing partners, and changes in household nutrition outcomes differentiated by agro-ecology, seasonality, wealth factors, and gender. Such research relates to the second column of boxes in Figure 1, which has a box on ‘climate, seasonality, and volatility at the top’. *Second* is on **neglected biological pathways** that are believed to play an under-appreciated role in nutrition outcomes. This stream of work focuses on issues in the fourth column, which is headed by a box on ‘nutrient-poor natural resources’. *Third* is on **household resilience** to shocks, as well as to climatic and food price volatility. This research cuts horizontally across all columns in Figure 1 since it relates to disruptions to food systems and to dietary patterns that result in various (not always predictable) forms of malnutrition.

The Nutrition Innovation Lab research is translated first and foremost into peer reviewed publications. The use of these publications to drive future thinking on these three research streams is critical to achieving impact. Further the translation of peer reviewed findings into policy will be crucial and the Innovation Lab aims to do this through ensuring presentations in policy forums in domestic and international settings. All partners and collaborators are encouraged to develop research questions within these three research streams that are policy relevant.

Overlaid on the translation of three research stream findings into policy action is the need to have consistent and continued cross-disciplinary institutional capacity building. This is key for sustaining policy attention to food system quality and nutrition. Nepal’s government has argued that “capacity needs to be complemented with a multidisciplinary approach that views their respective contribution from the perspective of nutrition improvement [...] The structure for improving capacity must include several line ministries.”¹ Similarly, Uganda’s government acknowledges a need for strengthening the “institutional capacity” of government for “increased harmonization, coordination and management.”⁴ Thus, capacity building as defined by host country institutions are a key component of the Nutrition Innovation Lab’s theory of change. Activities to achieve capacity include:

¹ Government of Nepal. 2009. *Nepal Nutrition Assessment and Gap Analysis*. Final Report, Kathmandu, Nepal. ⁴ Government of Uganda. 2012. *National Local Government Capacity Building Policy*. Kampala: Ministry of Local Government.

- Raising understanding through workshops, training activities and scientific meetings of the importance of working across sectors/ministries to meet nutrition goals;
- Building local capacity to conduct multidisciplinary research involving local academics and professionals in the research agenda. For example, the director of Nepal's Child Health Division is directly involved in the ME's aflatoxin study because of its potential policy significance;
- Strengthening the human capital in key institutions by offering short-term training to nationals;
- Supporting national partners to build training or educational capabilities so that they can teach the next generation of researchers and professionals - including curricular and course support, the establishment of a first dietetics education program in Malawi, assessment of the medical school curriculum in Malawi, support to the MPH program at the IOM in Nepal among other activities.

VI) Research Project Reports

Objective 1: Agriculture to Nutrition Pathways

I. Empirically understanding agriculture to nutrition pathways in Asia and Africa

i) Understanding agriculture to nutrition pathways

This question is being answered through several different activities.

PoSHAN Community Studies: A key activity is the PoSHAN Community studies in Nepal. A nationally representative survey that has been conducted annually from 2013 through 2016. It has collected data from over 5,000 households, this longitudinal panel study explores the pathways from agriculture through incomes and diets to nutrition.

Ecological Analyses on Affordability of Nutritious diets: In addition, analyses are underway on nationally representative data sets across Africa on understanding the relationship of food prices.

Hypothesis-driven research examining connections between agriculture and human nutrition: Using a wide range of field experiment and observational data, pathways by which agriculture is linked to nutritional outcomes are being examined. Collaborators at Purdue University are working with graduate students, colleagues at Tufts and other universities to conduct policy-relevant economic research related to agriculture, nutrition, and human health in Feed the Future countries.

Micronutrient deficiencies, cognitive function and maternal education: Analysis of existing data from Bhaktapur translated into a paper on understanding the relationship of vitamin B 12 and cognition. A number of analyses to determine the relationship between maternal iron and vitamin A level and birth outcomes is ongoing using the Uganda birth cohort data.

Assessment of the impact of a Homestead agriculture and nutrition project (HANU) in Rufiji district, Tanzania: As with the case of Sierra Leone, this study represents a window of opportunity for the Nutrition Lab to generate new findings relevant to its core mission by leveraging ongoing work funded by other donors. Also, Tanzania is a Feed the Future country, this furthers Tufts relationship with our partners at Harvard, and the topic fits under our Nutrition to Agriculture Research Theme. In the case of Tanzania, the main study is being undertaken by Nutrition Lab partners at the Harvard Chen School of Public Health. They reached out to the ME to determine if student analyses could be supported in relation to data collected through a baseline, midline and endline assessment of the HANU project. Baseline data analysis for the HANU study in Tanzania, a collaboration effort among Harvard, IHI and

SUA, examined the effect of agricultural diversity on dietary diversity among women of reproductive age. The ME is using a small grant from core to support a female Tanzanian doctoral student at Harvard to prepare one or more manuscripts from these data.

ii) *Collaborators:*

Tufts University, Johns Hopkins University, National Agriculture Research Centre (NARC) Nepal, Tribhuvan University, New Era, Nepali Technical Assistance Group (NTAG), UNICEF, Purdue University, University of Bergen, University of Ghana, Ifkara Health Institute in Tanzania, Sokoine University, Tanzania, Addis Continental Public Health Institute, Makerere University, VitMin Lab (Germany)

iii) *Accomplishments:*

This year, the PoSHAN community studies completed extensive data cleaning and consistency checks of all annual surveys (2013-2016) to create publicly shareable versions of datasets. The datasets were uploaded for curation to the USAID Digital Data Library (DDL) and are currently under review by the DDL team. A paper by Dorsey et al, which explored the risk factors for child malnutrition in Nepal, was cited in the policy document “Towards Zero Hunger in Nepal, a strategic review of food security and nutrition” by the government of Nepal (National Planning Commission, 2018, [link](#)) in relation to the need to understand how different causes of stunting and wasting operate within different regions of the country. In addition, a paper published in *Nutrients* (Miller et al, 2019) is among the first to demonstrate that dietary diversity over young childhood may be an important predictor of child development in rural agrarian settings. The paper found both animal source food consumption (mainly milk) and vegetable/fruit consumption as important predictors of child development even after adjusting for maternal education and socioeconomic status. This follows up on work previously done by the Nutrition Lab showing that Vitamin B12 (found naturally only in animal source foods and fortified foods) was strongly tied to child development in Nepal and helps to make a stronger case for the need to invest in programs that result in dietary diversity of children and women for human capital development (Kvestad et al, *AJCN*, 2017).

A paper on dietary patterns from Bangladesh (Thorne-Lyman, 2019, *Journal of NYAS*) used latent class analysis to reduce dietary data and generate dietary patterns of adolescents. The paper served as a proof of concept that the dietary patterns generated by aggregating data from consumption recall of numerous food items are associated with multiple measures of socioeconomic and nutritional status, and a similar approach is being used to understand associations in the Nepal PoSHAN data (preliminary results were presented at the 6th Scientific Symposium in Nepal and the paper is in advanced stages of preparation).

Secondary data analysis, by Shively et al, demonstrated in Nepal, that characteristics of children and households explain most of the variance in height-for-age and weight-for-height, with statistically significant but relatively smaller overall contributions from community-level factors. Approximately 6% of total variance and 22% of explained variance in height-for-age z-scores occurs between districts. For weight-for-height, approximately 5% of total variance, and 35% of explained variance occurs between districts. This work is important because it can guide resource allocation by policy makers between interventions at the household, community and district levels. For example, some between-child variance in stunting occurs at a level that could be addressed by targeting households, and some occurs at a level that could be addressed by targeting communities. As a result, a 50-25-25 “rule of thumb” might be appropriate for policymakers in Nepal: when developing policies aimed at improving child growth outcomes, a starting point might be to focus 50% of efforts and attention directly on children, 25% on households, and 25% on communities, keeping in mind that the benefits of invested resources and the costs of those resources must be weighed, and might differ markedly across potential interventions. Similarly, in Uganda, research based on nationally representative data from Uganda highlights the importance of the household’s disease environment for a child’s short-term health. This work is

important because we find a partially offsetting positive association between crop yield and WHZ that is sensitive to the rainfall regime. In areas that receive low rainfall, the yield effect dominates, and greater rainfall is associated with improved weight gain. In areas that receive high rainfall, the disease effect dominates, and greater rainfall undermines child growth. This information can help justify and guide the targeting of interventions and resources.

Transportation development accompanies economic development, both as a driver of growth and as an outcome of economy-wide investments made possible by growth. Combining two rounds of nationally representative data on child growth from the 2006 and 2011 Nepal Demographic and Health Surveys with district level information on roads and road quality, Shively et al, estimate a dose-response function for height-for-age and weight-for-height z-scores. Results suggest that roads and road quality matter for short- and long-term nutrition outcomes for children under five years of age. Using a spatial econometric model, we also observe statistically significant geographic spillovers from roads. This work is important because it suggests broad and beneficial health and nutrition payoffs from transportation development. This can be useful in building alliances among policy makers with different spheres of responsibility, for example by demonstrating to those in transportation how their investments matter for nutrition outcomes and by building support among those in health and nutrition domains for investments in basic infrastructure on nutrition grounds.

Preliminary findings from the Uganda birth cohort study show that iron status of the mother (sTFR) might be associated with increased risk for preterm births while vitamin A status (RBP) of the mother is associated with better birth outcomes. Whereas the latter finding is relatively commonplace, the former is controversial and the subject of recent debate. Currently, WHO recommends mandatory iron supplementation in pregnant women based off a body of evidence that is in agreement with this policy. However, findings like ours serve to introduce alternative perspectives that may ignite a debate on long-established protocols with the end goal of improving the nutritional and health status of target populations. A manuscript is being prepared for submission in October 2019 to the *Nutrients Journal*.

In collaboration with Ifakara Health Institute (IHI) and Sokoine University of Agriculture (SUA), collaborators at Harvard have completed the HANU intervention in September 2019 and conducted end-line data collection from July to September 2019 in the Rufiji district of Tanzania. Data cleaning and analysis is ongoing to examine the effect of the intervention over three years. A postdoctoral research fellow has joined the team to explore pathways through which agriculture and homestead food production can improve nutritional status. Over the reporting period, training and capacity building for Tanzanian scientists was integrated into research activities.

iv) *Presentations and Publications:*

Publications

1. Harding L. K, Aguayo M. V, Webb P. Birthweight and feeding practices are associated with child growth outcomes in South Asia. *Maternal & Child Nutrition*. November, 29, 2018;14(S4):e12650. DOI: 10.1111/mcn.12650.
2. Mouchered C, Chandyo RK, Henjum S, Strand TA, Ulak M, Fawzi WW, Locks LM, Webb P, Thorne-Lyman AL. Engagement in agriculture protects against food insecurity and malnutrition in peri-urban Nepal. *Current Developments in Nutrition*. 2018 Nov 1;3(1):nzy078.
3. Thapa G, and Shively G. A dose-response model of road development and child nutrition in Nepal. *Research in Transportation Economics* 70: 112-24. November 19, 2018. doi.org/10.1016/j.retrec.2018.11.002.

4. Thorne-Lyman A, K.C A, Manohar S, Shrestha B, Nonyane BAS, Neupane S, Bhandari S, Klemm RW, Webb P, West KP Jr. Nutritional resilience in Nepal following the earthquake of 2015. *PLoS ONE*. 2018. 13(11): e0205438. doi: 10.1371/journal.pone.0205438
5. Bhandari S, Thorne-Lyman A, Shrestha B, Neupane S, Sanny Nonyane B, Manohar S, Klemm R, West K. Determinants of infant breastfeeding practices in Nepal: a national study. *International Breastfeeding Journal*. 3 April 2019, <https://doi.org/10.1186/s13006-019-0208-y>
6. Thorne-Lyman AL, Shaikh S, Mehra S, Wu LSF, Ali H, Alland K, Schultze KJ, Mitra M, Hur J, Christian P, Labrique AB, West KP Jr. Dietary patterns of >30,000 adolescents 9-15 years of age in rural Bangladesh. *Ann N.Y. Acad. Sci.* 2019. doi: 10.1111/nyas.14207
7. Thorne-Lyman AL, Shrestha M, Fawzi WW, Pasqualino M, Strand TA, Kvestad I, Hysing M, Joshi N, Lohani M, Miller LC. Dietary diversity and child development in the far west of Nepal: A cohort study. *Nutrients*. 2019. 11(8), 1799
8. Hicks C, Cohen P, Graham N, Nash K, Allison E, D'Lima C, Mills D, Roscher M, Thilsted S, Thorne-Lyman A, MacNeil A. Harnessing global fisheries to tackle micronutrient deficiencies. *Nature*, September 25, 2019. <https://doi.org/10.1038/s41586-019-1592-6>
9. Kadjo D, Ricker J, Gilbert Tahirou A, and Shively G. Food Safety and Adverse Selection in Benin's Rural Maize Markets. *Journal of Agricultural Economics*. July 29, 2019. doi: 10.1111/1477-9552.12350.
10. Smith T, and G Shively. 2019. "Individual, household, and community factors in child growth: a multilevel approach for Nepal." *BMC Pediatrics*. April 5, 2019 <https://doi.org/10.1186/s12887-019-1469-8>.

Publications (non-peer reviewed)

Non-peer reviewed

1. 6th Annual Scientific Symposium in Nepal, 'Food, Diets & Nutrition: 25 years of Progress and a Vision for Nepal', 2018
https://www.nutritioninnovationlab.org/sites/default/files/inlinefiles/2018%20Nepal%20Symposium%20Final%20Report_3.13.19.pdf

Publications under review

1. Broaddus-Shea ET, Manohar S, Thorne-Lyman AL, Bhandari S, Nonyane BAS, Winch PJ, West KP Jr. Small-scale livestock production in Nepal is directly associated with children's increased intakes of eggs and dairy, but not meat. *Under review at Journal of Nutrition*.
2. KC A, Thorne-Lyman AL, Manohar S, Shrestha B, Klemm R, Adhikari RK, Webb P, West Jr. KP. Preschool child nutritional status in Nepal in 2016 and comparative trends. *Under review at Food and Nutrition Bulletin*.
3. Agrawal P, Manohar S, Thorne-Lyman AL, KC A, Shrestha B, Klemm RD, West KP Jr. Prevalence of Damaged and Missing Teeth among Women in Southern Rural Nepal as Assessed by a Survey-based Approach. *Under review at Plos One*.
4. Arega, M. and G. Shively. Food Aid, Cash Transfers and Producer Prices in Ethiopia. Forthcoming in *African Journal of Agricultural and Resource Economics*.
5. Miller L, Joshi N, Shrestha M, Neupane S, Neupane S, Lohani M, Thorne-Lyman AL, Both dietary diversity and consumption of animal source foods over time protect young rural Nepali children from poor development. *Under review at Maternal and Child Nutrition*
6. Thorne-Lyman AL, Parajuli KR, Paudyal N, Chitekwe S, Shrestha R, Manandhar DL, West Jr KP. To see, hear and live: 25 years of the vitamin A program in Nepal. *Under review at Mat. and Child Nutr.*
7. Shively, G. and A. Evans. Dietary Diversity in Nepal: A Latent Class Approach. *Under review at Public Health Nutrition*.
8. Shively, G., T. Smith and M. Paskey. Altitude and Child Growth in Nepal. *Under review at Mountain Research and Development*.

9. Debela, B., G. Shively and S. Holden. "Food for Work and Diet Diversity in Ethiopia." Under review at *Review of Development Economics*.
10. Omiat, G. and G. Shively. "Rainfall and Child Growth in Uganda." Under review at *Economics and Human Biology*.
11. Darko, F., J. Ricker-Gilbert, T. Kilic and G. Shively. Profitability of Fertilizer Use in SSA: Evidence from Malawi. Under review at *Journal of African Economies*.
12. Josephson, A. and G. Shively. "Unanticipated Events, Perceptions, and Household Labor Allocation in Zimbabwe." Under review at *World Development*.

Presentations

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Swetha Manohar	TOPS USAID, Asia Regional Knowledge Sharing Meeting	Bangkok, Thailand	Factors Associated with Undernutrition and Household Food Security (PoSHAN Community Studies).	October 2018	~45
Andrew Thorne-Lyman	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Factors associated with dietary patterns in Nepali women.	November 2018	~350
Andrew Thorne-Lyman	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition (workshop)	Kathmandu, Nepal	Anthropometric Assessment	November 2018	40
Andrew Thorne-Lyman	2019 American Society for Nutrition Conference	Baltimore, MD	Nutrition Within the Sustainable Development Goals	June 2019	~60
Andrew Thorne-Lyman	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston MA	Vitamin B12 deficiency in infancy and cognitive development	August 2019	~25
Andrew Thorne-Lyman	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Nutritional resilience in Nepal after the 2015 earthquake	August 2019	~25
Keith P. West Jr.	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	PoSHAN Community Studies in Nepal Rationale, Design, Achievements and Lessons	August 2019	~25
Keith P. West Jr.	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	A Vision for Nutrition in Nepal During the Sustainable Development Goals Era (2015-2030)	November 2018	~350

Keith P. West Jr.	Micronutrient Deficiencies: Single Burden in a Double-Burdened World	Hohenheim University, Germany	Micronutrient Deficiencies: Single Burden in a Double-Burdened World	February 27, 2019	~150
Keith P. West Jr.	Vitamin Angels 25 th Anniversary summit	Santa Barbara, CA	Micronutrient Deficiencies: Single Burden in a Double-Burdened World	March 18, 2018	~100
Keith P. West Jr.	Invited lecture at University of Nebraska	Lincoln, Nebraska	Micronutrient Deficiencies: Single Burden in a Double-Burdened World	March 21, 2018	~50
Swetha Manohar	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Growth Faltering & Associated Risk Factors Among Infant and Young Children from Nepal: Findings from the PoSHAN Community Studies Cohort	August 2019	~25
Poster presentations					
Angela KC	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Risk factors for underweight and overweight among reproductive aged women in a national sample in Nepal	November 2018	~100
Andrew Thorne-Lyman	2019 American Society for Nutrition Conference	Baltimore, MD	Livestock ownership and children's intakes of animal source foods in Nepal	June 2019	~100
Andrew Thorne-Lyman	2019 American Society for Nutrition Conference	Baltimore, MD	Dietary Patterns of Women in Relation to Risk of Over- and Underweight in Nepal	June 2019	~100
Angela KC	2019 American Society for Nutrition Conference	Baltimore, MD	Preschool child nutritional status in Nepal in 2016 and comparative trends	June 2019	~100
Gerald Shively	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Dietary Diversity in Nepal 2013-16	November 27-29 2018	~350
Gerald Shively	Purdue University Interdepartmental Nutrition Seminar	West Lafayette, Indiana	International Nutrition: An Economist's Perspective	January 2019	
Gerald Shively	ARENA-II Year 2 Workshop, International Food Policy Research Institute	Washington DC	Climate, transport and dietary diversity	March 2019	
Gerald Shively	National Press Club	Washington DC	Innovations in Agriculture: Scaling Up to Reach Millions	April 2019	
Gerald Shively	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Drivers of Diet Complexity in Nepal	August 2019	~55

Gerald Shively	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Altitude and Child Linear Growth in Nepal	August 2019	~55
Gerald Shively	African Green Revolution Forum	Accra, Ghana	Framing Remarks. Policy Symposium on Scaling Models for Agricultural Transformation	September 4, 2019	
Monica Pasqualino	2019 American Society for Nutrition Conference	Baltimore, MD	Anemia among Preschool-aged Children in Nepal: Variations in National Prevalence and Strength of Associated Risk Factors from 2013 to 2016	June 2019	~100
Swetha Manohar	2019 American Society for Nutrition Conference	Baltimore, MD	Growth Faltering Among Pre-School Aged Children in the Plains of Nepal	June 2019	~100

2. Policy Process Research

i) *Name:*

Policy and Governance within Nutrition and Agriculture: PoSHAN Policy and Process Survey

ii) *Locations:*

21 districts; Taplejung, Terhathum, Morang, Solukhumbu, Saptari, Ramechhap, Dhanusha, Sarlahi, Bara, Sindhupalchowk, Rasuwa, Kathmandu, Lamjung, Nawalparasi, Arghakhachi, Rolpa, Banke, Jumla, Mugu, Bajhang, and Doti.

iii) *Description*

The PoSHAN policy process survey collects data from roughly 500 government and non-government civil servants and other professionals at various administrative tiers across Nepal in the same areas as the PoSHAN Community Studies. The goal is to measure better and understand the role of enhanced 'nutrition governance' in meeting the goals of policies seeking to enhance nutrition. The fourth round ended in October 2016. A fifth round of data collection is planned at the end of the year.

This year, the ME conducted data management and cleaning of datasets that has over 1800 person-visits conducted during four annual visits in 21 PoSHAN districts of Nepal. The updated dataset will allow to better measure and understand the role of enhanced 'nutrition governance' in meeting the goals of policies seeking to enhance nutrition implementation and programming. Due to the restructuring of the federal states in Nepal, the fifth round of data collection could not happen in FY2019 and was postponed to November 2019. In the meantime, the ME and the Nepal team has periodically interacted with in-country collaborators such as Helen Keller International (HKI), Suaahara and Valley Research Group (VaRG) to continue planning for the fifth round of data collection.

iv) *Theory of Change and Impact (Pathways)*

The research contributes to better understanding of the linkages and **agriculture to nutrition impact pathways**. This research includes the Nutrition Lab's innovative focus on policy implementation efficiency, measuring the capacity of implementing partners, and changes in household nutrition outcomes. Such research relates primarily to the second column of boxes in Figure 1, which

has a box on 'climate, seasonality, and volatility at the top (refer to the Nutrition Innovation Lab's main theory of change).

v) *Collaborators:*

Patan Academy of Health Sciences, HKI Nepal, Valley Research Group (VaRG), and Tufts University

vi) *Achievements:*

Datasets from all four rounds with over 1800 person-visits was successfully cleaned. During the 6th Annual Scientific Symposium in Nepal, a novel method to measure nutrition governance at the sub-national level (district down to the wards) was presented using a multi-year data. The innovative Nutrition Governance Indicator (NGI) defines a first standardized approach to quantifying the 'quality of governance' in relation to national plans of action to accelerate improvements in nutrition. Applied as a series of questions to civil servants in multiple sectors/line ministries (i.e. Agriculture, Livestock, Health, Water, Sanitation and Hygiene, Education, Local Development, etc.), the NGI consist of six domains (nutrition knowledge, capacity, collaboration, access to financial resources, leadership, commitment/support). The final score ranges from 1 to 5, groupings of issues established using principle components analysis (PCA). Findings suggest that the health sector did well with a better mean NGI score followed by the agriculture sector in the index. About fifty percent (50%) of respondents from the health sectors were more likely to score higher compared to other sectors (OR 0.52, 95% CI 0.36 – 0.74). Training on nutrition was associated with an improved NGI score (OR 1.40, 95% CI 0.79-2.48). The new method of NGI was successful in measuring quality of nutrition governance in Nepal across different sectors (health, agriculture, livestock, local development, WASH and education) with the Multi-Sector Nutrition Plan (MSNP) framework and also revealed an improvement in overall governance over a two-year period in the nation's various administrative levels/governance sectors. These findings underscore the practical utility of the index and its importance to the policy world. A manuscript has been submitted to BMJ and is under review.

Building on to the NGI paper, a number of subsequent analyses are underway. An analysis on identifying key determinants of Nutrition Governance Indicator (NGI) at the sub-national level has just started in September 2019. The finding will be presented during the 7th Scientific Symposium in Nepal in December 2019 and are eagerly awaited by numerous policymakers in Kathmandu.

In addition, a 5th and final round of data is being planned for the end of 2019. This additional survey round will be used to assess how the determinants has transferred from the previous administrative structure to the new federal structure of Nepal. Adding data from the fifth round will also provide a valuable and critical insights to policymakers and stakeholders at both the central and provincial level on how adoption of the federal structure has affected governance around nutrition and multi-sectoral initiatives on nutrition in Nepal.

vii) *Capacity Building*

As part of the institutional capacity building, an important accomplishment this past year was the use of previous papers (Webb et al, 2016) on measuring nutrition governance in Nepal that was used as a desk review paper by the stakeholders of the government of Nepal in relation to the implementation of the second phase of multisectoral nutrition plan (MSNP) at the sub-national level in Nepal.

viii) *Lessons Learned*

The research outputs from this research so far suggest that data generated from policy process surveys can be very important for documenting strengths and weaknesses in governance processes for nutrition. The positive external reviews of the articles and a subsequent highlight of the Food and

Nutrition Bulletin articles in an online network (ENN Online) confirmed strong global research interest in this innovation domain of study and the credibility of the data. The newly designed Nutrition Governance Indicator (NGI) defines a **first standardized approach** to quantifying the 'quality of governance' in relation to national plans of action to accelerate improvements in nutrition.

ix) *Presentations and Publications:*

Publications:

- I. Namirembe G., Shrestha R., Houser R., Ghosh S., Baral K., Davis D., Webb P. Measuring Governance: Developing a novel metric for assessing the translation of policies into action in Nepal. Submitted to BMC Nutrition, July 2019 (under peer-review).

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral presentations					
Grace Namirembe	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Measuring the Policy Process: Applying a Nutrition Governance Indicator at the sub-national level in Nepal	November 2018	~350

3. Impact on Nutrition of Specific Behavior Change Communication (BCC) Layered over a Livestock Training Intervention

The agriculture to nutrition pathway continues to be explained through several projects.

Project 2: This project began in the spring/summer of 2013 in Banke District, Nepal. The goal was to investigate child health and nutrition in communities randomized to receive one of three interventions: (1) Heifer community development activities and livestock training, supplemented by specific training in child nutrition; (2) livestock training and nutrition training alone; or (3) no activities. Five rounds of data collection for this project were completed.

Project 2B: This project was funded by the Nutrition Innovation Lab by a grant to the Harvard School of Public Health (HSPH). Heifer International was invited to collaborate with HSPH, the Institute of Medicine (Nepal), and the University of Bergen (Norway) to conduct a field trial of a child development assessment tool (Ages and Stages Questionnaire, ASQ). Specific aims of this project were to 1) validate the use of this instrument in rural Nepal, and 2) explore the feasibility of training non-professional field staff to administer this test accurately. This was accomplished as an ancillary activity during Round 3 of data collection of Project 2. The details of this collaboration are described in reports submitted by the HSPH.

Project 2C: This project was a direct extension of Project 2B. The developmental assessment conducted in Project 2B was extended to include testing of children ages 5-6 years. For this activity, funding was provided by the Nutrition Innovation Lab to Heifer International. Data collection for this activity was completed in August of 2017.

Project 3: Funding was obtained from the Livestock Systems Innovation Lab to implement a research project assessing the impact of a targeted nutrition curriculum on milk consumption by young children.

Additional funding has been obtained from the Nutrition Innovation Lab to enhance several components of the research design. Field activities for this project will begin in November 2019.

i) This activity is implemented by Heifer Project Nepal and focuses on answering the question: “*What is the value-added for nutrition of BCC beyond enhanced agricultural practices associated with livestock management?*” We hypothesized that inclusion of a nutrition intervention within a program that enhances agricultural practices around livestock would further improve child nutritional outcomes. A basic nutrition education curriculum was developed, and field tested by Heifer Project Nepal. However, the effect of the use of this curriculum on child growth is unknown. In addition, Heifer Project Nepal activities in Project IA were not disaggregated with regard to specific animal husbandry training, provision of livestock, and community/social capital development. Heifer Project Nepal community development activities typically include broad supports related to promotion of social capital (values training, facilitation of formation of women’s groups, social mobilization, training in savings, microcredit, and enterprise development), along with training in animal husbandry and provision of livestock.

Given the results in Project IA and IB, it was important to attempt to isolate the effect of the community development activities on the child health and growth outcomes. Therefore, a trial was designed to include matched communities in Heifer Project Nepal’s working areas. Communities were randomly assigned to receive either: (1) Heifer activities plus the nutrition curriculum; (2) training in child nutrition and animal husbandry, and provision of livestock, without social capital activities; or (3) no interventions. Surveys to address demographics (family composition, socioeconomic status, income sources, livestock ownership, child health, child nutrition, and dietary diversity) were conducted at baseline, and then every six months for two years (five surveys total). Anthropometric measurements are obtained on all household children at each survey time, along with indicators of child health and diet.

Specific Aim 1: Disaggregate the effect of nutrition and livestock training from social capital development in the longitudinal assessment of child health and growth. Assess the impact of training alone, training in the context of social capital development, vs no inputs (control group) on

- a. household status (income, SES, animal ownership, etc.)
- b. child and household diet quality (consumption of animal source foods, dietary diversity)
- c. child health
- d. child growth

Specific Aim 2: Analyze the effects of the introduction of the nutrition curriculum on child growth and nutritional status

- a. Assess child nutritional outcomes
- b. Determine characteristics of families related to child nutritional and health status
- c. Identify behavioral changes among participants as a result of curriculum
- d. Conduct focus group discussions with participants to evaluate responses to the use of the curriculum

ii) *Location:*
Banke district in Nepal

iii) *Theory of Change and Impact Pathway(s):*

Results of Project I highlighted the impact of community development and livestock training on child outcomes, even if these latter were not targeted directly. However, the improvements in child diet and growth were modest. We hypothesized that focused nutrition training would have more direct benefits

on these child outcomes. Additionally, it was of interest to disaggregate the “social capital development” component from the training components of the intervention. The theory was that training in the context of community development would be more effective than training alone. In other words, the community development activities (which included a women’s empowerment component) would provide a framework favoring household decisions which would benefit children. Other pathways, independent of women’s empowerment, were also considered.

iv) *Collaborators:*

Heifer International (Little Rock, Arkansas), Heifer Nepal (Kathmandu, Nepal), Dr. Laurie Miller (Heifer International, Consultant), Dr. Beatrice Rogers (Professor, Friedman School of Nutrition Science and Policy, Tufts University), and Dr. Robert Houser (Statistician, Friedman School of Nutrition Science and Policy, Tufts University). Additional guidance and input from Nutrition Innovation Lab leadership (Dr. Patrick Webb, Dr. Shibani Ghosh and Dr. Eileen Kennedy).

v) *Achievements:*

- (a) Approvals, progress reports, and renewals submitted as required to Tufts University Institutional Review Board and the NHRC.
- (b) Appropriate MOUs developed and maintained between Heifer International, Heifer Project Nepal, and Laurie Miller.
- (c) Five rounds of data collection were completed (Round 1: July-August 2013; Round 2: April 2014; Round 3: November-December 2014, Round 4: November 2015; Round 5: May 2016). The interval between Round 1 and Round 2 was eight months (there was a delay in starting the project activities due to local conditions); between Round 2 and 3 was seven months, between Round 1 and 3 was 15 months, and between Round 3 and 4 was 12 months. The difficulties in this schedule reflected unfortunate local circumstances. For example, Round 4 was initially scheduled for April 2015, but was cancelled due to the earthquake in Nepal. It was finally completed in November 2015, at a time when conditions were difficult due to the border blockade from India. The final round (Round 5) was completed in the spring to permit analysis of seasonal trends.
- (d) The baseline data collection included 960 households (289 assigned to Heifer plus nutrition training group, 367 assigned to training-only group, and 304 assigned to control group). These households had a total of 1,300 children <5 years of age (350 from Heifer plus nutrition training group, 510 from training only group, and 440 from control group). Altogether, there were 1,057 mothers interviewed (some households had >1 eligible mother as extended family often share a single household in Nepal).

The number of participants over four rounds of data collection is summarized in the table below. Altogether, 974 unique households were enrolled. The number of unique households is greater than the number of households at baseline as some households “split” during the study period (e.g., some members of the enrolled household left to form a new, separate household).

Total households visited	Intervention	Partial	Control	Total
First round	289	367	304	960
Second round	263	347	292	902
Third round	263	349	289	901
Fourth round	261	343	283	887
Fifth round	256	334	277	867

- (e) After the baseline survey, Heifer field teams began work with the Full Intervention group as well as the Training Only group.
- (f) The Heifer Intervention was provided to Partial and Control groups after completion of Round 5 of data collection.
- (g) The data was cleaned and entered for all five rounds.
- (h) In the last 12 months: the first peer-reviewed paper was published.
- (i) In the last 12 months: 2 abstracts were presented at international meetings.
- (j) In the last 12 months: A graduate student at Friedman School has begun an analysis of the women's empowerment results in the dataset.
- (k) Study findings are still emerging. The first published paper describes the impact of the community development component of the intervention, in comparison to the Training Only and Control groups. Participants in the Full Intervention had better household outcomes (increase in wealth), while their children had better growth and better diets. This provides compelling support for the importance of context when training is provided. Many programs provide training without this context. While more expensive and difficult to administer, a supportive structure for interventions markedly increases the efficacy of an intervention. Previous research has suggested that when the community mobilizes itself to become an active agent of change, individuals may more readily alter socio-environmental risk factors including home care practices and household decision making, with subsequent benefits to the children in the household. When community mobilization efforts are sustained and successful, there is the potential to produce a long-term and fundamental shift in village, family, and gender power relations, resulting in improved food security, reduced childhood illness, and increased ability of the family to care for the child. In this project, we attempted to disaggregate some of these factors in order to gain insight into the mechanisms by which behavior change communication improves child nutritional outcomes.

vi) *Capacity Building:*

- (a) Heifer Project Nepal office and field staff, as well as the Valley Research Group team, received training in Ethics of Human Subjects Research prior to each round of field work
- (b) In the last 12 months: Heifer Project Nepal and Valley Research Group teams received mentoring in conduct of longitudinal research
- (c) In the last 12 months: Heifer Project Nepal and Valley Research Group teams received mentoring in statistical methods
- (d) Valley Research Group received training in child growth and anthropometry methodologies
- (e) Nepali dieticians were mentored in development of nutrition training curriculum

vii) *Lessons Learned:*

We encountered several serious problems which interfered with data collection in our project area. The baseline data collection took place during July-August 2013. Round 2 data collection, which was initially scheduled for January-February 2014, was postponed until March-April 2014 due to unexpected political activity in the area which made travel difficult. The third round of data collection took place in November 2014, but at the end of August 2015, the region was devastated by severe mud slides. There was extensive loss of life, property, and livestock, and the situation was chaotic for many weeks. The scheduled Round 4 data collection was cancelled due to the major earthquake in April 2015. This was rescheduled for November 2015, which was further complicated by the border blockade from India. Round 5 data collection was undertaken in June 2016 (to provide seasonal data for comparative purposes). The underlying lesson is to “expect the unexpected” and build flexibility into research plans. .

viii) *Presentations and Publications*

Publication (peer-reviewed)

1. Miller LC, Neupane S, Joshi N, Lohani M, Rogers BL, Neupane S, Ghosh S, Webb P. Multisectoral community development in Nepal has greater effects on child growth and diet than nutrition education alone. Public Health Nutrition, Sept 2019. doi:10.1017/S136898001900260X.
2. Varijakshapanicker P, Mckune S, Miller LC, Hendrickx S, Balehegn M, Dahl GE, Adesogan AT. Sustainable livestock systems to improve human health, nutrition, and economic status. Animal Frontiers October 2019, Vol. 9, No. 4doi: 10.1093/af/vfz041.

Presentations

Presenter	Event	Location	Topic	Date	Audience
Abstract presented (poster presentation)					
Laurie Miller	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Multisector community development improves child diet quality relative to other household members more than nutrition training alone in rural Nepal	November 2018	~350
Laurie Miller	Livestock Science Innovation Lab Symposium	Kathmandu, Nepal	Multisector community development improves child diet quality relative to other household members more than nutrition training alone in rural Nepal	April 2019	~100

Presenter	Event	Location	Topic	Date	Audience
Abstract accepted (poster presentation)					
Laurie Miller	7 th Annual Scientific Symposium	Kathmandu, Nepal	Children of depressed mothers in rural Nepal consume diets with less diversity and fewer animal source foods (ASFs)	December 2019 (Under review)	
Laurie Miller	7 th Annual Scientific Symposium	Kathmandu, Nepal	Nutrition education as part of a multisectoral community development program improves women's hygiene practices and knowledge of infant and young child feeding (IYCF), but not their breast-feeding practices: comparison with women who received	December 2019 (Under review)	

			nutrition education alone		
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4. Child Development in Rural Nepal: relationship to diet and livestock (Project IA and IB)

Project IA: This project consisted of a longitudinal survey (2009-2011) of child growth and nutritional status in a cohort of 415 rural families residing in three districts in Nepal: Nawalparasi, Chitwan, and Nuwakot. The research activities were conducted in the context of a two-year randomized controlled trial of the effects of community development activities (supervised by Heifer Project Nepal) on child health and nutrition. Five rounds of data collection were completed.

Project IB: This project was a follow-up survey of the households previously studied in Project IA, four years after baseline. The goals of this study were to assess primary outcomes of child health and growth, as well as secondary outcomes of household socioeconomic status, income, animal ownership, land ownership, and dietary diversity over a longer time period.

i) *Name:*
Livestock Interventions in Rural Nepal: Effects on Child Health and Nutrition

ii) *Location:*
Nawalparasi, Chitwan, and Nuwakot Districts, Nepal

iii) *Description:*
This project consisted of a longitudinal survey (2009-2011) of child growth and nutritional status in a cohort of 415 rural families. The research activities were conducted in the context of a two-year randomized controlled trial of the effects of community development activities (supervised by Heifer Project Nepal) on child health and nutrition. The goals of this study were to assess primary outcomes of child health and growth, as well as secondary outcomes of household socioeconomic status, income, animal ownership, land ownership, and dietary diversity. In Project IA (funded by Heifer Project Nepal), 5 rounds of data collection were completed, every six months for two years. A 125-item questionnaire addressing demographics (family composition, socioeconomic status, income sources, livestock ownership, child health, child nutrition, and dietary diversity) was administered, and anthropometric data on all household children was collected. While important trends and differences in outcomes were seen at 12 and 24 months, it was hypothesized that improvements in child health and nutrition will increase with longer duration of Heifer interventions. Alternatively, reduced benefits of Heifer activity on child nutrition might have been seen as time progressed. Project IB (funded by NIL) was designed to test these hypotheses. Thus, a follow-up survey, with the following specific aims, was conducted four years after baseline:

Specific Aim I: Extend data collection for previous existing project. The opportunity to extend this project provided a special opportunity to obtain longitudinal nutritional data in a large sample of children, in the context of socioeconomic, demographic, and other parameters.

Specific Aim 2: Analyze effects of Heifer Project Nepal activities on outcomes of child health and nutrition four years after the initiation of the intervention.

- a. Evaluate longer-term outcomes of Heifer activities on child growth and health.
- b. Identify characteristics of families and children who demonstrate most improvement in child nutrition.
- c. Identify characteristics of families and children who demonstrate the least improvement in child nutrition.
- d. Use this information to further refine program activities.

iv) *Theory of Change and Impact Pathway(s):*

This project was designed to assess the impact of a community development intervention on important child outcomes, even though these outcomes were not the target of the intervention. These research activities were conducted in collaboration with Heifer Project Nepal, the local partner of Heifer International. The organization uses the introduction of livestock and related training as tools for poverty alleviation, citizen empowerment, and community development. Heifer International activities focus on the distribution of livestock and training to rural women's groups with an emphasis on income generation. These activities occur within the context of a strong focus on the development of social capital, specifically citizen empowerment, values training, social mobilization, microcredit, and enterprise development, and are based in women's Self-Help Groups. However, it was not clear that these activities were benefiting children. The possibility that children were harmed by these activities was also considered, e.g., via less parental time for children, increase in zoonotic disease risk, etc. Thus, the research was designed to assess child growth and diet in households which did or did not receive the Heifer intervention. As expected, the Heifer intervention was successful in increasing the household wealth and socio-economic status of participating families. Child growth and child diet also improved, related to household participation in the Heifer program even though these outcomes were not specifically targeted. However, improvements were limited. This led to questions about how these outcomes could be addressed more effectively in the context of the Heifer program.

Heifer International values research as a means to inform their field activities and policies. As Heifer has active programs in more than 20 countries throughout the world, research findings may be quickly disseminated into field practice to benefit child health and nutrition outcomes in project areas. Indeed, results of Project 1A (the initial 24 months of data collection in the Nawalparasi, Nuwakot, and Chitwan Districts) revealed a deficiency in nutrition education as part of the Heifer Nepal program. Subsequently, a nutrition curriculum was developed for Heifer International programs in Asia and Africa and is currently being used as a supplement to existing Heifer International activities in these regions. Similarly, recent findings showed an impact of women's educational level on the success of program implementation. This has resulted in considerable discussion at Heifer Headquarters regarding ways to address this issue in the field, and a detailed internal review of field programs related to behavior change communication. In addition, the initial findings related to child developmental status has opened a serious conversation about this important parameter and how it can best be addressed. Thus, the Nutrition Innovation Lab research has had a direct and immediate impact on policy and practice at Heifer, not only in Nepal, but in all of Heifer's programs world-wide. The findings have allowed a rapid translation of research into practice. Overall, the research activities have strongly focused Heifer's attention on the well-being of children as a central part of their programs.

v) *Collaborators:*

Heifer International (Little Rock, Arkansas), Heifer Project Nepal (Kathmandu, Nepal), Dr. Laurie Miller (Heifer International, Consultant), Dr. Beatrice Rogers (Professor, Friedman School of Nutrition Science and Policy, Tufts University), and Dr. Robert Houser (Statistician, Friedman School of Nutrition Science and Policy, Tufts University). Additional guidance and input from Nutrition Innovation Lab leadership (Dr. Patrick Webb, Dr. Shibani Ghosh).

vi) *Achievements:*

Successfully completed data collection and child anthropometry to obtain 48-month results in 415 households in the Nawalparasi, Nuwakot, and Chitwan Districts. 7 abstracts presented; 6 manuscripts published in peer-reviewed journals. There are several notable scientific achievements of these research activity. First, the results demonstrated that a community development program which did not target children and offered no specific nutrition training nevertheless impacted the important outcomes of child growth and child diet. Second, the intervention unexpectedly improved intrahousehold food distribution practices. Third, the research demonstrated that the impact of the program became more apparent over time. Specifically, a greater impact was seen on growth outcomes 4 years after baseline. This provides the important message that the results of an intervention may not become manifest within an “expected” time frame, and that longer project cycles may provide valuable information about program efficacy. This message is important for government and other groups which provide community interventions: interpretation of results may differ depending on the time frame. As child growth reflects cumulative experiences, examining this outcome “too early” may obscure important results of an intervention. Fourth, results of interventions are very dependent on personal characteristics of the recipients of these inputs. While it’s obvious that this is the case, the importance of specific personal factors has not been well-studied. Our analysis quantified the difference that maternal education made in response to the intervention, in terms of household wealth, child diet, and child growth.

vii) *Capacity Building:*

- (a) Successfully mentored Nepal-based research NGO (Nepal Technical Assistance Group, NTAG) over four years in the conduct of a longitudinal research project. This was their first longitudinal project, so the experience contributed greatly to their capacity.
- (b) Supervised Nepali staff in data cleaning and data management for longitudinal research project.
- (c) Developed research skills and awareness of Heifer Project Nepal office and field staff.
- (d) Heifer Project Nepal staff and NTAG staff received training in Ethics of Human Subjects Research.

viii) *Lessons Learned:*

- (a) Special expertise is required to successfully conduct longitudinal research projects.
- (b) Feedback from Field Enumerators can provide valuable insights into project success and candid assessments of interventions.

ix) *Presentations and Publications*

N/A

5. Action Against Malnutrition through Agriculture (AAMA)

i) *An evaluation of the sustained activities of a combined home garden, poultry, and nutrition education intervention in Kailali, Baitadi, and Bajura districts of far western Nepal.*

The AAMA program was implemented by the Helen Keller International in the three districts of Western Nepal from 2009 through 2012, with the period of implementation being the longest in Kailali followed by Baitadi and Bajura districts. All three districts were exposed to at least one program component, that is, the homestead food gardening (HFG). A qualitative survey was conducted by the Nutrition Innovation Lab using focus group discussions and in-depth interview methods from 114 AAMA program implementers and beneficiaries across three intervention districts of Nepal. The survey rolled out in January 2017 and was completed in February 2017.

ii) *Theory of Change:*

The research contributes to better understanding of the linkages and **agriculture to nutrition impact pathways**. This research includes the Nutrition Lab's innovative focus on policy implementation efficiency, measuring the capacity of implementing partners at the front-line level, and changes in household nutrition outcomes. Such research relates primarily to the second column of boxes in Figure I, which has a box on 'climate, seasonality, and volatility at the top (refer to the Nutrition Innovation Lab's main theory of change).

iii) *Collaborators:*

Government of Nepal Ministry of Health Child Health Division, Tribhuvan University Institute of Medicine, Patan Academy of Health Sciences, Helen Keller International Nepal, Valley Research Group and Tufts University.

iv) *Achievements:*

Data transcripts and translations were completed and cleaned. Initial findings from the qualitative survey found that the fidelity of the AAMA program was different in each of the targeted districts. In some of the location, the program had interactions with participating households. This happened in locations where multiple inputs were provided to the participants and where model farmers were already well trained, and where most of the model farmers were female health volunteers (led to building trust in the community before AAMA arrived). Locations where interactions were fewer were where model farmers and health volunteers were different individuals (non-FCHVs). A report was completed and is under review. Findings on factors impacting sustainability of AAMA program activities was presented at the 6th Annual Scientific Symposium in November 2018, in Kathmandu Nepal.

v) *Presentations and Publications:*

Qualitative analysis and findings have been put together in a survey report that is under review. Paper writing, publication identification, and submission timeline will follow.

vi) *Issues and concerns:*

There was a slight delay during the analysis phase as the team revisited the original transcripts and translated documents that were translated and coded by in-country translators for focus group questions, particularly on sustainability. The coding and thematic areas were revised, and the team was able to resume the data analysis.

vii) *Lessons Learned:*

Initial analysis and findings have suggested that although certain components of community programs like AAMA (especially home gardens, nutrition education) may have self-sustained and/or scaled up and the sustainability, capacity of local resource persons and local governance needs to be strengthened for a sustainability of impacts. Measuring impacts of a program over the time (4-5 years in this case) is a novel approach but understanding what sustains impact beyond that time matters even more.

6. Frontline Workers Study (Nepal)

- i) This study represents an in-depth assessment of the knowledge, attitudes and practices of the network of individuals who work in different sectors at Village Development Committee (VDC) and ward level—interacting with households. The study is linked to the front-line worker survey conducted in late 2015 to determine the effectiveness of USAID's Suaahara Project's approach to building the knowledge and skills of the FLWs, with a view to disseminating key program messages to the community. The latter

study was conducted in a sub sample of Suaahara sites; the present survey adopted the same instruments and applied them to PoSHAN sites surveyed in 2015 along with five “expansion” districts where Suaahara began to operate from 2015 onward.

ii) *Locations:*

13 districts: Jumla, Arghakhanchi, Doti, Dadeldhura, Baitadi, Achham, Banke, Nawalparasi, Morang, Saptari, Dhanusa, Sarlahi and Bara.

iii) *Theory of Change and Impact Pathways(s):*

The research contributes to better understanding of the linkages and **agriculture to nutrition impact pathways**. This research includes the Nutrition Lab’s innovative focus on policy implementation efficiency, measuring the capacity of implementing partners at the front-line level, and changes in household nutrition outcomes. Such research relates primarily to the second column of boxes in Figure 1, which has a box on ‘climate, seasonality, and volatility at the top (refer to the Nutrition Innovation Lab’s main theory of change).

iv) *Collaborators:*

Save the Children, IFPRI, Patan Academy of Health Sciences, Hellen Keller International, Valley Research Group and Tufts University.

v) *Achievements:*

Data collection was completed in most of the intended sites, despite the logistical challenges posed by the April 2015 earthquake. Preliminary descriptive analyses have shown that most FLWs in the surveyed districts received trainings within their own sectors but were less likely to have trainings across sectors. Awareness of longer-term consequences to malnutrition and benefits of acting early within the first 1000 days of a child’s life was evident. There were, however, gaps in knowledge about potential benefits of nutrition-sensitive actions. A poster presentation on the assessment of the capacity of frontline workers in the implementation of integrated nutrition programs in Nepal was presented during the 6th Annual Scientific Symposium being held in November 2018, in Kathmandu Nepal. The presentation highlighted that majority of FLWs received training in nutrition, agriculture and health through MSNP trainings, as well as trainings from programs like Suaahara, KISAN, etc. The analysis also found that capacity and knowledge on nutrition actions is strong within the health sectors (Government Health, FCHVs). Nonetheless, the analysis also demonstrated an inadequate nutrition knowledge among health sector FLWs in correctly identifying malnutrition. There was, however, variability across non-health sectors (Government of Agriculture and other non-profit Agriculture sectors) trained in nutrition topics and their knowledge on nutrition.

vi) *Lessons Learned:*

As Nepal rolls out its second phase of MSNP, further investment on increasing nutrition capacities of FLWs’ is highly recommended at all levels and sectors. Further analysis from the Nutrition Innovation Lab will focus on how the knowledge on nutrition and personal practices match among FLWs.

vii) *Presentations and Publications:*

Presentations

Presenter	Event	Location	Topic	Date	Audience
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Lindsey M. Locks	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Understanding nutrition capacities of FLWs in implementation of integrated nutrition programs in Nepal	Nov 27-29 2018	~100
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I. Birth Cohort Study, Uganda

The Uganda Birth Cohort Study examined the effect of interventions that integrate nutrition, health, agriculture, and livelihoods on maternal and child nutritional outcomes. The study enrolled 5044 pregnant women and followed them and their children to study birth and growth outcomes in districts targeted by USAID's Community Connector Project (CCP) versus those in non-targeted districts.

Specific Aim 1: To determine the effect of aflatoxin exposure and environmental enteropathy on health and nutritional status of mothers and children under two years of age.

Specific Aim 2: To compute and identify discrete growth trajectories in Ugandan infants using linear growth, determine the pattern of growth in each trajectory and assess the pre and post-natal factors associated with each trajectory.

Specific Aim 3: To determine the relationship between maternal iron and vitamin A biomarkers (ferritin, soluble transferrin receptor, body iron index, Hemoglobin and retinol binding protein) and birth outcomes (body weight, z scores, head circumference, small-for-gestational-age and preterm birth) after adjusting for relevant factors.

Specific Aim 4: To identify an empirical threshold level of aflatoxin exposure beyond which there is a notable difference in adverse birth outcomes.

- i) *Locations:*
Nine districts of Northern Uganda and six districts of Southwestern Uganda
- ii) *Theory of Change and Impact Pathway(s):*
The Nutrition Lab has a specific research theme that focuses on elucidating **neglected biological pathways** that may affect nutrition outcomes particularly birth outcomes in pregnancy and linear growth in infants and young children. This theme is embodied by the Uganda birth cohort study that looks at the relationship between mycotoxin (aflatoxin) exposure and growth outcome in children. This stream of work focuses on issues in the fourth column, which is headed by a box on 'nutrient-poor natural resources' in Figure I (refer to the main framework discussed above in the report).
- iii) *Collaborators:*
Makerere University, Harvard University, International Food Policy Research Institute (IFPRI) and Tufts University
- iv) *Achievements:*
This year, the birth cohort study completed extensive data cleaning and consistency checks of all survey visits to create a shareable version of datasets. A number of analysis and write ups have been completed this year. An analysis examining the growth pattern within the first 1000 days is ongoing. Preliminary findings from the aflatoxin analysis suggest a lack of link between maternal aflatoxin

exposure (using absolute values) and adverse birth outcomes. However, aflatoxin exposure per kilogram of body weight in mothers yielded a significant negative association with birth weight in the newborns. The findings are similar to the study conducted by Nutrition Lab in Uganda by Lauer et al, that found a negative association with maternal aflatoxin levels and head circumference in infants (Lauer et al).

In addition to the aflatoxin analysis, a separate analysis was undertaken to try to identify a cut-off or a threshold level for aflatoxin exposure. Using data from the birth cohort study in Uganda and another birth cohort in Nepal, a number of sensitivity and specificity tests were conducted for each cut-off point of aflatoxin levels in relation to actual birth outcomes. Unfortunately, this analysis has so far not succeeded in identifying an empirical threshold value. Further work is needed to understand the nature of the relationship and to look at child aflatoxin exposure and growth outcomes over time.

Analysis focused on micronutrient status of mothers and their infants in Uganda is ongoing. The preliminary findings show that iron status of the mother (sTFR) might be associated with increased risk for preterm births. We also found that Vitamin A status (RBP) of the mother is associated with desirable birth outcomes. Whereas the latter finding is relatively commonplace, the former is controversial and the subject of recent debate. Currently, WHO recommends mandatory iron supplementation in pregnant women based off a body of evidence that is in agreement with this policy. However, findings like ours serve to introduce alternative perspectives that may ignite a debate on long-established protocols with the end goal of improving the nutritional and health status of target populations. A manuscript is ready for submission in October 2019 to the *Nutrients Journal*.

v) *Capacity Building:*

The former graduate students who cleaned and managed the database have since graduated from Tufts University. Julieta Mezzano is now affiliated with the research team at Tufts, working as a research assistant and tutoring graduate students in Biostatistics methods. Binita Subedi went on to work at the Tufts Human Nutrition and Research Center for Aging (HNRCA).

vi) *Lessons Learned:*

The Uganda birth cohort database is rich because it has several modules and data points that offer numerous variables to tease out important relationships. Longitudinal study designs give more flexibility and information: with the Uganda Birth Cohort study, we had the liberty to compare data not only within cross-sections but also longitudinally and at multiple time points.

vii) *Presentations and Publications*

Publications (peer reviewed abstract)

1. Mezzano J., Namirembe G., Ausman L., Marino-Costello E., Shrestha R., Erhardt J., et al. Iron and Vitamin A Biomarkers in Mothers and Infants in Rural Uganda: Using the BRINDA Approach to Adjust for Inflammation (P10-108-19). *Curr Dev Nutr*. Published 2019 Jun 13. doi:10.1093/cdn/nzz034.P10-108-19

Manuscripts for submission (ready for submission)

1. Mezzano J., Namirembe G., Ausman L., Marino-Costello E., Shrestha R., Erhardt J., Webb P., and Ghosh S. Iron and Vitamin A levels in pregnant mothers and birth outcomes: results from the Uganda Birth Cohort Study. To be submitted to *Nutrients journal* in October 2019.
2. Ghosh S., Namirembe G., Mezzano J., Ausman L., Marino-Costello E., Shrestha R., Wang JS., and Webb P. Maternal aflatoxin levels are not associated with birth outcomes in children from rural Northern and South West regions of Uganda.

3. Ghosh S., Namirembe G., Mezzano J., Ausman L., Marino-Costello E., Shrestha R., Wang JS., and Webb P. Four growth trajectories identified in Ugandan infants from birth to 12 months: An assessment of stunting and linear growth over time: findings from a Uganda birth cohort study

8. Uganda Panel Evaluation of USAID Community Connector Program

- i) *Assessing the linkage between agriculture, food security, nutrition and health among women and children in rural Ugandan households*

The panel surveys were conducted to determine if, and how, the USAID Uganda Community Connector (UCCP) has improved production practices, incomes and nutrition. Panel surveys were conducted by holding face to face interviews with households and by taking body anthropometric measurements and an assessment of anemia and malaria using rapid diagnostic kits.

- ii) *Locations:*

Agago, Dokolo, Kole, Lira, Kamwenge, Kisoro

- iii) *Theory of Change:*

This research includes the Nutrition Lab's innovative focus on large scale program implementation efficiency, measuring the fidelity and impact and changes in household nutrition outcomes differentiated by agro-ecology, seasonality, wealth factors, and gender. Such research relates primarily to the second column of boxes in Figure 1 (refer to the main Theory of Change framework), which has a box on 'climate, seasonality, and volatility' and 'information and behavior change communication'.

- iv) *Collaborators:*

Makerere University, Harvard, and International Food Policy Research Institute (IFPRI) and Tufts

- v) *Accomplishments:*

Several analyses continued in the past year. A key message from a pooled analysis highlights crop diversity at farm level to be positively associated with women's diet diversity score and child's diet diversity score, but proximity to markets was negatively associated with child diet diversity. This implies that there is need for rural smallholder households in Uganda to grow diverse crops and rear different types of livestock to be able to attain the minimum recommended diverse diets. Moreover, it is not clear yet whether food markets play an important role in providing diverse diets for children in Uganda. Another key message from the pooled analysis that owning livestock was associated with higher intake ASF and better nutrition. Further learning on the multisector programming to diversify farming and diet was shared.

An analysis to assess the causal linkages between agriculture, nutrition and health for improved outcomes in Uganda based on the a 3-year panel study is underway. This analysis is focused more on the impact of the 5-year integrated agriculture-nutrition program—the Community Connector (CC) Program—implemented by FHI360 to reduce maternal and child malnutrition in Uganda. The analysis found that CC had significantly improved cropping and production diversity, particularly concerning the cultivation of nutrient-rich vegetables and fruits. CC modestly improved access to loans from the social saving groups but the effects were substantial if these groups were closely linked to agricultural innovations. CC had significant impact on promoting the construction of drying racks for utensils, which increased by up to 15% over time. CC increased health-seeking behavior by up to 15% with the proportion of women delivering at health centers increasing by 5%. The combined effect of CC interventions linking agriculture and nutrition increased the proportion of children (aged 6-23 months) receiving a recommended minimum diet by 6%. Moreover, CC had a very notable positive impacts on maternal diet quality, which augments well for intergenerational effects of nutrition (i.e. the health and growth of subsequent babies). The many positives from this complex

program, coupled with lessons learned regarding implementation fidelity, suggest that multisector programming for nutrition has further potential across Uganda and other countries in similar contexts.

Additional analysis on relationship between cattle ownership, childhood malaria and anemia in Uganda have shown that cattle ownership significantly increased prevalence of malaria in children under five years of age. Malaria was in turn linked to a 28% increase in anemia. In districts where indoor residue spraying (IRS) had taken place to kill mosquitoes, both childhood malaria and anemia prevalence were much lower but cattle ownership enhanced child exposure to mosquitoes, which increased malaria prevalence by 4% to 8% in areas with IRS. The implication is that IRS, which kills indoor mosquitoes, may affect residual malaria transmission by outdoor mosquitoes that feed on both cattle and humans. Efforts to enhance nutrition and health by the agricultural intervention of cattle promotion may need to include livestock-oriented vector control.

The findings on the linkages between food and water for sanitation to explain the regional differences in child undernutrition rates in Uganda have shown that contrary to conventional wisdom, the differentials in undernutrition across regions of Uganda are not necessarily due to differences in food production or diet diversity but are heavily driven by differences in domestic water use. This finding does not negate the need to address food insecurity but suggest a need for greater attention to WASH interventions alongside agricultural productivity enhancement.

Finally, evidence on the role of improved agricultural technologies in dairy cows and how the technology benefits smallholder farmers in Uganda showed that household ownership of improved dairy cow breeds significantly increased milk production, household's participation in milk markets and food expenditure. Consequently, improved dairy cows reduced household poverty and stunting for children younger than age five. The analyses are being drafted into manuscripts, led by Nassul Kabunga and researchers at Tufts. In July 2019, a team from Tufts University together with Makerere University visited Kamwenge and Kitagwenda districts and presented results of the panel data analysis. The key takeaway messages from this workshop were that (a) there was a significant positive change in the implementation and coverage of nutrition-specific interventions (health and nutrition) in the two districts of Kamwenge and Kitagwenda but implementation of nutrition-sensitive interventions (agriculture, WASH, etc.) had remained stagnant in both districts during the study period. (b) The prevalence of overweight women was increasing while child stunting (chronic undernutrition) in children under the age of 2 years remained high (>30%) in all study sub-counties. Wasting and underweight were also higher than the recommended minimum in both districts.

The team recommended local government stakeholder to continue the successful implementation of nutrition-specific interventions and concurrently prioritize nutrition-sensitive interventions and public services for a significant reduction in acute (wasting) and chronic undernutrition (stunting) in both districts. The dissemination was useful to understand the willingness of the local government stakeholders to implement interventions that mattered for nutrition but the level of knowledge and understanding of nutrition, pathways and the technical capacity was limited and needs to improve to impact overall nutrition governance and planning. All these findings were also discussed with the USAID mission in Kampala and a factsheet on assessing the linkage between agriculture, nutrition and health for improved nutrition outcomes in Uganda was published and shared.

During the August partners' meeting, Kabunga et al, showed that there were many positive impacts achieved by the USAID's supported integrated Community Connector program in Uganda. Among others, there were increased levels of production productivity, enhanced women's dietary diversity/quality, improved rural finance and health care seeking behaviors, which should all reduce undernutrition in women and children. Long-term interventions with much more intensified and wider coverage of key packages (the Agric-WaSH-Nutrition combinations) were likely to lead to more consistent results. Program implementation fidelity

issues notwithstanding, it is possible that multisectoral programs for nutrition can potentially improve the nutrition and health status of rural agro-based households across Uganda and countries in similar contexts.

vi) *Presentations and Publications:*

Presentations

Presenter	Event	Location	Topic	Date	Audience
Oral Presentations					
Nassul Kabunga	The 2nd NARO-MAK Scientific Conference and 1st Nutrition Innovation Lab Symposium	Kampala, Uganda	Linkages between agriculture, nutrition and health for improved outcomes from the Uganda panel study	November 12-15, 2018	~350
Nassul Kabunga	The 2nd NARO-MAK Scientific Conference and 1st Nutrition Innovation Lab Symposium	Kampala, Uganda	Food and water for sanitation to explain the regional differences in child undernutrition rates in Uganda	November 12-15, 2018	~350
Nassul Kabunga	The 2nd NARO-MAK Scientific Conference and 1st Nutrition Innovation Lab Symposium	Kampala, Uganda	Impact of improved dairy cow breeds on household welfare and child nutrition outcomes: Empirical evidence from Uganda	November 12-15, 2018	~350
Nassul Kabunga	The 2nd NARO-MAK Scientific Conference and 1st Nutrition Innovation Lab Symposium	Kampala, Uganda	Cattle ownership, childhood malaria and anemia in Uganda.	November 12-15, 2018	~350
Nassul Kabunga	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, USA	The evaluation of the USAID Community Connector Program in Uganda	August 6-7, 2019	~55
Nassul Kabunga (with B. Bashaasha, R. Shrestha, E. Agaba, and E. Marino-Costello)	Dissemination Workshop	Kamwenge, Uganda	The causal linkages between agriculture, nutrition and health for improved outcomes: Evidence from the panel study of Kamwenge and Kitagwenda Districts	July 23, 2019	~40
Patrick Webb	The 2nd NARO-MAK Scientific Conference and 1st Nutrition Innovation Lab Symposium	Kampala, Uganda	Post-Harvest Management, Food Security and Nutrition for Improved Livelihoods	November 12-15, 2018	~350

9. Bangladesh Aquaculture and Horticulture for Nutrition Research

- i) *Linking Agriculture and Health for dietary diversity, income and nutrition: Lessons learned from programs in Bangladesh that integrate aquaculture, horticulture and nutrition actions*

The Nutrition Innovation Lab, in collaboration with the Horticulture Innovation Lab, the AquaFish Innovation Lab, and other partners in Bangladesh, is studying the population-level effects of exposure to one or more agricultural interventions (specifically horticulture and aquaculture) and post-harvest technologies on diets and nutrition.

- ii) *Locations:*

Dhaka, Barisal and Khulna divisions

- iii) *Collaborators:*

HKI/Bangladesh, Tufts University, Horticulture Innovation Lab, WorldFish, AquaFish Innovation Lab, Dhaka University, Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING).

- iv) *Achievements:*

In the past year, datasets from the 3 panel were processed and merged. Upon completion of the surveys, documents were compiled and submitted to the Institutional Review Board of Tufts University and Bangladesh Medical Research Council (BMRC) to officially close the survey. Over the reporting period, the team continued to advance with several data analysis using all three panel and technology datasets. Efforts are in place to build them up as manuscripts. Analysis using the land use survey (LUS) and the technology survey panel data is currently ongoing. A research papers assessing the cost-effectiveness of chimney dryer is being finalized. The merged datasets are being used to understand the effects of interventions (focused on aquaculture and horticulture) on diets and nutrition within the Zone of Influence in Bangladesh. Some key findings emerging from the analysis are as follows:

- Children living in households that participate in either aquaculture or horticulture were more likely to meet infant and young child feeding (IYCF) minimum diet diversity
- Children living in households that participate in both aquaculture and horticulture were more likely to meet IYCF minimum diet diversity
- Children living in households that participate in both aquaculture and horticulture were more likely to consume animal source foods.
- Stunting in children under 5 years decreased in over the study period, while stunting in children under 2 years increased. Wasting is high and similar to national rates of Bangladesh (14%).
- Consumption of animal source foods (ASFs) increased over time (after adjustments for age, wealth and education) in children under the age of 2.
- Consumption of dark green leafy vegetables (DGLV) decreased and vitamin A rich fruits and other vegetables increased in children under the age of 2, but still low.
- Child ASFs and Women's diet is positively associated with aquaculture-horticulture engagement and production diversity.

In addition, analysis focused on female caregiver's overweight and obesity and consumption of packaged and processed foods to address the double burden of malnutrition in Bangladesh is making a good progress. Preliminary results have shown that the prevalence of overweight and obesity in female caregivers has increased significantly over the study period and were positively associated with the female caregiver's age, household wealth and diet diversity. Overweight and obesity was found to be negatively associated with female caregiver's and household head's education. Similarly, over half of the households in the study period reported expenditures on sugar sweetened beverages (SSBs) and almost

all (98%) reported expenditures on processed snacks and sweets. Expenditure on SSBs and snacks and sweets were positively correlated with household wealth and education level of the household head.

An analysis focused on assessing diet quality in terms of nutrient adequacy among households in the Feed the Future zone of influence exposed to USAID programming is currently being led by a Bangladeshi PhD candidate, Rumana Akter. The results will be presented during the December 2019 Symposium in Bangladesh.

A number of dissemination activities were successfully held in Bangladesh in the past year. In March 2019, the Nutrition and Horticulture Innovation Labs co-organized a Partners' Meeting in Dhaka to share preliminary study results with the in-country partners, development organizations and implementers at the mission. A team of researchers led by Shibani Ghosh from the Nutrition Innovation Lab and Elizabeth Mitcham from the Horticulture Innovation Lab presented preliminary study findings at a Partners' Meeting in Dhaka. The meeting was used to share preliminary results on diet and nutrition outcomes in women and children of aquaculture and horticulture producing households. Findings shared during the meeting attended by more than 60 participants from different development organizations, USAID program implementers and colleagues at the Bangladesh mission were on diet diversity (of women and children) and animal source food consumption in early life in rural Bangladesh households and its association with engagement in both aquaculture-horticulture. The findings highlighted USAID programs (single or multiple) in ZOI of Bangladesh were positively associated with aquaculture-horticulture engagement and production diversity. While diets are getting nutrient dense, consumption of packaged and processed foods is increasing (as measured through expenditure), and, overweight and obesity rates in women are increasing in FTF ZOI-future programmatic implications of nutrition transition and the co-existence of the double burden.

Between August and September, three regional dissemination events in Barisal, Khulna and Dhaka divisions of Bangladesh were organized. The objective of these disseminations was to go back to the study sites and local stakeholders and share regional level findings from the research conducted by the Innovation Lab on diet, nutrition and health with local stakeholders (government, implementers, community leaders from the divisions, districts, and the unions) of Bangladesh. The events were successfully held in three divisions of Bangladesh, Barisal, Khulna and Dhaka divisions on August 28th, September 2nd and September 5th respectively and was attended by more than 130 stakeholders from the three divisions (46 from Barisal, 50 from Khulna and 35 from Dhaka). Representatives from the health, agriculture, fisheries department, local academic institutions, development partners attended the workshops. Presentations made by the ME were focused towards sharing division level findings on the nutrition outcomes (stunting, wasting) and diet (dietary diversity, consumption of animal source foods, consumption of fruits and vegetables) of households engaged in aquaculture and/or horticulture in the three divisions within the zone of influence.

Overall, the Nutrition Lab research activities in Bangladesh has important policy and programmatic implications. Our findings have suggested that all forms of malnutrition (undernutrition, overnutrition and micronutrient deficiencies) co-exist across the three ZOI divisions of Bangladesh. Our findings further emphasize that diet diversity improvements through investments in nutrition sensitive interventions is important. Although sustainable diets, reduction of food security and improved nutrition security are achievable goals, they may be offset by poor purchasing practices and availability of ultra-processed foods. More data and evidence are warranted to understand if this is due to poor market linkages or households deriving income from nutrition sensitive agriculture, aquaculture and horticulture.

Manuscripts and Reports (in progress)

1. A proceedings/report of the regional level dissemination in three divisions (Barisal, Khulna and Dhaka) is being finalized. The report will include descriptive statistics from all three panel, especially focusing on health, nutrition and agriculture variables specific to the division.
2. Assessing diet quality in terms of nutrient adequacy among households in the Feed the Future zone of influence exposed to USAID programming versus those that are not exposed
3. Measuring resilience using a triple difference approach. This paper develops a method to measure resilience using panel data and applying it to nutrition outcomes. Resilience is being defined in a population as the extent to which a desirable outcome recovers from adverse shocks, relative to mean reversion. The method is applied to measure nutritional resilience of women and children in Nepal and from southwest Bangladesh. Initial findings show that dietary diversity of women and children is resilient in Nepal, but not in Bangladesh. We further explore how nutritional resilience in Nepal varies by household characteristics such as agricultural practices and market activity, and by the quality of local infrastructure.

v) *Capacity Building:*

Technical support to beneficiary households of the pilot technologies has been ongoing. However, financial support from the project was eliminated for all three technologies (Floating Gardens, UC-Davis Chimney Dryer and CoolBot Cold Room) to encourage sustainable maintenance by the communities. The project team successfully completed farmers' trainings on the floating gardens to ensure farmers' better understanding for their future sustainability. The trained farmers were able to understand the alternative source of garden media, suitable crops and minimum cultivation practices for garden sustenance. Farmers have taken responsibility for the cold room operating costs. They were also trained on optimum temperature settings for selected crops to ensure future sustainability of cold room use before the project ends.

Refresher training for beneficiary farmers': In October 2018, refresher training was provided to the farmers in Agailjhara site. The training focused on ensuring appropriate growing practices for the floating gardens. The training focused on making alternative media from local materials such as charcoal, decomposing kitchen scrapes, as well as by burning poultry litter. In addition, the training covered low cost manure production using cow dung; water hyacinth and kitchen scraps. Moreover, the team shared ideas on how to ensure floatation with used plastic bottles, giving the farmers ideas to replace if needed. During the session, a total of 8 participants attended, including 6 males and 2 females.

vi) *Future Directions (FY2020):*

A national level dissemination and a scientific symposium is being planned December 3-4, 2019, in Dhaka. The symposium will offer an important platform for Bangladeshi researchers, implementers, early career professionals and students to promote sharing, understanding and adoption of concrete evidence on factors determining positive or negative outcomes along the pathways from agriculture to nutrition. The symposium will fulfill the objective of a national level dissemination of findings and outputs from the Nutrition Innovation Lab's research in Bangladesh.

vii) *Presentations and Publications*

Presentations

Presenter	Event	Location	Topic	Date	Audience
Poster Presentations					
Chloe Andrews	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Dietary diversity, eating animal source foods, and maternal nutritional status in Bangladesh	November 2018	~100
Katherine Heneveld	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Aquaculture and Horticulture Linkages with Dietary Diversity in Children 6-23 Months of Age.	November 2018	~100
Oral presentations					
Elizabeth Mitcham	Joint Innovation Lab meeting at USAID Bangladesh	Bangladesh	Implementation, Utilization and Assessment of Innovative Agricultural Technologies in Rural Bangladesh	March 2019	
Sabi Gurung	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Pilot testing of agricultural technologies: uptake and impacts on diet diversity in Bangladesh	November 2018	~350
Shibani Ghosh	Joint Innovation Lab meeting at USAID Bangladesh	Bangladesh	Generating evidence around the potential for aquaculture and horticulture in improving nutrition and diet quality in rural Bangladesh	March 2019	~50
Shibani Ghosh	Feed the Future Innovation Lab for Nutrition Regional dissemination event	Barisal, Bangladesh	Generating evidence around the potential for aquaculture and horticulture in improving nutrition and diet quality in rural Bangladesh	August 28, 2019	~120
Shibani Ghosh	Feed the Future Innovation Lab for Nutrition Regional dissemination event	Khulna, Bangladesh	Generating evidence around the potential for aquaculture and horticulture in improving nutrition and diet quality in rural Bangladesh	September 2, 2019	~120
Shibani Ghosh	Feed the Future Innovation Lab for Nutrition Regional dissemination event	Dhaka, Bangladesh	Generating evidence around the potential for aquaculture and horticulture in improving nutrition and diet quality in rural Bangladesh	September 5, 2019	~120

Shibani Ghosh	6th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Household Food Expenditure on Processed Foods and Sugar-Sweetened Beverages in southwest Bangladesh.	November 2018	~350
Swetha Manohar	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Growth Faltering & Associated Risk Factors Among Infant and Young Children from Nepal: Findings from the PoSHAN Community Studies Cohort	August 2019	~55

10. Cost of nutritious diets in Malawi

i) *Measuring the cost of foods needed for nutrient adequacy over time and space*

To measure changes in access to healthy diets in Malawi, we assembled all available food prices, combined with new data on the nutrient composition of those foods, and computed novel price indexes for the cost of meeting nutrient needs at each marketplace every month. Results reveal variation in the cost of nutritious foods associated with local agricultural production and market infrastructure, for future use in measuring the impacts on intervention on affordability and use of healthier foods.

Specific Aim 1: Obtain and digitize the widest possible range of food price data from the National Statistical Office (NSO), for 55 food items from 29 markets, 2007-17.

Specific Aim 2: Validate and use the new food composition table (FCT) for Malawi, testing for biologically plausible variation by comparison with existing FCTs, to construct a validated regional food composition table for Malawi and Tanzania.

Specific Aim 3: Merge market prices and food composition data with dietary requirements to compute heterogeneity in nutrient needs by age, sex and pregnancy status, aggregated into households for analysis of survey data on food consumption.

ii) *Locations:*

Boston (using data from Malawi and elsewhere)

iii) *Collaborators:*

Stevier Kaiyatsa (Economist, Min. of Finance, Planning & Economic Development),
Yan Bai and Kate Schneider (PhD students, funded by the CANDASA project)

iv) *Accomplishments:*

Initial seed funding from Nutrition Innovation Lab for Stevier Kaiyatsa to identify and obtain the price data, combined with the Nutrition Innovation Lab's work on food composition in Malawi, allowed us to leverage CANDASA project funding into potentially high-impact analyses for presentations in summer 2019. Peer-reviewed articles will follow later in 2019

v) *Presentations and Publications:*

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Poster Presentations (accepted)					
Yan Bai	International Food Data Conference (IFDC)	Lisbon, Portugal	Validation and compilation of regional food composition data for nutrition research: Pilot results for Southeastern Africa	October 2019	~100
Oral presentations					
Kate Schneider	2019 American Society for Nutrition Conference	Baltimore, MD	Nutrient Adequacy at the Household Level and the Cost of Nutritious Diets in Malawi	June 2019	~100
Kate Schneider	Annual meetings of the Agricultural & Applied Economics Association (AAEA)	Atlanta, USA	Advancing the use of household surveys for nutrition: Nutrient adequacy at the household level and the cost of nutritious diets in Malawi	July 2019	~100
Stevier Kaiyatsa	Annual meetings of the Agricultural & Applied Economics Association . (AAEA)	Atlanta, USA	Do remote rural people pay higher prices for more nutritious foods? Evidence from 130,975 price observations at rural markets in Malawi, 2007-2017	July 2019	~100
Stevier Kaiyatsa	Malawi National Planning Commission Research Symposium	Malawi	Do remote rural people pay higher prices for more nutritious foods? Evidence from 130,975 price observations at rural markets in Malawi, 2007-2017	September 2019	~100
Yan Bai	Annual meetings of the Agricultural & Applied Economics Association (AAEA)	Atlanta, USA	Heterogeneity in nutrient needs and the cost of nutritious diets in Malawi	July 2019	~100
Yan Bai	2019 American Society for Nutrition Conference	Baltimore, MD	Heterogeneity in the cost of nutrient adequacy by age, sex, pregnancy or lactation status and other influences on individual requirements in Malawi	June 2019	~100

vi) *Lessons Learned:*

By developing a statistical test for biologically plausible variation in food composition, we found an outer limit of variation from 0.37 to 2.7 the nutrient density found in USDA data, when combining test results for a combined regional dataset from Malawi and Tanzania. This establishes a precedent for regional collaboration on food composition that combines evidence from neighboring countries, for use in measuring food system performance.

vii) *Issues and Concerns: N/A*

Objective 2: Study Neglected Biological Mechanisms and Pathways

i) Aflacohort Study, Nepal

ii) *Location:*

17 Village Development Committees of Banke district in Nepal

iii) *Description:*

This study considers the impact of mycotoxin exposure (maternal and infant) on birth outcomes and length-for-age. The study also seeks to validate the use of low-cost data collection methods (e.g. dried blood spots versus venous blood samples) for mycotoxin analysis.

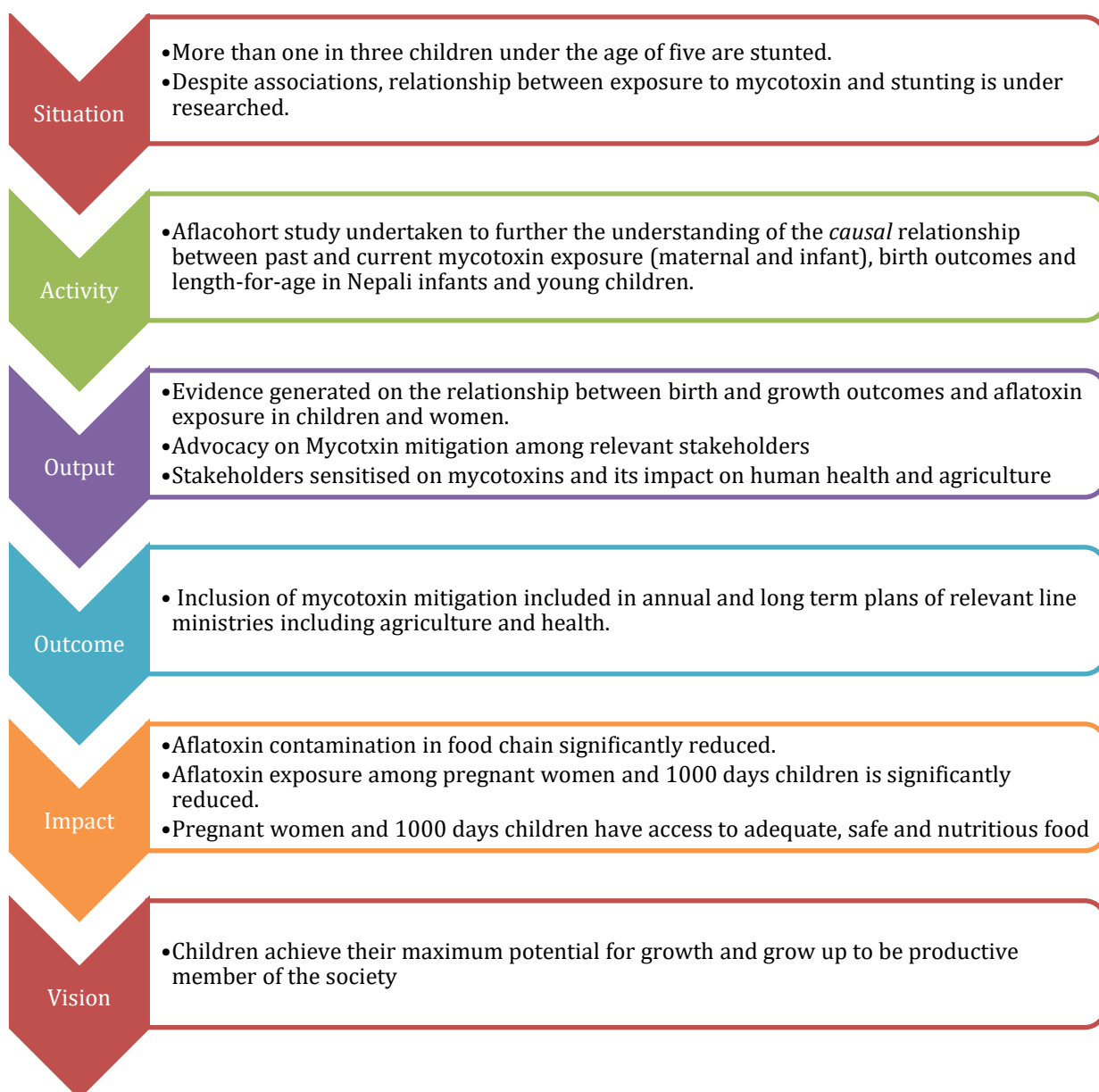
The specific aims of this study are:

1. To examine the relationship of maternal mycotoxin exposure in pregnancy and birth outcomes, including infant birth weight.
2. To examine the relationship of exposure to mycotoxin of infants through breast milk and their linear growth.
3. To examine the relationship of exposure to mycotoxin through complementary feeding and linear growth.
4. To enumerate the relative contributions of maternal and infant mycotoxin exposure in impairing linear growth and cognitive development, controlling for other potential explanatory factors.
5. To examine dietary exposure to mycotoxins from a sub sample of households via collection and analysis of commonly consumed crops such as maize, chilies, rice and groundnuts.

iv) *Theory of Change and Impact Pathway(s):*

The Innovation Lab for Nutrition has a specific research theme that focuses on elucidating neglected biological pathways that may affect nutrition outcomes particularly birth outcomes in pregnancy, linear growth and later cognitive development in infants and young children. This theme is embodied by the ongoing AflaCohort Study that looks at the relationship between mycotoxin (aflatoxin) exposure and growth outcome in children. Data collection for AflaCohort study is complete and the study team are now in process of analyzing data as well as presenting findings in seminars, conferences, peer reviewed journal articles and policy briefs.

Based on the findings from AflaCohort study, The Innovation Lab is advocating for inclusion of mycotoxin mitigation in national, provincial and municipal level plans and programs. The Innovation Lab initiated a policy dialogue in mycotoxin mitigation through a National Stakeholder Consultation Workshop on Mycotoxin Mitigation for Health, Nutrition, Agricultural Productivity and Prosperity in South Asia held in November 2018, in Kathmandu. The event was successful in sensitizing the participants on mycotoxins and its impact on human health and agriculture. The event has been followed up by further discussions with stakeholders on mycotoxin mitigation and importance for its inclusion in policies and strategic plans.



v) *Collaborators:*

Tufts University's Friedman School of Nutrition Science and Policy leads the study in collaboration with the Patan Academy of Health Sciences, Helen Keller International, Purdue University, Nepalgunj Medical College and the Government of Nepal. The study is generously supported by the United States Agency for International Development, Bureau of Food Security and USAID Mission in Nepal.

vi) *Achievements:*

This past year the AflaCohort study completed its data collection. This longitudinal birth cohort study was able to collect data during the first 1000 days, a time in which there is both great potential and enormous vulnerability in child health and nutrition.

Data collection

- Phase II, the final phase of the AflaCohort Study was completed this year. In this phase, face-to-face interviews, venous blood and urine sample collection, anthropometric measurements, food sample collection, market and health services centers mapping surveys and development assessment surveys were carried out. This final phase focused on measuring an array of mycotoxins (urinary DON and fumonisins and serum aflatoxin and Ochratoxin A).
- Data were collected from 1184 participants who were re-enrolled in the 2nd phase of the study (representing 88% of the total 1340 eligible participants).
- This phase of the study included urine sample collections. Urine was collected for two reasons: 1) to measure lactulose mannitol ratios as a measurement for Environmental Enteropathy Dysfunction (EED) and 2) to test for two additional mycotoxins – DON and fumonisin. A total of 690 urine samples were collected. Samples were air-shipped to Baylor University for EED testing and to the University of Georgia for mycotoxins testing. This will be one of the first ever studies to examine the association between EED and other mycotoxins. It will also be the first to concurrently examine 4 mycotoxins in children and examine association between multiple mycotoxins and child growth.
- In collaboration with the Feed the Future Innovation Lab for the Reduction of Post-Harvest Loss (PHLIL), the Nutrition Innovation Lab collected food samples and data from a sub-sample of 173 participants for aflatoxin testing in food. This collaboration between Innovation Labs was able to leverage existing resources and personnel on the ground to implement this additional component of the research study. Enumerators who had worked on the first phase of the study or were hired to work on parts of the second phase of the study were trained on rigorous food collection techniques. Hiring local enumerators who had experience collecting longitudinal data and were familiar with both the area and the study households enhanced the team's ability to streamline data collection efforts and improve efficiency on the field. The PHLIL and NIL teams have met both virtually and in-person to discuss data analyses. In August 2019 all data necessary for the collaborative analyses was merged together and analyses are currently being undertaken. Three manuscripts are expected to emerge from this collaboration. One of the manuscripts will be the first, to our knowledge, quantifying levels of aflatoxin B1 in a variety of foods and comparing those levels to serum aflatoxin exposure in children.

Biomarker and data analysis

- Final aflatoxin results and results on Ochratoxin A levels in the serum samples from the 18-22-month children were sent to Tufts University in August 2019. Results for urinary DON and fumonisins are pending and expected by the end of 2019. Existing biomarker data has been merged with the survey data and team members, both in Boston and Nepal, are tackling a series of research questions.
- The L:M results are still being cleaned. Once those data are ready, they will be merged with the main dataset for an additional analysis looking at the possible mediation effect of EED, aflatoxin and child growth.
- The laboratory results show that exposure to aflatoxin is widespread among the pregnant women (94%) and children (80% at 3 months, 75% at 6 months, 81% at 12 months and 85% for a sub-set of children ages 18-22 months). This study is the first to provide evidence of aflatoxin at a very young age (starting at 3 months), a critical period of growth and development. We were able to measure aflatoxin exposure early on when most kids were still exclusively breastfed and follow-up when kids were introduced to solids and twice more when their diets were similar to adult diets. Our results showing widespread exposure to aflatoxin highlight the importance of examining the relationship between aflatoxin exposure and poor child growth. Aflatoxins may play a role in malnutrition, a persistent problem in Nepal, where 36% of children are stunted. The manuscript on the relationship between aflatoxin exposure and child growth is expected to be complete and ready for journal submission by the end of 2019.
- Analyses have also shown that seasonality plays an important role in exposure levels both among women and children, with higher levels generally found in the dry winter months. The majority of rainfall is received during May-September, the months prior to the dry winter season begins. It is possible that the

hot humid conditions foods are exposed to during the monsoon season increase food crops' susceptibility to *Aspergillus* contamination. Knowledge of these seasonal patterns can be used to further investigate particular foods and efficient aflatoxin prevention and control strategies for the region.

- Results also showed a small but significant association between gestational aflatoxin exposure and being born small-for-gestational age; however, gestational aflatoxin was not associated with other birth outcomes. Results on the relationship between gestational aflatoxin exposure and birth outcomes have been published in the Journal of Nutrition (see list of peer-reviewed manuscripts below).
- Our study will help increase public awareness on the widespread threat of aflatoxins to human health. While these toxins are natural and difficult to completely eliminate from the food system, there are successful aflatoxin control measures that can be implemented to reduce exposure to safe levels.
- Ongoing secondary analyses are being conducted and 3 abstracts for these analyses have been submitted to the 7th Annual Scientific Symposium in Nepal in December 2019. One analysis has examined the determinants of AFMI in breast milk. A second cross-sectional analysis examined associations between aflatoxin exposure and children's growth outcomes at 3 months. The third analysis examined dietary and health determinants of aflatoxin exposure in children at 12 months of age. The first analysis on determinants of AFMI in breastmilk, found negative association between legume consumption and AFMI levels while positive association with yogurt, hydrogenated oils, milk, pumpkin consumption and AFMI. Seasonality was a strong predictor of AFMI levels with samples collected in cooler seasons having higher mean AFMI compared to warmer seasons. The second analysis found aflatoxin exposure was significantly associated with lower weight-for-age Z-scores but not with other growth outcomes such as length-for-age, weight-for-length, or head circumference-for-age z-scores. The third analysis found that consumption of fish and infant formula was positively associated with aflatoxin exposure, while consumption of banana and mangoes were negatively associated with aflatoxin. Similarly, seasonality was a strong predictor of aflatoxin exposure. These results show that aflatoxin exposure is widespread, and reduction in aflatoxin might be beneficial to achieve better nutrition.

Other

- The First National Consultation Workshop on *Mycotoxin Mitigation for Health, Nutrition, Agricultural Productivity and Prosperity in South Asia* was held in National Academy of Science and Technology in Lalitpur, Nepal on November 30, 2018. The workshop brought together representatives from ministries of health, agriculture, research and academic institutions, UN and other donor organizations such as UNICEF, Gates Foundation, DFID, civil society and nutrition focused organizations and programs such as Suaahara, SABAL, PAHAL, HKI and private sector such as Mars and Feed Industry. The workshop was attended by 76 participants in the plenary session and 24 participants in the round table discussion. During the workshop, stakeholders had the opportunity to deepen their knowledge on the impact of mycotoxins (especially aflatoxin) and food safety in human health in Nepal, and innovative technologies to mitigate mycotoxins during post-harvest storage. A new laboratory at NAST to test food samples was inaugurated during the workshop. Upon completion of the workshop, the team in Nepal held several post-workshop evaluations with representatives at the Ministry of Health, Ministry of Agriculture, Department of Food Testing and Quality Control, private sectors, UN and nutrition programs in Nepal. The team also met with former government stakeholders and nutrition champions to plan for the way forward and next set of plans on policy discussions and meetings. The workshop was jointly organized by the Feed the Future Innovation Lab for Nutrition and Feed the Future Innovation Lab for Reduction of Post-Harvest Loss.
- Following up on the first national consultation workshop, a 4-day strategic workshop titled "Building a Better Response: Mycotoxin Planning Workshop" was organized by Feed the Future Post Harvest Loss Reduction Innovation Lab in collaboration with Helen Keller International, Nepal and Nepal Development Research Institute (NDRI) from August 18-21, 2019. In this workshop, Aflacohort study overview and findings on aflatoxin levels were shared with the participants and stakeholders.

vii) *Capacity Building:*

- Four study staff (2 female and 2 male) participated in the data analysis workshop.
- One intern (1 female) did a 6-week internship at AflaCohort study where she learned about study protocol, implementation, data collection, and data management.
- Four female and 2 male staff were provided a training on food sample collection and market and health center mapping survey.

viii) *Lessons Learned:*

One key lesson learned is that this type of complex study design requires long-term staff support. There were a large number of samples collected for this longitudinal study. While most samples collected matched the shipment and results list, there were at times inconsistencies that needed to be investigated further. Additional long-term staff would ensure timely follow-up to issues such as those of mismatched biological sample IDs. Also, data cleaning was ongoing throughout the study, the copious amount of data needing cleaning was overwhelming and not all complete right after study completion. Cleaning data retrospectively has proven challenging because there is no real-time communication with enumerators/field researchers. The study team is reviewing enumerator records and master tracking sheets to recover as much data as possible, but some questions will not be answered to the time that has lapsed between data collection and cleaning.

Moreover, coordination with the government stakeholders (i.e. health personnel at VDC and ward level) is essential to the success of the program, given their engagement with the local community members. Regular coordination helped the study to leverage the available resources (such as meeting halls, voluntary time from FCHVs) which was critical in the success of the study.

ix) *Issues and Concerns:*

There were some issues with storage of samples at -80 freezer space at the PAHS lab. However, the team was able to store samples in a -20 freezer at the Public Health laboratory in Kathmandu for an additional few weeks while making space in the -80 freezer at PAHS. An additional sample shipment from Kathmandu to the USA was made for mycotoxin testing to make space in the -80 freezer.

ix) *Presentations and Publications:*

Published manuscripts:

1. Andrews-Trevino JY, Webb P, Shively G, Rogers B, Baral K, Davis D, Paudel K, Pokharel A, Shrestha R, Wang JS, Ghosh S. Relatively low maternal aflatoxin exposure is associated with small-for-gestational-age in a prospective birth cohort study of Nepalese infants. *J Nutr.* 2019 Oct 1;149(10):1818-1825. doi: 10.1093/jn/nxz122.

Publications submitted for peer review:

1. Andrews-Trevino JY, Webb P, Shively G, Rogers B, Baral K, Davis D, Paudel K, Pokharel A, Shrestha R, Xue KS, Wang JS, Ghosh S. Dietary determinants of aflatoxin B1-lysine adducts in pregnant women consuming a rice-dominated diet in Nepal. Submitted to *European Journal of Clinical Nutrition*.
2. Andrews-Trevino, J., S. Ghosh, G. Shively, B. Rogers, K. Baral, D. Davis, A. Pokharel, R. Shrestha, J.-S. Wang, and P. Webb "Aflatoxins in the blood of pregnant women, their food sources, and agricultural practices in rural Nepal." Under review at *Environmental Research*.

Publications in final stages of preparation for submission:

- I. Andrews-Trevino JY, Patrick Webb, Baral K, Davis D, Shrestha R, Pokharel A, Paudel M, Acharya S, Lamichhane A, Shively G, Paudel K, Wang JS, Ghosh S. AflaCohort Study: protocol for a prospective birth cohort to study early life exposure to aflatoxins and child linear growth in Banke, Nepal. For submission to *BMC Public Health*.

Peer reviewed abstracts (presentations and posters):

Presenter	Event	Location	Topic	Date	Audience
Abstract-Driven Poster Presentations					
Ashish Lamichhane	7th Annual Scientific Symposium	Kathmandu, Nepal	Aflatoxin B1 exposure and its determinants in Nepalese children at 12 months of age	December 2019 (under review)	
Ashish Pokharel	7th Annual Scientific Symposium	Kathmandu, Nepal	Occurrence and Factors Associated with Aflatoxin M1 exposure in Breast Milk of Mothers in Bane, Nepal	December 2019 (under review)	
Johanna Andrews-Trevino	7 th Annual Scientific Symposium	Kathmandu, Nepal	Serum aflatoxin B ₁ -lysine adduct concentrations are associated with length but not length-for-age Z-score in the first year of life	December 2019 (under review)	
Sudikshya Acharya	7th Annual Scientific Symposium	Kathmandu, Nepal	Association between Aflatoxin B1 Exposure and Growth Outcomes Infants at 3 months of Age in Banke District, Nepal	December 2019 (under review)	
Oral Presentations					
Ashish Pokharel	Mycotoxin Planning Workshop	Kathmandu Nepal	Aflatoxin and Human Health/Nutrition. Building a Better Response	August 18-21, 2019	~30

Shibani Ghosh	6 th Annual Scientific Symposium on Agriculture to Nutrition Pathways & 25 Years of Nepal's Progress in Nutrition	Kathmandu, Nepal	Dried Blood Spots for aflatoxin B1 assessment in a field study with pregnant women	November 2018	~350
Johanna Andrews-Trevino	2019 American Society for Nutrition Conference	Baltimore, MD	Relationship between wasting and stunting in infants from Banke, Nepal.	June 2019	~60
Johanna Andrews-Trevino	Annual Agriculture, Nutrition and Health (ANH) Academy Week	Hyderabad, India	Seasonality of serum aflatoxin levels (AFBI) in pregnancy and early childhood in a longitudinal cohort study in Banke, Nepal	June 2019	~100

10. Aflatoxin Levels in Women and Infants: Birth Cohort Study, Uganda

- i) Livelihood and nutrition interventions to improve maternal and child nutrition in Uganda - A Birth Cohort Study.
- ii) *Location:*
Nine districts of Northern Uganda and six districts of Southwestern Uganda.
- iii) *Description:*
The Uganda Birth Cohort Study examined the effect of interventions that integrate nutrition, health, agriculture, and livelihoods on maternal and child nutritional outcomes.

Specific Aim 1: To explore the relationship between aflatoxin exposure and birth outcomes.

Specific Aim 2: To compute and identify discrete growth trajectories in Ugandan infants using linear growth, determine the pattern of growth in each trajectory and assess the pre and post-natal factors associated with each trajectory.

Specific Aim 3: To identify an empirical threshold level of aflatoxin exposure beyond which there is a notable difference in adverse birth outcomes.
- iv) *Theory of Change and Impact Pathway(s):*
The Nutrition Lab has a specific research theme that focuses on elucidating **neglected biological pathways** that may affect nutrition outcomes particularly birth outcomes in pregnancy and linear growth in infants and young children. This theme is embodied by the Uganda birth cohort study that looks at the relationship between mycotoxin (aflatoxin) exposure and growth outcome in children. This stream of work focuses on issues in the fourth column, which is headed by a box on 'nutrient-poor natural resources' in Figure 1 (refer to the main framework discussed above in the report).

v) *Collaborators:*
Makerere University, Harvard University, International Food Policy Research Institute (IFPRI) and Tufts.

vi) *Achievements:*
This year, the birth cohort study completed extensive data cleaning and consistency checks of all survey visits to create a shareable version of datasets. A number of analysis and write ups have been completed this year. An analysis examining the growth pattern within the first 1000 days is ongoing. Preliminary findings from the aflatoxin analysis suggest a lack of link between maternal aflatoxin exposure (using absolute values) and adverse birth outcomes. However, aflatoxin exposure per kilogram of body weight in mothers yielded a significant negative association with birth weight in the newborns. The findings are similar to those of Lauer et al, that found a negative association with maternal aflatoxin levels and head circumference in infants (Lauer et al).

In addition to the aflatoxin analysis, a separate analysis to identify a cut-off or a threshold level for aflatoxin exposure is underway. A multi-country analysis using data from the birth cohort study in Uganda and another birth cohort in Nepal. Sensitivity and specificity tests were conducted for each cut-off point of aflatoxin levels in relation to the birth outcomes. Analysis did not find an empirical threshold value, suggesting that the relationship between maternal aflatoxin exposure and birth outcomes may be more nuanced and complex. Further work is needed to understand the nature of the relationship and to look at child aflatoxin exposure and growth outcomes over time.

vii) *Capacity Building:*
The former graduate students who cleaned and managed the database have since graduated from Tufts University. Julieta Mezzano is now affiliated with the research team at Tufts, working as a research assistant and tutoring graduate students in Biostatistics methods. Binita Subedi went on to work at the Tufts Human Nutrition and Research Center for Aging (HNRCA).

viii) *Lessons Learned:*
The Uganda birth cohort database is rich because it has several modules and data points that offer numerous variables to tease out important relationships. Longitudinal study designs give more flexibility and information: with the Uganda Birth Cohort study, we had the liberty to compare data not only within cross-sections but also longitudinally and at multiple time points.

ix) *Presentations and Publications:*

Publications ready for submission

1. Ghosh S., Namirembe G., Mezzano J., Ausman L., Marino-Costello E., Shrestha R., Wang JS., and Webb P. Maternal aflatoxin levels are not associated with birth outcomes in children from rural Northern and South West regions of Uganda.
2. Ghosh S., Namirembe G., Mezzano J., Ausman L., Marino-Costello E., Shrestha R., Wang JS., and Webb P. Four growth trajectories identified in Ugandan infants from birth to 12 months: An assessment of stunting and linear growth over time: findings from a Uganda birth cohort study.

II. Assessment of Environmental Enteropathy in Uganda

i) *Studies: a) Environmental Contributors and Nutritional Consequences of Environmental Enteric Dysfunction (EED) in Southwest Uganda*

Using data from the Uganda Birth Cohort Study and lactulose: mannitol (L:M) sugar tests, the objective of this sub-study is to explore the environmental contributors of EED, particularly regarding poor water quality, and the associations between EED and growth outcomes, particularly stunting.

Specific Aim: Examining the presence of Environmental Enteric Dysfunction (EED) and aflatoxins in pregnant women and its association with birth outcomes in Mukono, Uganda.

The objective of this sub-study is to examine the association between EED biomarkers (L:M test and serum anti-flagellin and anti-lipopolysaccharide (LPS) antibodies) in pregnant women and subsequent adverse birth outcomes, particularly shorter gestational age, lower birth weight and length, and smaller head circumference, in Mukono District, Uganda. A sub-objective of this study is to examine the association between aflatoxin exposure in pregnant women and subsequent adverse birth outcomes.

ii) *Locations:*

Birth cohort sub-study in the districts of Kabale, Kamwenge, Kabarole and Rukungiri (7 sub-counties: Bugangari, Buyanja, Bwizi, Kebisoni, Kibiito, Nyamweru, Ruhija) | I) pregnancy study in Mukono District, Uganda (about 20 km outside of Kampala).

iii) *Collaborators:*

The Friedman School of Nutrition Science and Policy at Tufts University in Boston, MA; Makerere University in Kampala, Uganda; Harvard T.H. Chan School of Public Health in Boston, MA; Mengo Health Center and Hospital in Kampala, Uganda; Mukono Health Center IV in Mukono, Uganda; and Uganda Christian University in Mukono, Uganda.

iv) *Accomplishments:*

Overall, the work on EED has contributed to the field in a number of ways. First, we have provided additional evidence to support the hypothesis that poor water, hygiene, and sanitation conditions are an underlying risk factor for the condition. Using water quality test kits, we established a link between poor water quality and poor intestinal health in rural Ugandan children. Furthermore, we have provided additional evidence to support the link between EED and poor growth outcomes, including the first study to demonstrate a link between maternal EED and adverse birth outcomes. Finally, BCH has contributed to the field by exploring novel biomarkers for the assessment of EED in the field, including anti-flagellin and anti-LPS Igs.

During the last project year, a number of manuscripts were published from NIL-supported work in Uganda. A paper on unsafe drinking water is associated with environmental enteric dysfunction and poor growth outcomes in young children in rural southwestern Uganda. A paper by Lauer et al, examining the relationships among water quality, EED, and growth in a sample of 385 children living in rural southwestern Uganda found that children from households with safe water (assessed using a portable water quality test when children were 6 months) had significantly L:M and significantly higher length-for-age and weight-for-age Z-scores at 12–16 months. Furthermore, L:M ratios at 12–16 months significantly decreased with increasing length-for-age Z-scores at birth, 6 months, and 9 months. Overall, the data suggest that programs seeking to improve nutrition should address poor WASH conditions simultaneously, particularly related to household drinking water quality.

A second paper by Lauer et al, examining the relationship between maternal aflatoxin exposure during pregnancy and adverse birth outcomes in a sample of 220 pregnant women and their newborn infants in Mukono, Uganda found that elevations in maternal AFB-Lys levels were significantly associated with lower weight, lower weight-for-age z-score, smaller head circumference, and lower head

circumference-for-age z-score in infants at birth. Overall, the data suggest an association between maternal aflatoxin exposure during pregnancy and adverse birth outcomes, particularly lower birth weight and smaller head circumference, but further research is warranted.

The third paper by Lauer et al, that examined the relationship between maternal EED and adverse birth outcomes in a sample of 220 pregnant women and their newborn infants in Mukono, Uganda found that higher concentrations of anti-flagellin immunoglobulin G (IgG) and anti-LPS IgG were significantly associated with shorter length of gestation and with reduced and LAZ at birth. This was the first paper to examine this association between maternal EED and birth outcomes and findings suggest that further research is warranted.

x) Publication and Presentations

Publications (Peer reviewed):

1. Lauer J, Duggan C, Ausman L, Griffiths J, Webb P, Bashaasha B, Agaba E, Turyashemererwa F, Ghosh S. Unsafe drinking water is associated with environmental enteric dysfunction and poor growth outcomes in young children in rural southwestern Uganda. 2018;99(6):1606-12. PMID: [30350765](#) PMCID: PMC6283503 DOI: [10.4269/ajtmh.18-0143](#).
2. Lauer J, Duggan C, Ausman L, Griffiths J, Webb P, Wang JS, Xue K, Agaba E, Nshakira N, Ghosh S. Association between maternal aflatoxin exposure during pregnancy and adverse birth outcomes in Uganda. *Maternal and Child Nutrition*. 2019;15(2):e12701. PMID: 30242967 DOI: [10.1111/mcn.12701](#)
3. Lauer J, Duggan C, Ausman L, Griffiths J, Webb P, Agaba E, Nshakira N, Tran H, Gewirtz A, Ghosh S. Biomarkers of maternal environmental enteric dysfunction are associated with shorter gestation and reduced length in newborn infants in Uganda. *American Journal of Clinical Nutrition*. 2018;108(4):889-96. PMID: 30247538 PMCID: PMC6186209 DOI: [10.1093/ajcn/nqy176](#).
4. Lauer J., McDonald C., Kisenge R., Aboud S., Fawzi W., L Enju., Tran H., Gewirtz A., Manji K., Duggan C. Markers of Systemic Inflammation and Environmental Enteric Dysfunction Are Not Reduced by Zinc or Multivitamins in Tanzanian Infants: A Randomized, Placebo-Controlled Trial. *Journal of Pediatrics*. April 2, 2019. <https://doi.org/10.1016/j.jpeds.2019.02.016> (Published abstract)

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral Presentations					
Isabel Madzorera	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Diet diversity during pregnancy and infant growth outcomes in Uganda	August 2019	~55
Jaqueline Lauer	2019 American Society for Nutrition Conference	Baltimore, MD	Water source correlates with E. coli contamination and markers of environmental enteric dysfunction in rural Ugandan infants	June 2019	~55
Jaqueline Lauer	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Assessing maternal environmental enteric dysfunction and its association with adverse birth outcomes in Uganda	August 2019	~55
Jaqueline Lauer	The 2nd NARO-MAK Scientific Conference and 1st Nutrition Innovation Lab Symposium	Kampala, Uganda	Environmental enteric dysfunction, aflatoxin exposure, and poor growth outcomes in Uganda	November 2018	~350

12. Mozambique Aflatoxin Survey

- i) *Assessing the Relationship of Aflatoxin Exposure and Stunting in Children 6-59 Months of Age in 10 Districts of Nampula Province, Mozambique*

This project aims to assess the aflatoxin levels in children 6 to 59 months old in Nampula province, Mozambique as well as enumerate the association with stunting/height for age in the children. The project is being conducted through buy-in support from the USAID mission in Mozambique.

- ii) *Location:*
Ten Feed the Future districts in Nampula Province, Mozambique.

- iii) *Description*
This project aims to assess the aflatoxin levels in children 6 to 59 months old in Nampula province, Mozambique as well as enumerate the association with stunting/height for age in the children. The project is being conducted through support from the USAID mission in Mozambique.

- iv) *Theory of Change and Pathway(s)*
Stunting is a significant problem in Mozambique, where almost half of the children in the study sample were found to be stunted. Aflatoxins are ubiquitous in the value chain of key staple crops, such as maize and groundnuts, in Mozambique, where 80% of the population depend on agriculture as a source of

income. Very little is known about the extent to which the prevalence or presence of aflatoxin in food translates into aflatoxin serum levels in children under five years of age, and its association with linear growth as a measure of stunting. This study aims to provide evidence of the association between serum aflatoxin and stunting in children under 5 years of age in Nampula province, Mozambique, while also adding to the growing body of evidence worldwide.

v) *Collaborators:*

University Lúrio (UniLúrio), Association for Food and Nutrition Security (ANSA), National Institute of Health (INS).

vi) *Achievements:*

The primary achievements of the past year include the launch of the study, training of enumerators, completion of data collection, successful shipment and analysis of serum samples, and completion of data cleaning.

Study Launch:

A half-day long event was held to commemorate the beginning of the study. Government representatives from the ten study districts attended the event, in addition to study partners and the data collection team (supervisors, enumerators, anthropometrists and phlebotomists). Presentations were given on an overview of aflatoxin and the state of malnutrition in Nampula, a description of the study design, and the plan for data collection.

Training:

Enumerators, anthropometrists, and phlebotomists participated in six days of training. Enumerator training focused on the study design and data collection tool (household questionnaire), as well as, practical training on conducting data collection in the field and use of the electronic tablets.

Anthropometrists were trained on the study design, theory of anthropometry measurements, the use of anthropometric tools on children, and entering measurements into the tablet. Phlebotomists were trained on the study design, conducting finger or heel pricks on children, conducting HemoCue and malaria tests, drawing a venous blood sample, and entering all data into the tablet. All data collection team members were trained on the ethics of the study and bioethics of conducting blood draws from children. Training was conducted by supervisors and partners from UniLúrio, ANSA, and INS. Five Tufts team members participated in training activities.

Data collection:

Data collection was conducted over six weeks, covering all 75 enumeration areas. 1007 households were enrolled, and 916 blood samples were collected from enrolled children. In-depth household surveys were conducted, as well as anthropometry assessments of the mother, anthropometry assessment, finger prick, and venous blood draws of children. All serum samples were shipped to the University of Georgia for aflatoxin B1 analysis.

Serum sample analysis:

Results for all serum samples shipped to UGA for testing were received in August 2019.

Data cleaning:

Data cleaning activities included resolving errors in household identification numbers, verifying anthropometry measurements and blood test results from the finger prick, labeling variables and values, and checking skip patterns. Data cleaning is complete, and the data are suitable for analysis.

vii) *Capacity Building*

Four medical team supervisors (2 male and 2 female), 42 household enumerators, 8 anthropometrists (4 male and 4 female), 3 phlebotomists (1 male and 2 female), and 1 lab technician (male) were trained.

viii) *Lessons Learned:*

Almost half (47%) of the children in the study sample were found to be stunted (height-for-age z-score <-2), and 90% of children from which a blood sample was taken had a detectable aflatoxin contamination. 55% and 70% of households reported growing maize and groundnuts, respectively, while 75% of children and female caregivers reported consuming maize or groundnuts in the past week, showing a heavy reliance on potentially contaminated foods.

ix) *Publications and Presentations:*

Presentations:

Presenter	Event	Location	Topic	Date	Audience
Oral Presentations					
Joao Salavessa	Mozambique: Framework of the Study Protocol and Objectives	Nampula, Mozambique	Assessing the Relationship of Aflatoxin Exposure and Stunting in 10 Districts of Nampula Province	October 2018	99
Shibani Ghosh	Mozambique: Introduction	Nampula, Mozambique	Assessing the Relationship of Aflatoxin Exposure and Stunting in 10 Districts of Nampula Province	October 2018	99
Shibani Ghosh	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Assessing mycotoxin exposure (examples from Nepal and Mozambique): Rationale, design, accomplishments, challenges	August 2019	~55

Objective 3: Household and Community Resilience to Shocks

14. Understanding Household Resilience to Shocks

The focus of this research is to understand the issues of household risk, price volatility, and environmental and other shocks for agricultural development and program implementation. Under this new research portfolio, a number of analyses have been undertaken to understand resilience post-earthquake in Nepal. In addition, analysis aimed at developing a novel method to measure resilience using multi-year panel data has started and the method has been applied to survey data on maternal and child diets from Nepal and Bangladesh.

i) *Accomplishments:*

The 2015 earthquake in Nepal caused massive damages and triggered relief activities to minimize human suffering. The longer-term post- earthquake nutrition and food security situation in the hardest hit areas remains uncertain. With this question in mind, we undertook before-after analysis of cross sectional and longitudinal data from the PoSHAN study of 7 village Development Committees (VDC's) categorized as 'earthquake affected' by the government. The post hoc sample included 982 households (HH), 1015 women, and 883 children from 2014 and 1056 HH, 1083 women, and 998 children from 2016 living in these areas. A special module was included in the 2016 survey round to assess the damages, and before-after comparisons were made of agricultural production, nutritional status (child stunting and wasting and child and maternal anemia), food security, dietary diversity, and infant and young child feeding practices.

The paper led by a post-doc (Sonia Zaharia) is focused on developing a method to measure resilience from panel data and apply it to nutrition outcomes using a triple difference approach. The method is applied to measure nutritional resilience of women and children from the Terai region in Nepal and from the Feed the Future Zones of in Bangladesh. The analysis that dietary diversity of women and children is resilient in the Nepal sample, but not in the Bangladesh sample. We further explore how nutritional resilience in Nepal varies by household characteristics such as agricultural practices and market activity, and by the quality of local infrastructure.

ii) *Lessons Learned:*

From the work in Nepal, we found that despite incurring major shocks (45% of households reported structural damages, 20% reported crop loss and 9% reported business losses), the nutrition and food security situation appeared stable or improved a year after the earthquake compared with the year with improvements observed in the prevalence of child wasting (4.5% in 2014 to 2.1% in 2016) and food insecurity (17.6% in 2014 to 12.4% in 2016). Improvements were also evident in dietary diversity and breastfeeding indicators. While we cannot attribute improvements to the interventions implemented as part of the earthquake response, it is plausible that the response and/or existing interventions in the earthquake- affected areas may have contributed to the nutritional resilience that was observed.

The novel method to measure resilience using triple difference approach (at least three panel data needed) have led to the conclusion that there are difficulties when measuring resilience mainly due to unavailability of long time series data. In addition, shocks are not always observable, and the proposed method does not require to identify the initial shock. Moving forward, this novel method needs to be applied and tested to other outcomes, and levels of aggregation and also try to show causality (for example, what makes households more resilient?).

iii) *Presentations and Publications:*

Publications (Peer reviewed)

- I. Kim J.J., Stites E., Webb P., Constanas M., Maxwell D.. The effects of male out-migration on household food security in rural Nepal. Food Security. May 30, 2019. <https://doi.org/10.1007/s12571-019-00919-w>

Presentations

Presenter	Event	Location	Topic	Date	Audience
Oral Presentations					
Andrew Thorne-Lyman	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	Nutritional Resilience following the 2015 Earthquake in Nepal	August 2019	~ 55
Shibani Ghosh	2019 American Society for Nutrition Conference	Baltimore, MD	A Novel Method to Measure Resilience in Nutrition: Application to diets of rural women and children in Nepal and Bangladesh	June 2019	~100
Sonia Zaharia	Feed the Future Innovation Lab for Nutrition Partners Meeting on Supporting Program Design through Research on Agriculture to Nutrition Linkages	Boston, MA	A Novel Method to Measure Resilience in Nutrition: Application to diets of rural women and children in Nepal and Bangladesh	August 2019	~ 55
Sonia Zaharia	Annual meetings of the Agricultural & Applied Economics Association (AAEA)	Atlanta, GA	Measuring Resilience: A Triple-Difference Approach	July 2019	
William Masters	4 th Annual Agriculture, Nutrition and Health Academy Week	Hyderabad, India	A Novel Method to Measure Resilience in Nutrition: Application to diets of rural women and children in Nepal and Bangladesh	June 2019	

VII) Human and Institutional Capacity Development

I. Short term training

i. Number trained:

A total of 1249 individuals (714 men, 535 women) were trained across Nepal, Bangladesh, Uganda, and Mozambique.

Country of Training	Brief Purpose of Training	Sector Trained	Number Trained		
			M	F	Total
Africa					
Mozambique	Household Enumeration	Civil	24	18	42
Mozambique	Survey Anthropometrics	Civil	5	3	8
Mozambique	Phlebotomy	Civil	4	4	8
Uganda	1 st Annual Scientific Symposium	Civil, Government, and Private	229	125	354
Uganda	Kamwenge and Kitagwenda district dissemination	Civil, Government, and Private	26	13	39

Asia					
Bangladesh	Chole Andrews	Civil	0	1	1
Bangladesh	Refresher training for beneficiary farmers	Civil, Government, and Private	8	2	10
Bangladesh	Dhaka Dissemination	Civil, Government, and Private	29	13	42
Bangladesh	Barisal Dissemination	Civil, Government, and Private	35	7	42
Bangladesh	Khulna Dissemination	Civil, Government, and Private	43	4	47
India	BBNC 1/7/2019	Civil	3	1	4
Nepal	6 th annual symposium	Civil, Government, and Private	221	217	438
Nepal	Mycotoxins and Post-Harvest Control Measures in LMICs	Civil	15	20	35
Nepal	Assessing Quality of Registered Dietetics Program in Nepal	Civil	17	35	52
Nepal	Data Analysis Workshop	Civil	2	2	4
Nepal	IOM student Internship	Civil	0	1	1
Nepal	Food Sample collection and market and health center mapping survey	Civil	2	4	6
Nepal	USAID Family Planning Statutory and Policy Requirements Training	Civil	1	0	1
Nepal	Second Annual Workshop 2019	Civil	7	13	20
Nepal	Lecture at a dietetics school (CAFODAT)	Civil	20	10	30
United States					
USA	Annual Partners meeting	Civil, Government, and Private	28	37	65

2. Long-Term Training

i. Number Trained:

19 scholars (7 post-doctoral, 6 doctoral and 6 master's - 3 men, 16 women) students were supported for graduate-level studies.

Trainee number	Sex	University	Degree	Major	Program End Date (year)	Degree Granted (yes/no)	Home Country
Africa							
1	F	Harvard TH Chang	Doctoral	Nutrition	2019	No	Zimbabwe
2	F	Tufts University	Doctoral	Food Policy and Applied Nutrition	2018	Yes	USA
3	M	IFPRI	Post-doctoral	Agricultural Economics	2020	Yes	Uganda
Asia							
4	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal

5	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal
6	F	Tufts University	Doctoral	Food Policy and Applied Nutrition	2020	No	Nepal
7	F	Purdue University	Doctoral	Nutrition	2020	No	USA
8	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal
9	F	Johns Hopkins	Doctoral	Intl Health	2018	Yes	USA
10	F	Tufts University	Post-doctoral	Food Policy and Applied Nutrition	2018	Yes	USA
11	F	Tufts University	Post-doctoral	Nutrition	2019	Yes	USA
12	F	Johns Hopkins	MPH/Post-doctoral	Intl Health	2017	Yes	Nepal
13	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal
14	F	University of Tokyo	Doctoral	Nutrition	2020	No	Bangladesh
15	F	Tufts University	Post-doctoral	Finance, Economics	2020	Yes	USA
16	F	Johns Hopkins	Doctoral	Intl Health	2019	No	Singapore
17	M	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal
18	M	Purdue University	Post-doctoral	Nutrition	2020	No	USA
19	F	Institute of Medicine	Master's	MPHN	2019	Yes	Nepal

3. Institutional Capacity Building and Support

Nutrition capacity development to meet National priorities - Malawi

The goal of this project is to build pre-service nutrition education and training capacity in Malawi through guiding the development and implementation of a dietetics program sensitive to national needs and priorities; review and provide recommendations to improve the existing medical curriculum for nutrition content (in partnership with national stakeholders), which can be adopted by targeted medical training institutions; and to compile a national food composition table. The Department of Human Nutrition and Health at the Lilongwe University of Agricultural and Natural Resources (LUANAR) and the College of Medicine (COM), School of Public Health focus on the dietetics program. LUANAR and the South African Medical Research Council (SAMRC) work collaboratively to produce the first national Food Composition Table. The clinical medicine curricula will be reviewed for nutrition content in collaboration with COM. Stakeholders engaged across all the activities include the Ministry of Health, Department of Nutrition and HIV/AIDS (DNHA) and the directorate of clinical services. Additional stakeholders engaged in the implementation of the dietetics program are the Strengthening Agriculture and Nutrition Extension (SANE) and Baylor College of Medicine.

- i) *Location:*
Lilongwe University of Agriculture and Natural Resources (LUANAR), and the College of Medicine.
- ii) *Collaborators:*
Tufts University; College of Medicine; South African Medical Research Council; University of Cape town, South Africa; Strengthening Agriculture and Nutrition Extensions in Malawi (SANE); Baylor College of Medicine, Malawi.
- iii) *Achievements:*

Progress of second cohort

The second cohort of dietitians completed didactic training in April 2019. All students successfully met requirements to enter supervised practical rotations, which began in May 2019.

In addition to retaining rotation sites established with the first cohort of students, that include the University of Cape town, Baylor College of Medicine and Kamuzu Central Hospital, the program has expanded dietetics training to Queen Elizabeth Central Hospital led by the clinical coordinator. Further collaborations with Partners in Hope, which is one of Malawi's largest non-government health care centers. This new collaboration is likely to lead to the development of a new clinical or community nutrition rotation site for the next cohort of students.

Admission of LUANAR staff for supervised clinical internships

Two LUANAR staff members were admitted into the internship program in order to complete the requirements for registration as a dietitian. Both staff members have received didactic training in the US but did not complete internship requirements.

Deployment of dietitians at Kamuzu Central Hospital

The first cohort of four dietitians that graduated from the program in May 2018 were deployed to the first dietetics department in Malawi, established at Kamuzu Central Hospital. Thus far the department has been allocated office space at KCH. The Nutrition Innovation lab has supported the department by purchasing equipment blended tube feeds.

Dietetics education and credentialing guidelines

Comments from a cross section of practicing dietitians in Malawi have been received on the first draft of dietetics practice registration guidelines. The SD is working on the second draft of the document based on the comments received. The document will go through a second round of review by practicing dietitians before submission to the medical council for review and adoption.

Development of national food service/catering guidelines

The Malawian food service guidelines have been finalized and approved by senior management of the Ministry of Health. These guidelines were developed with support of dietitian graduates and the supervising dietitian. This is the first-time that dietitians have been at the forefront of establishing government guidelines.

Progress of the Food Composition Data Program

One of the key outputs of the nutrition innovation lab in Malawi has been the development of the first edition of the Malawi Food Composition Database (MFCDB), which had been concluded by December

2018. The Malawi Food Composition Table (MFCT) derived from the MFCDB, reports the nutritive value of 316 locally produced and imported foods commonly consumed in the country in a book publication. The publication also gives a brief background of the development process, sustainability structure and guidelines on how to read the information provided in the tables. Twelve rounds of review and values check were performed through the development process, leading to final publication of the MFCT in August 2019 and is now awaiting an official launch. The table presents a very important milestone for Malawi, as a valuable scientific tool for dietetic practice, research, nutrition programming and policy purposes. We have already had an outpouring of requests for table and have been able to share with people in government institutions, non-governmental organizations and students carrying out various research.

Another important direct output of the project has been capacity building of an in-country food composition compiler who apart from compilation work has also started assisting Master of Science students studying Food Science and Technology and Human Nutrition and Health with practicals in Food Composition Data Production, Management and Use. The areas covered are those that will also directly or indirectly input into the objectives of the food composition data program. The areas covered during the practical sections this year were as follows;

- Quality evaluation of food composition data
- Comparison of food composition databases
- Recipe calculation
- Selection of foods to prioritize in the Malawian Food Composition Database and;
- Food composition data additional tools development

Apart from the master's students, the compiler has also raised awareness among undergraduate students studying various programs, on food composition data, the importance of having food composition data as a country and the approach that was undertaken to develop the first edition of the MFDB, through class presentations scheduled in July, 2019. It is aimed that this will increase the number of people that are aware and understand the importance of food composition data and promote their interest to pursue a career or activities related to food composition data in Malawi.

Looking forward, we believe that the partnerships formed through the process of developing the first edition will be sustained to create a sustainable food composition program for Malawi. This is very important because currently the database has a lot of missing food items inherent to the Malawian diet and this will obviously create challenges when using the table to analyze nutrient intakes. Work to develop and publish the second edition has already commenced with data collection for newly published food composition data. Through student theses and compilers' measurements, an initiative has started to compile Malawi's own food quantities manual. However, we need commitment from the Department of Nutrition and HIV & AIDS (DNHA), because a proposed and endorsed custodian to not stall the program but immediately start lobbying for more partnerships and funding to analyze priority foods and compile the necessary food quantities manual. Based on our experience, we can all agree that collaboration is very essential and has been key in establishing sustainable food composition activities in Malawi. We will therefore, utilize the launch to advocate and bring on board the industry, private sector and any possible food composition data generators and users.

Medical curriculum development

Findings of the review are ready for dissemination, following final review by the Tufts University consultant and team. Discussions have also been held to conduct a formal and objective assessment of the knowledge, attitudes and perceptions of medical nutrition education of medical students and

practicing doctors. This assessment has the potential of providing baseline data which can be used as a point of reference to evaluate the impact of the recommendations from the review.

iv) *Capacity building:*

All activities mentioned above are capacity-building initiatives.

v) *Lessons learned:*

Joint degree and sustainability

The joint degree negotiations between COM and LUANAR have stalled. Both parties still express an interest to corporate with each other on the joint degree. However, no action has been taken to this effect. The main reasons cited for this are delays in getting buy in and the necessary approvals of the proposal for the joint degree, which is drafted last year in September 2018. The two deans from COM and LUANAR had a meeting to discuss the proposal in October 2018. Since then no significant steps have been made to move the agenda forward. Meanwhile, COM has developed an undergraduate degree in dietetics that has been approved up to senate level. This first intake of students is expected before the end of 2019. LUANAR has also expressed an intention to develop their own undergraduate program. These developments suggest that both parties are not as committed to co-implementing a joint degree as previously thought. However, at a meeting held in early August in Boston, both parties agreed that now, none of them have independent capacity to implement a program without support from each and agreed to develop a plan for collaboration. There is consensus that undergraduate programs are more likely to be sustained in Malawi, given the preference of government funding for undergraduate, front line workers. It remains to be seen how both programs will co-exist without duplication and competition.

vi) *Presentations and Publications:*

Presentations

Presenter	Event	Location	Topic	Date	Audience
Oral Presentations					
Bernadette Chimera	4th Federation of African Nutrition Societies (FANUS) conference	Kigali, Rwanda	Development of an Innovative, Novel, Gold Standard Framework for Incorporating Nutrition Education into Medical School Curriculum.	August 2019	~150
Sanele Nkomani	Partners in Hope Journal club	Lilongwe, Malawi	Dietary principles in the management of diabetes.	July 2019	~50
Abstract-Driven Poster Presentations					
Bernadette Chimera	4th Federation of African Nutrition Societies (FANUS) conference	Kigali, Rwanda	Policy maker involvement in sustainable dietetics practice; The case of building and strengthening nutrition capacity in Malawi.	August 2019	~100
Sanele Nkomani	4th Federation of African Nutrition Societies (FANUS) conference	Kigali, Rwanda	Strengthening clinical nutrition capacity in Malawian healthcare facilities: Lessons learned in implementing dietetic supervised clinical rotations	August 2019	~100

Accepted Abstract					
Sanele Nkomani	Food & Nutrition conference & Expo (FNCE)	Philadelphia, PA	Strengthening clinical nutrition capacity in Malawian healthcare facilities: Implementing Dietetics supervised practice in a resource limited setting	October 2019	

The 6th Nepal Annual Scientific Symposium

The Feed the Future Innovation Lab for Nutrition Scientific Symposium: **‘Food, Diets & Nutrition: 25 Years of Progress for Nepal’** was held on November 27-29, 2018 at hotel Yak and Yeti, Kathmandu. This annual knowledge sharing event has gained tremendous momentum over the years and has allowed for the sharing of findings from agriculture – nutrition research conducted in, or relevant to, Nepal. A diverse audience of academia, policy makers, program implementers and students provide for an enriching and stimulating environment for those eager to learn and translate research into policy and practice.

This year, the Feed the Future Innovation Lab for Nutrition partnered with Government of Nepal and UNICEF to host the 6th Annual Scientific Symposium on Agriculture - Nutrition pathways & 25 Years of Nepal's Progress on Nutrition. The event, funded by USAID and EU, was co-hosted by Johns Hopkins Bloomberg.

School of Public Health, Tufts Friedman School of Nutrition Science and Policy, UNICEF – Nepal, Government of Nepal, Tribhuvan University's Institute of Medicine (IOM) Community Medicine & Public Health Department, Nepal Agricultural Research Council (NARC) and the Nepali Technical Advisory Group (NTAG). This year, the event featured: abstract driven sessions on the agriculture to nutrition pathway, oral and poster presentations, policy panels featuring reflections on 25 years of nutrition progress, achievements and challenges in Nepal and student workshops. The abstract review committee reviewed over 130 poster and oral abstracts and 13 learning lab proposals. Planning for the 7th Symposium is now underway.

The 2nd National Workshop on Implementation and Design of Intervention Studies in Nepal

It was implemented by Tufts University in collaboration with Patan Academy of Health Sciences and Institute of Medicine at Tribhuvan University. The key objectives of the workshop were i) to identify a research question with measurable precise objectives, determine the appropriate research design, data collection, and analysis methods to answer the research question, and ii) gain substantive knowledge on the developmental and structural processes in preparing a research protocol.

Out of the applications received, participants were selected for the one-week intensive course. The workshop was generously supported by 11 national and international faculty instructors from accredited US and non-US institutions like Tufts University, Tribhuvan University Institute of Medicine, Patan Academy of Health Sciences and St. Johns Institute. The workshop was also attended by panel guest speakers from USAID Nepal, UNICEF and NTAG.

The one-week intensive workshop included participants from academic institutions such as Tribhuvan University Teaching Hospital, Government of Nepal Child Health Division, Helen Keller International, USAID Suaahara program, Hams Hospital, and many other non-profit organizations in Nepal.

Participants were rigorously exposed to understanding the basic concept of research design, processes and components. Participants worked in groups based on their topics of interest. The outcome of the workshop were ten research proposals that were presented by the group of two on the final day of the presentation. The final day also highlighted special guest speaker, Dr. Ahmed Kablan from USAID, and four distinguished panelists from Government of Nepal, Patan Academy of Health Sciences, College of Applied Food and Dairy Technology and USAID Mission.

Participants found the workshop well organized and appreciated interacting directly with mentors through the workshop. Strong recommendations were made for organizing the workshop/course on an annual basis in Nepal. Participants as well as the faculty appreciated and highlighted the importance of continued interactions post course completion.

A list of the course presentations follows:

Presenter	Location	Topic	Date
Ahmed Kablan	Budanilkantha, Nepal	Food Safety Consideration when Scaling of Livestock Production	April 2019
Ashish Pokharel/ Sudikshya Acharya/ Robin Shrestha	Budanilkantha, Nepal	Data Collection, Quality and Management	April 2019
Elizabeth Marino-Costello and Xuemeng Chen	Budanilkantha, Nepal	Nutrition & Diet Quality	April 2019
Laurie Miller	Budanilkantha, Nepal	Selecting a Method of Data Collection	April 2019
Laurie Miller	Budanilkantha, Nepal	Nutrition & Child Development	April 2019
Laurie Miller	Budanilkantha, Nepal	Protection of Human Subjects in Research	April 2019
Lynne Ausman	Budanilkantha, Nepal	Introduction to Second National Workshop on Nutrition Research Designs and Methods	April 2019
Lynne Ausman	Budanilkantha, Nepal	Selecting a Study Design	April 2019
Lynne Ausman	Budanilkantha, Nepal	Vitamin D	April 2019
Shibani Ghosh	Budanilkantha, Nepal	Determinants of Stunting and Wasting	April 2019
Shibani Ghosh	Budanilkantha, Nepal	How to formulate Research Questions, Hypotheses, Objectives/Specific Aim and Tools to undertake the Research Process	April 2019
Shibani Ghosh	Budanilkantha, Nepal	Non-Communicable Diseases” Diabetes Mellitus, Hypertension, Cardiovascular disease	April 2019
Sumanta Neupane	Budanilkantha, Nepal	Novel Data Collection Methods and tools Use of electronic data capture tools	April 2019
Tinku Thomas	Budanilkantha, Nepal	Sample size estimation and Sampling strategy	April 2019
Tinku Thomas	Budanilkantha, Nepal	Basic Statistical Analysis	April 2019

Bangalore Boston Nutrition Collaborative

The Nutrition Innovation Lab continued to support the Bangalore Boston Nutrition Collaborative through a sub-award to St. John’s Medical College. Four scholars from Nepal and Uganda were supported (3 men and 1 woman) to attend the two-week workshop in FY2019.

BBNC was first established in 2009 as a collaboration between St. John’s Research Institute (SJRI), Harvard T.H. Chan School of Public Health (HSPH), and Tufts University. BBNC is designed as a two-week short-

course with a focus on nutrition research and training taught by faculty mentors at SJRI, HSPH and Tufts. The overall goals are to a) explore the role of nutritional factors and health outcomes, through critical evaluation of the scientific literature and exploration of demographic, epidemiological, biological, social, political, and economic determinants, b) gain substantive knowledge in topic areas related to public health nutrition research, including clinical nutrition, physiology, biochemistry, and molecular nutrition, c) enhance methodological skills in areas of nutritional, infectious disease, and chronic disease epidemiology, with emphasis on clinical, research, and laboratory areas, and, d) discuss the latest findings from epidemiologic studies on the role of nutrition in the prevention, care, and treatment of health outcomes, and to integrate research findings to inform public health recommendations and program design and implementation, based on current evidence.

This year BBNC celebrated its 10th year with roughly 50 participants from different regions of India, Nepal, Sri Lanka, and Uganda in attendance. The backgrounds and interests of the students were diverse; spanning nutrition, clinical, research, program, policy, and laboratory work, including medical and PhD students, physicians, and allied health professionals. However, all participants shared an unyielding commitment to tackling our greatest nutrition challenges of our time, both within their home countries as well as globally. Throughout the entire two-weeks, students worked in teams to design innovative nutrition research proposals, which were presented on the last day of class. This year, students explored a range of research topics, including the determinants of catch-up growth in young children and the effect of zinc supplementation on patient outcomes post heart-attack. To date, over 500 students have successfully completed the BBNC course, and the strong alumni network ensures that the relationships built at BBNC don't end after the two weeks are over.

Curriculum development for a Master in Public Health Nutrition degree, Institute of Medicine, Tribhuvan University, Nepal

The Tufts ME and in-country partners of the Innovation Lab continued their support to the Master in Public Health Nutrition (MPHN) at Institute of Medicine, Tribhuvan University (TUTH IOM). The Nutrition Innovation Lab continued to provide guest lectures to the master's students. This year, the in-country Nutrition Innovation Lab experts mentored five second year students on their research thesis topics. Support on data collection, cleaning and analysis has been ongoing. In coordination with the TUTH IOM faculty, the Nutrition Innovation Lab experts started a monthly journal club for the first year and second year master's students. In total, eleven master's students successfully attended trainings provided by the Nutrition Innovation Lab experts on nutrition assessment tools and electronic data collection.

The 1st Uganda Annual Scientific Symposium

The Nutrition Innovation Lab partnered with Makerere University National Agriculture Research Organization (NARO) to co-host the first Annual Scientific Symposium in November 12-15, 2018. The first Joint-NIL-Makerere and NARO meeting was held on 27th March, 2018 at Makerere University to discuss plans for the symposium. The meeting was chaired by Imelda Kashaija, Deputy Director General of NARO and co-Chair, Professor Bernard Bashaasha, Principal of the Agricultural College at the Makerere University.

Over 300 stakeholders, including key stakeholders from the government of Uganda came together for the first symposium that put national-level attention on nutrition. There was a call for a paradigm shift and a transformation in the mind-frames of the people involved in the social and legal structures to emphasize more support to nutrition sensitive interventions. Right Hon. Ruhakana Rugunda, the Prime

Minister of Uganda, concluded the event by stating that Uganda recognizes that nutrition is the biggest problem facing humankind.

A second Scientific Symposium is being planned for FY2020.

VIII) Information Dissemination

The Nutrition Lab focused on several different national and international conferences. All the abstracts and presentations made in FY2019 are enumerated under each research report. In addition, the ME and partners also utilized all possible opportunities to present findings at different academic conferences and policy events/fora. This year, the Nutrition Lab organized a number of dissemination events, focused at the regional level. The events have been enumerated under each research accomplishments report. The Nutrition Lab also maintained and updated the website and extensively using Twitter and Facebook for transferring information and new findings.

IX) Governance of the Nutrition Innovation Lab

The Nutrition Lab hosted an all-partners meeting in August 6-7, 2019 followed by two days of individual meetings with partners to discuss work plans for the final year. Before the partners meeting, the ME had the opportunity to debrief with the technical advisory board and listen to their ideas for messaging our findings and identifying future research and gaps. The main objective of the partners meeting was to share all of the research findings from the past 9 years with each other who are part of the Nutrition Lab as well as representatives from USAID, and other collaborating Innovation Labs. In addition to sharing findings, detailed discussions ensued on identifying other research outside of the Lab and to bring all this knowledge together to determine what to recommend for future research. Plans in 2020 for a follow up research dissemination in Washington DC where the audience will include a different audience of stakeholders is planned for the middle of fiscal year.

X) Innovation Transfer and Scaling Partnerships

Unlike other Innovations Labs, which focus on generating new varieties of seeds, techniques for pest control or tools for market analyses, the Nutrition Innovation Lab's main intellectual property relates to dissemination of research findings which directly impact policy and program design and the methods of implementing both. One technology transfer which represents an important step forward in research across all the focus countries is the programming and use of electronic tablets for implementing surveys in the field. In addition, the Innovation Lab has implemented three technologies from the Horticulture Innovation Lab including floating gardens, chimney dryers and cool rooms (CoolBots).

XI) Environmental Management and Mitigation Plan (EMMP)

As per the USAID regulations, the ME has an approved Initial Environmental Evaluation (IEE) in place which was updated in August 2018. Based on the approved IEE conditions, an Environmental Monitoring and Mitigation Plan (EMMP) was developed by the Nutrition Innovation Lab ME. An EMMP format was prepared and shared by the Tufts ME with its partners. The IEE regulations were translated into specific mitigation actions to be implemented in Nepal, Uganda and Bangladesh. Specific monitoring measures, timelines and responsible parties were identified as necessary. Institutions responsible for monitoring the environmental plan of action include UC Davis Horticulture Innovation Lab (Bangladesh), Patan Academy of Health Sciences (Nepal), Makerere University (Uganda) and Nepalgunj Medical College (Nepal). A quarterly review of EMMP monitoring and mitigation activities was conducted and information for each IEE condition was compiled by in-country study coordinators. Updates on EMMP for all three country

activities with IEE conditions attached in Appendix 2. Also attached are manuals highlighting standard operating procedures (SOPs), monitoring reports and certificates.

XII) Open Data Management Plan

In October 2015, the Nutrition Innovation Lab developed its data management plan (DMP), which was approved by the USAID. The Nutrition Innovation Lab will generate a series of diverse data sets which range from longitudinal household panel data, including: agriculture, food security, household consumption and expenditure, water, hygiene, sanitation, water quality, longitudinal individual data on nutrition, diet, health, biomarkers (i.e., serum aflatoxins, micronutrients, gut microbiome, environmental enteropathy) and anthropometry, as well as longitudinal policy level data on nutrition and governance. Institutions, which are responsible and/or involved in this effort, include Tufts University, Johns Hopkins Bloomberg School of Public Health, Harvard TH Chan School of Public Health, Makerere University and Purdue University.

In FY2016, the Innovation Lab worked with Tufts Technology Services in developing a platform for data sharing (Lab Archives). Currently, the platform hosted by Tufts University allows sharing of data across all the Innovation Lab partner institutions. Per the DMP, data will be also released to public access on this platform. Significant amount of work is still ongoing particularly on developing the metadata and procedures as well as coding manuals for the different studies (listed in the DMP). The work is expected to be completed by the end of FY2020. However, the 3-panel PoSHAN Community study (led by Johns Hopkins) has been submitted to the USAID DDL and is currently under review. In FY2019, the Innovation Lab reviewed the DMP and no changes were made to the DMP.

XIII) Project Management Activity

The ME, in FY2019 continued its core activities in Nepal and Uganda with associate award activities in Malawi, Bangladesh and Mozambique. The Lab continued support of data analysis of research conducted in Ethiopia and Tanzania. The Lab had significant presence at several international meetings. Post-doctoral researchers at Tufts, Purdue and Harvard continued analysis through FY2019 that allowed for finalizing manuscripts and reports. ME staffing remained consistent for the last two years. The ME focused then on ensuring that researchers at Tufts and in our partner, institutions submitted abstracts to conferences and tried to increase the productivity around publications.

XIV) Other Topics (Impact Assessment, Gender Initiatives)

Not applicable

XV) Issues and how they are being addressed (Financial, Management, Regulatory)

This year's budget fully supported all existing research. Travel included multiple trips to Washington, DC made mostly by the Program Director as he was invited by USAID to participate in a number of FTF activities. Most of the effort for the Africa program consisted of sorting out and reconciling survey data and managing the serum samples preparing them for analysis.

XVI) Future Directions

The Innovation Lab is working with the Kansas State University researchers on extending the aflatoxin study activities in Nepal and planning for extensive stakeholder engagement. The Lab has published several seminal papers across all its three research streams and aims to continue producing manuscripts

of high caliber. The focus and emphasis of the way forward is to compile findings to gain an understanding of the way forward.

Appendix I: Three Success Stories

Success Story I: Supporting Women Leaders in Science



Johanna Andrews-Trevino, Postdoctoral Research Fellow at Tufts University/USAID Feed the Future Innovation Lab for Nutrition

Having grown up in Honduras, I gained an early understanding of how hunger and malnutrition can affect various aspects of life, particularly for mothers and children. As a young female researcher at Tufts University, I was given the chance to co-lead and co-design a USAID-funded birth cohort study in Nepal. This cohort tackled an imperative research question regarding the link between aflatoxin exposure and child growth during the first 1000 days. In my role as a PhD student and as a postdoctoral research fellow, I was able to advocate for a supportive research environment that empowered women to be nutrition champions in their households and their communities.

During our frequent household interviews, we made sure to provide mothers with information and support regarding maternal, infant and young child feeding practices, which was a topic of great interest to our study participants. We carefully built rapport with our study communities via multiple strategies, such as hiring local research teams. These efforts to build trust with our study communities helped us maintain a strong relationship with our participants throughout the study.

Our solid link to the communities and our participants allowed us to generate a rich longitudinal dataset that has permitted us to explore both our main research question and to better understand maternal and children's health and nutrition overall. With this dataset, we were able to rigorously study the relationship between gestational aflatoxin exposure and birth outcomes and are currently exploring the complex relationship of this toxin to child growth.

Rumana Akter, doctoral candidate, The University of Tokyo

My research aimed to assess whether the dietary quality of household members varied by exposure or non-exposure to one or more of the United States Agency for International Development (USAID) projects. The study investigated multiple micronutrient deficiencies, especially among young children (aged 6-59 months) and women during their reproductive age (15-49 years) in Bangladesh. My research further assessed whether the dietary quality of the household members varied by exposure to a specific USAID-funded project, compared to non-exposure to a specific USAID-funded project.



Under the auspices of the Feed the Future Innovation Lab for Nutrition, my research included the following USAID programs: USAID Shikha, USAID Spring, USAID AIN, UNICEF/FAO IAHBI and USAID CIP-Horticulture. Each project included elements of agriculture (i.e. homestead food production, livestock production, and aquaculture) and nutrition (i.e. infant and young children feeding, behavior change communication) interventions, targeting the beneficiary populations. Nutrients of interest for this research included energy and 11 key micronutrients, such as: iron, calcium, zinc, vitamin A, thiamine, riboflavin, niacin, vitamin B6, folate, vitamin B12, and vitamin C.

The study demonstrated that overall dietary quality was significantly better among household members exposed to the USAID AIN project, compared to household members who were not exposed to this project. Similarly, intake of vitamin A, calcium, folic acid, riboflavin, iron, zinc, thiamine, niacin, and vitamin B12, was significantly higher among household members exposed to the USAID AIN project, compared to household members having had no project exposure; although it was not clear whether the result yields through direct food consumption pathway. This study would be an important document to guide researchers and public health practitioners to better understand about the most effective nutrition-sensitive intervention components for improving food and nutrition security, among the most vulnerable population groups in Bangladesh.



Sabi Gurung, *Feed the Future Innovation Lab for Nutrition/USAID & Tufts University*

The experience of working at the Nutrition Innovation Lab helped me understand the impacts of different approaches linking agriculture, nutrition, and health on diet and the nutritional status of women and children in developing countries. The results generated by the Nutrition Innovation Lab, which encompasses a multisectoral outlook towards malnutrition, will be crucial to understand, guide and accelerate progress through subsequent research programs and policies in the future. It will also help optimize and improve existing interventions on reducing undernutrition and micronutrient

deficiencies in resource-limited settings by helping to understand factors related to food production and availability, market system, food consumption pattern, and health status.

Not only did the experience strengthen my technical and analytical skills, but it also made me aware of the intricacies surrounding undernutrition in women and children, and which left me wanting to learn more about refining my research skills. The field work and interactions with families in Bangladesh made me aware of how deeply rooted religious beliefs, behavior, and sociocultural norms are. They can pose greater obstacles to prevent women and children from living a healthier life, and only cemented my passion for working in this field.

Sanele Nkomani, *Supervising Dietitian-Feed the Future Innovation Lab for Nutrition, Bunda College of Agriculture*

I have taught two cohorts of students as the supervising dietitian of the first Malawian program to train post-graduate, diploma level dietitians. My teaching responsibility involves teaching medical nutrition therapy, nutrition counseling, and behavior change, as well as supervising students during eight months of clinical internships. In addition to this, I have played a major role in advocating and guiding the government of Malawi to create employment opportunities for graduates of the program. This included organizing learning visits for top management at the Ministry of Health to learn about the deployment of dietitians, their role in clinical care and the resources needed for their optimal practice. These learning visits and continuous teamwork with the government led to the first posts for clinical dietitians in Malawian hospitals, complete with job descriptions and career progression options for dietitians.



I have also led the way for the development of national foodservice and nutrition guidelines about the prevention of non-communicable diseases. The broader importance of my work is to build the

foundation necessary for the growth of a dietetics practice in a country where very little existed in the past. Dietitians play a very important role in patient care. Their work significantly improves clinical outcomes and saves costs related to medical care in a variety of medical conditions. Hence, their introduction in Malawi is poised to improve the outcomes of hospitalized patients, while also impacting the prevention and management of undernutrition and overnutrition related non-communicable diseases.

Success Story 2: Building Evidence-based Policy Options to Address Negative Impacts of Aflatoxins in Health, Nutrition and Agriculture

Context

Understanding the relationship of agriculture and nutrition through a health lens is a major focus of the USAID-funded Feed the Future Innovation Lab for Nutrition, managed by Tufts University. Under this lens, research activities are underway to elucidate previously little known neglected biological pathways of mycotoxins (for example, aflatoxins) exposure and its effect on nutrition and health outcomes. Since 2014, researchers at the Nutrition Innovation Lab have been undertaking large-scale, complex, flagship research activities to generate evidence about nutrition and health risks from dietary aflatoxins in Nepal, Uganda and Mozambique.

The Nutrition Innovation Lab has made significant contributions to the global evidence base about pregnant women's exposure to aflatoxin and its subsequent effect on children after birth. Early analysis in Nepal and Uganda has shown a widespread exposure to aflatoxins in pregnant women and a relationship between aflatoxin exposure during pregnancy and low birth weight in newborns. Findings also show a strong association between the consumption of maize and groundnuts and maternal aflatoxin levels in the blood.

These findings imply the need to further explore sources, causes, innovative solutions, and cost-effective interventions, and policy mechanisms to reduce mycotoxin contamination in health, food, feed supply and markets value chain.

Fitting Evidence to Policy

The research and evidence generated about aflatoxins are powerful tools for national and regional policymakers and stakeholders to frame and integrate specific policies targeting their mitigation. To facilitate this process and promote multi-sectoral policy engagement in Nepal, the Nutrition Innovation Lab has partnered with other Feed the Future Innovation Labs (Post-Harvest Loss Reduction and Livestock Systems), development partners, health and agriculture sectors of the government of Nepal since 2017 through a series of high-level consultation and strategic workshops and capacity building activities.

Key Initiatives and Activities

A high-level national consultation workshop titled *Mycotoxin Mitigation for Health, Nutrition, Agricultural Productivity and Prosperity in South Asia* was held at the National Academy of Science and Technology in Lalitpur, Nepal on November 30, 2018. The workshop brought together more than 80 representatives from ministries of health, agriculture, research and academic institutions, donor agencies (UNICEF, Gates Foundation, DFID), civil society, implementation partners and private sector partner (Mars Inc. and other companies for e.g. within the animal feed industry) to deepen their knowledge about the impact of mycotoxins (especially aflatoxin) and food safety in human health in Nepal, and to bring innovative technologies to mitigate mycotoxins during post-harvest storage.

Following up on the first national consultation workshop, a 4-day strategic workshop titled *Building a Better Response: Mycotoxin Planning Workshop* was held from August 18-21, 2019, which brought together

more than 100 representatives from federal and provincial government stakeholders (health, agriculture, livestock, planning commission) and non-government stakeholders.

Key Policy Actions

Strong Political Commitment

The two workshops were highly successful in bridging multi-sectoral partnerships between different government ministries (health, agriculture, livestock, and National Planning Commission), in establishing policy dialogues around mycotoxin contamination as a major food safety issue in Nepal and in exploring collaboration to examine its food safety policies, regulatory framework, and strategies about mycotoxins. The continued dissemination and policy engagement have facilitated policymakers from health and agriculture sectors in generating a demand for well-informed, designed and targeted policy actions to inform, and influence awareness, communication and capacity on mycotoxins and its mitigation within the broader national food safety strategy. Integrated comprehensive multi-sectoral approaches from policy and advocacy will foster national regulatory standards to detect and control mycotoxins in food and feed and explore innovative and cost-effective interventions that is economically and environmentally sustainable and scalable. The government of Nepal has shown a strong political commitment for investment and continuous engagement with a range of stakeholders, including private sectors required for safeguarding food safety, and ensure effective implementation of mycotoxins mitigation strategies.

The two workshops resulted in a strong financial and strategic willingness from provincial level government representatives to implement farm and market-level actions focused on regulation, testing and remediation, and determining existing and promising technologies and/or practices that could be implemented at the farm or household levels to mitigate mycotoxin contamination. Further interactions and engagement with the stakeholders to develop sound policy actions is expected to continue during the upcoming dissemination and policy event in Nepal in December 2019.

Sustainable Human and Institutional Capacity Building

The joint partnerships of the Innovation Labs with government stakeholders and academic institutions has resulted in a strong human and institutional research capacity in Nepal, evidenced from successful conclusions of large-scale, complex research such as the Aflacohort study and risk assessment studies and establishment of a food sample analyzing unit at a government facility in Nepal. Building a strong human and research capacity and local infrastructure to test and analyze food commodities is expected to support the country in generating further evidence around mycotoxins in Nepal.

Future Directions

Moving forward, the Nutrition Innovation Lab will continue its activities to reinforce the evidence base for health and nutritional effects due to aflatoxin exposure at global and country levels through an upcoming evidence-sharing workshop in Nepal on December 2019. These successive workshops will aim to facilitate continued multi-sectoral engagement to develop strong political commitment and action plans for various provincial and federal government levels to evaluate different intervention options for mycotoxin mitigation and their feasibility for successful implementation across the agriculture value chains.

Success Story 3: Nutrition Innovation Lab Dissemination of District-level Findings: Opportunities to influence their local policy, planning and budgeting in Western Uganda

This success story was produced as a result of a dissemination workshop organized by the Innovation Lab for Nutrition, together with Makerere University, to present findings and recommendations on key causal linkages among agriculture, nutrition, and health for improved outcomes using evidence from the

Uganda panel study. The dissemination workshop was held on 19th July 2019 in Kamwenge District town. As background, the Nutrition Innovation Lab research agenda in Uganda was designed to determine, rigorously, interventions at the nexus of agriculture-nutrition-health, but also to un-pack linkages, associations, and relationships among agriculture, nutrition and health, and the effectiveness of interventions. Our research, therefore, has evolved around the Uganda Community Connector Program (UCCP) interventions, which were funded by USAID from 2012-2015. Our research goal was to reduce malnutrition among the most vulnerable populations (women and children) in rural areas and employed the integrated.

Method/approach: Since its inception, the Innovation Lab has conducted three-panel surveys (approx. 600 households): in 2012 (baseline), 2014 (midterm) and 2016 (final) in six districts: Kisoro, Dokolo, Agago, Lira, Kole, and Kamwenge. Specifically, in the Kamwenge district, a total sample of 600 similar households was surveyed three times to answer the key research questions using a similar tool to establish any differences. In FY2018, the government of Uganda split the Kamwenge district into two districts; Kamwenge and Kitagwenda. Hence, during our dissemination exercise, we also invited the political and technical leadership from both districts, civil and private sectors, to participate in this exercise. A total of 39 invited participants joined, including top district leaders.

Key issues:

Rare and unique food security, nutrition and health results at district level: The Innovation Lab looks at the dissemination of its results as an opportunity to close the loop that exists in research, which is not taking results back to the local authorities to use for planning and/or budgeting. Our approach has been to take the results back to the people to use them to influence program and policy. District leaders both in government and the private sector looked at this dissemination activity as a “rare but also unique” opportunity to get district and sub county disaggregated results.

Being a district focused: By taking the results back to the districts, the “users” saw this as an opportunity to brainstorm about key actions to solve challenges faced by the people they lead. It was clear that they were ready to share the results with their co-workers and others. In our discussions during this workshop, the findings triggered their thinking around how to grapple with community challenges related to food insecurity, nutrition and feeding practices, and poverty. They also acknowledged differences exist in terms of poverty levels. This can partly explain differences across the communities in their areas.

Key Ask: Provide specific and sensitive messages to key district leaders and administrators in nutrition. This is meant to reinforce and put to use the agreed actions as a result of the disseminated outcomes. Those key people to receive training include mainly community development and agricultural extension officers, political leaders and administrators. Administrators are critical because they are budget holders. The key training topics should cover topics such as understanding key nutrition issues and feeding, and advocacy for nutrition, among others, in a multi-sectoral in nature. This is expected to influence issues such as budgeting because the budget holders will be able to understand the causes and impacts of malnutrition. The other key outcome from such training included acquiring knowledge to support the on-going sensitization of different stakeholders and communities that they represent. The knowledge also helps them to monitor projects better.

Next Steps: Publish finalization of the dissemination workshops to other districts but also hold a national research dissemination workshop for national-level stakeholders, which will coincide with the 2nd Innovation Lab research symposium next year.

Appendix 2: Environmental Monitoring and Mitigation Plan (EMMP)

Bureau/Office: Bureau for Food Security/Agricultural Research and Policy

Program/Activity Title: Feed the Future Innovation Lab for Nutrition (Tufts University) (Nutrition Innovation Lab)

Functional objective 4: Economic Growth

Program Area:

4.5 Agriculture

4.5.2 Agricultural

Program Elements:

Sector Productivity

IEE Expires: September 30, 2020

Last updated: August 17, 2018

Country: Bangladesh

IEE activity 2: Pilot-testing selected small-scale food security technologies - Bangladesh					
IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
I. Technologies selected for pilot testing must be appropriate to local environmental conditions and integrate sector-specific best management practices (BMPs) such as those enumerated in the USAID Sector Environmental Guidelines and/or comparable resources	Ia. Provide instructions on proper construction and use of the solar dryer, CoolBot rooms, and floating gardens.	Ia. Identify locations where solar dryers, CoolBot rooms, and floating gardens will be used.	Ia. Make sure the SOP for use and disposal are in place and shared with those using the solar dryers. List responsible parties to do this (e.g. Nil Director, Associate director, or Local country coordinator or US PI. Etc.; and USAID AOR when feasible), same for every cell in this column	4.1.2018 8.1.2018	On the month of January, one chimney dryer was repaired in Parerhat to improve fish drying. All torn plastic and non-biodegradable materials were replaced in a given jute sack for recycling. The sacks were not full yet at any of the locations. The record keeping continued during the standard monthly technology checklist monitoring plan.
	Ib. Check solar dryer plastic after each use and repair holes/tears with tape or a sealant.	Ib. Keep inventory of solar dryer plastic covers and plastic containers provided to each community and those collected for recycling, and how they were disposed of.	Ib. Site visits and reporting will be performed twice a year and when contacted by the community to pick up the full sack.	4.1.2018 8.1.2018 21.1.2018 14.1.2018, 4.2.2018 15.2.2018, 1.3.2018	After chimney dryer repair in January, drying process has been monitored and checked. Dryers, floating gardens and cold rooms were monitored twice in a month or as needed. Two new plastic containers were added in one floating gardens at Agoiljhara to maintain floating balance, old one kept in the given just sack. The jute sack was not full at any of the locations yet. The record keeping is continuing during the standard monthly technology checklist monitoring plan.
	Ic. Plastic unsuitable for further use shall be reused by community members or placed in provided sacks for collection for appropriate recycling or disposal.		Responsible Party: Amrita Mukherjee	4.1.2018 8.1.2018 21.1.2018 15.2.2018 8.3.2018	One chimney dryer has been repaired in Parerhat, Pirojpur for Fish drying. Two pieces of plastic have been unused and placed in the given jute sack for recycling. The sacks were not full yet at any of the locations. The record keeping is continuing during the standard monthly technology checklist monitoring plan.

	Id. Plastic jars provided for storage of dried products will be recycled by project staff when no longer useable. They will be placed in provided sacks awaiting collection.			21.1.2018 15.2.2018 21.3.2018	Plastic jars are still in use, no record of damage found yet. Record keeping is continued as part of the monthly technology checklist monitoring plan.
	Ie. The sack provided for unusable plastic collection will contain the contact information of project staff to arrange for pickup.			4.1.2018 8.1.2018 21.1.2018 14.1.2018 4.2.2018 15.2.2018 1.3.2018	Since winter was the time for drying more monitoring has been done about technology and farmers preparation. Given sack are equipped with contact info of the project staff for all three technologies (Amrita Mukherjee and Mohammed Rezaul Islam)
	If. The plastic containers used to float the gardens are second hand 30 L containers that were used to store acetic acid (vinegar). Acetic acid poses no threats to humans or fishes/animals. The containers will be reused if possible after the floating gardens are dismantled or disposed of by the project staff if they are unusable.			14.1.2018 4.2.2018 1.3.2018	Since pond water quality and toxicity levels tested on the month of May 2017 and no effect found on pond water quality and toxicity levels on fish. Another water quality testing will be done on May,2018. But during farmers group discussion observation on water quality has been recorded and no negative feedback were found. No new repairing or replacing of plastic containers has been done after February,2018

<p>2. Worker health and safety must be addressed in the assessment of candidate technologies, including the use of personal protective equipment (PPE). Specific worker health and safety requirements must be established as one set of criteria for any subsequent scale-out of selected technologies.</p>	<p>2. We do not have plans to use synthetic pesticides in this project and participating farmers will be instructed not to use pesticides near the fish ponds. Natural plant extracts, such as Neem, may be used when needed. Farmer training will include some IPM strategies for pest management, including biological and mechanical approaches. For example, farmers may be provided with plastic for solarization of floating gardens and pest exclusion nets to place over the top of the beds.</p>	<p>2. Verify proper use of IPM techniques for pest control by interviewing farmers and inspecting floating gardens during site visits at least two times per year.</p>	<p>2. Site visits twice per year. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM.</p>	<p>Please report on site visit findings on proper use of IPM techniques</p>	<p>The team has introduced mechanical pest control measures, rat traps, soil solarization and netting for floating gardens. The team noted that these activities sometimes require labor need technical expertise. Neem extract is being used for pest infestation which sometimes works relatively slowly and is less effective in case of massive infestation compared to field cultivation practices which involve chemical fertilizers and pesticides. However, farmers have shared that vegetables grown in floating gardens had more taste and flavor compared to field grown ones and they feel safe to in case of feeding their children and household consumption.</p>
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IEE activity 3: Scale out of selected technologies - Bangladesh

IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
I. Financial support, either direct (e.g. via a grant-making mechanism or similar) or indirect (e.g. such as through a loan guarantee program or similar) to entrepreneurs, marketers, or other partners engaged in the scale out of successful technologies is disallowed until such time that an IEE amendment that fully addresses the nature and scope of anticipated activities is prepared and duly approved.	Ia. Financial support will not be provided to farmers or communities; however, the technologies will be provided to the communities for their use.	Ia. Develop protocols and agreements in collaboration with each community to guide common use of the shared cool room.	I. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM	23.5.2016 for Lebukhali. Patuakhali Cool room, 2.8.2017 for Madhukhali, Faridpur cool room, 23.11.2016 for Kalapara, Patuakahli cool room.	UC Davis has a written agreement with owner farmers for rent-free usage and common sharing of cold room. The agreement was done for two years.
	Ib. For the CoolBot cool rooms, the community leader will collect a rental fee for use of the cool room that will used to maintain the room when the project support ends. This will promote the sustainability of the technology once the project ends.	Ib. Visit technology sites at least two times per year and interview community about use of technology and any issues.			During trainings, field days and regular site visits project personnel set aside time for discussion, questions and sharing issues, local recommendations and success about technologies. For instance, Coolbot communities are seeking a way to manage cool room running cost during the lean season, the team has considered the issue and has started working on in a business model which might cover the electricity and maintenance cost during the lean season and even after the project.

2. Any technical assistance and capacity building to promote the scale out of successful small-scale approaches must incorporate and emphasize the respective environmental BMPs identified and implemented through the pilot testing phase.	2. Technical manuals and all presentations about the technologies will include environmental BMPs identified and implemented through the pilot testing phase.	2. Manuals and presentations will be archived by the Horticulture Innovation Lab.	2. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM	28.2.2016, 5.3.2016 and 24.4.2016 (chimney dryer, Coolbot, and Floating gardens	Developed manuals are stored at the Horticulture Innovation Lab, UC Davis cloud storage system (www.box.com)
3. Partners engaged in scale out efforts must receive a presentation or basic orientation on the environmentally sound design and management of Nutrition Innovation Lab-Asia-supported activities, including the promotion and proliferation of selected small-scale food security technologies. This presentation/orientation process will also identify needs for technical training and capacity building such that partners can competently train or advise smallholder farmers on the use/implementation of such technologies in a manner that is consistent with the methods, recommendations, and/or findings generated through the pilot testing phase.	3a. Presentations will be prepared and provided/presented to the Technical Advisory Group, partner universities and USAID Mission for sharing with partners engaged in scale-out activities.	3a. Copies of presentations will be maintained at the Horticulture Innovation Lab.	3. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM.	19.11.2017	A presentation has been presented at the USAID mission and stored at the UC Davis cloud storage system (www.box.com)
	3b. All parties will be invited to field days to view the technology in use and learn more about its construction and use.	3b. A list of all field days and the attendees will be maintained by the Horticulture Innovation Lab.		06.05.2017	Data has been maintained by Horticulture Innovation Lab staff. Last field day on floating garden was in Chandrahar, Gournadi with 13 males and 3 females present.

<p>4. The Nutrition Innovation Lab-Asia must prepare and make available for use by partners a technical manual or similar reference resource to accompany each of the technologies selected/promoted for scale out. The manual or reference resource will emphasize the importance of environmental BMPs and the means by which they are integrated or used for each technology. The manual or reference resource will be made available in local language and will rely on illustrations or other visual elements to promote understanding and adoption among marketers, as well as smallholder farmers and other beneficiaries.</p>	<p>4. Technical manuals emphasizing environmental BMPs and the means by which they are integrated into or used for each technology will be prepared translated, and disseminated to communities adopting the technologies, university partners, Technical Advisory Group, and other USAID implementing partners. Manuals will use appropriate illustrations and images to promote understanding and adoption by target stakeholders</p>	<p>4. Manuals will be archived by the Horticulture Innovation Lab for monitoring purposes, and the numbers of manuals disseminated, and recipient details will be summarized.</p>	<p>4. Responsible Party: UC Davis staff in California (A. Deltsidis) and Bangladesh staff (A. Mukherjee).</p>		<p>Manuals have been archived. Three manuals on each technology have been developed. Also, three flip charts and three leaflets have been developed and disseminated.</p>
<p>5. Any technology-specific PPE requirements that are established through the pilot testing phase must be treated as a required element of subsequent scale-out activities.</p>	<p>5. Any PPE requirements identified in the pilot testing phase will be emphasized in technical manuals and presentations about use of the technology in scaling activities.</p>	<p>5. Manuals will be archived for monitoring purposes, and numbers of manuals disseminated, and recipient details will be summarized.</p>	<p>5. Responsible Party: Amrita Mukherjee (Bangladesh), Angelos Deltsidis (UC Davis) and cognizant USAID AOR/AM.</p>	<p>Please report on site visit findings on proper use of IPM technique</p>	<p>Manuals have been archived. 36 floating garden manuals, 24 chimney dryer manuals, and 24 cold room manuals had been disseminated among the technology beneficiaries. Besides. One chimney dryer manual has been given to BAU. A copy of each manual also provided to Tufts University team.</p>

IEE activity 4: Aflatoxin and Other Mycotoxin Assessment - Uganda					
IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
Clear safety standards and practices/protocols will be established for proper blood sample collection and handling practices and followed throughout the duration of the study.	Field: Each study involving aflatoxin or mycotoxin measurement will have a standard operating manual for blood collection and handling in the field	Field: Training and testing staff involved in blood sample collection and processing and disposal of needles and other materials used for blood collection. Site visits and checks by research managers and study team members	Responsible Party: Annet Kawuma and Florence Kinyata- Makerere University	N/A	Data and Specimen collection completed in June 2015.
	Lab: All Assessments being conducted will have a standard operating procedure. Strict quality assurance procedures will be established. The lab will adhere to standard bio hazard protocols for lab safety as prescribed by their parent institution.	Lab: Quality assurance testing is routinely conducted by the Labs of Dr. Wang. Adherence to biohazard protocols. Training and testing of staff involved in handling and analyzing samples	Responsible Party: Aflatoxin Assessment for Nepal and Uganda: Dr. Jia Sheng Wang (UGA), Nutrition Innovation Lab partner.	Lab safety and biohazard training dates (based on the most recent certificates issued by Tufts University following the completion annual training): August 8, 2017; Monitoring visit dates: June 2017, September 2017 (attached); University of Georgia Lab: Quality assurance and lab safety inspection (research compliance) date: 12/07/2017, Training and testing of staffs: 1) Blood borne pathogens training: 01/16/2018 (updated), Biohazard waste handling: 9/6/2017, RTK Global Harmonized System training: 9/6/2017	Finding 1: The serum samples are further being processed at Tufts University lab after being shipped to the US in March 2017. Drs. Lynne Ausman and Robin Shrestha are overseeing all lab activities. A total of 5 lab technician were hired and trained to perform the sample aliquots. Before working in the lab, all staffs underwent bio-hazard and lab safety trainings provided by Tufts University's Environmental Health and Safety Department. The staffs were then trained by Drs Ausman and Shrestha on sample processing protocol. Each staff was provided with SOP manual. The monitoring visits are being performed every three month and a progress report was submitted to the PI and the research team. Finding 2: Lab safety inspection: IBC protocol is up to date, lab

					specific biosafety plan available, passed biohazard waste disposal inspection, Appropriate PPE is worn during lab activities, passed chemical and radiation safety checklist
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IEE activity 5: Assessment of Aflatoxin Mitigation Intervention - Uganda					
IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
Clear safety standards and practices/protocols will be established for proper blood sample collection and handling practices and followed throughout the duration of the study.	Field: Each study involving collection of blood samples will have a standard operating manual for blood collection and handling in the field	Field: Training and testing staff involved in blood sample collection and processing and disposal of needles and other materials. Site visits and checks by research managers and study team members	Responsible Party: Nutrition Innovation Lab partner (Uganda) and cognizant USAID AOR/AM	N/A since data collection completed in June 2015. A total of 32 staffs were trained in blood sample collection in 2014.	Data and Specimen collection completed in June 2015.

IEE activity 6: Environmental Enteropathy Assessment - Uganda					
IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit

1. The Nutrition Innovation Lab will ensure that clear safety standards and practices/protocols are established for proper blood and urine sample collection and handling practices are followed throughout the duration of the study.	Field: A standard operating manual for blood and urine collection and handling in the field	Field: Training and testing staff involved in blood and urine sample collection and processing. Site visits and checks by research managers and study team members	Set up of standard operating procedures at the start of the study with monitoring throughout. Uganda: Jacqueline Lauer and cognizant USAID AOR/AM	Study #1: L:M tests on children 12-16 months in Southwestern Uganda: Training for this study was conducted April 7-10, 2016 in Mbarara, Uganda. A refresher training was conducted June 24-15, 2016 in Mbarara, Uganda. I (Jackie) made a trip to the Southwest every two weeks for monitoring purposes. An external reviewer (Ugandan physician) also visited the sites for monitoring purposes.	Fourteen enumerators were trained (6 male, 8 female). All monitoring activities showed that SOP was followed throughout the study.
				Study #2: L:M tests and blood draw on pregnant women 18-45 years in Mukono, Uganda: Training for this study was done from Feb 17-19, 2017 in Mukono, Uganda. Monitoring was done every day, since I (Jackie) was in the field with the study team every day that blood and urine were collected. Also, Dr. Nathan Nshakira from Uganda Christian University came to monitor activities for one afternoon in June. Finally, Uganda IRB came one day in October for monitoring purposes	Six enumerators were trained (3 male, 3 female). Training was also done with the nurse and phlebotomist at Mukono Health Center IV. All monitoring activities showed that SOP was followed throughout the study.
2. Clear analytical procedures and lab quality assurance protocols will be put in place to ensure safe handling and disposal of waste	Lab: All Assessments being conducted will have a standard operating procedure.	Lab: Quality assurance testing is routinely conducted. Adherence to bio-hazard	Uganda: Nutrition Innovation Lab partner and	Quality assurance and lab safety inspection (research compliance) date: 12/07/2017,	Finding 1: Lab safety inspection: IBC protocol is up to date, lab specific biosafety plan available, passed biohazard waste disposal

materials generated from the ELISA analyses (for LPS flagellin, IgG, IgA, zonulin, and interleukin6).	Strict quality assurance procedures will be established. The lab will adhere to standard bio hazard protocols for lab safety as prescribed by their parent institution.	protocols. Training and testing of staff involved in handling and analyzing samples	cognizant USAID AOR/AM	Training and testing of staffs: 1) Blood borne pathogens training: 01/16/2018 (updated), Biohazard waste handling: 9/6/2017, RTK Global Harmonized System training: 9/6/2017	inspection, Appropriate PPE is worn during lab activities, passed chemical and radiation safety checklist
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IEE activity 7: Gut Microbiome Assessment - Uganda

IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
The Nutrition Innovation Lab will ensure that clear safety standards and practices/protocols are established for proper stool (human and livestock) sample collection, handling, and disposal practices and followed throughout the duration of the study.	Field: A standard operating manual for fecal sample collection and handling in the field	Field: Training and testing staff involved in fecal sample collection and processing. Site visits and checks by research managers and study team members	Set up of standard operating procedures at the start of the study with monitoring throughout. Responsible Party: Uganda: Annet Kawuma and Florence Kinyata and cognizant USAID AOR/AM, Egypt: Marwa Moaz and cognizant USAID AOR/AM	Fecal Samples were not collected	N/A
Clear analytical protocols and lab quality assurance protocols will be put in place to ensure appropriate handling of waste material generated from the analyses of the fecal DNA.	Lab: All Assessments being conducted will have a standard operating procedure. Strict quality assurance procedures will be established. The lab will adhere to standard bio hazard protocols for lab	Lab: Quality assurance testing is routinely conducted. Adherence to bio-hazard protocols. Training and testing of staff involved in handling and analyzing samples	Responsible Party: Uganda and Egypt: Nutrition Innovation Lab partner and Cognizant USAID AOR/AM	Since samples were not collected, no analyses were performed	N/A

	safety as prescribed by their parent institution.				
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IEE activity 8: Water quality Assessment - Uganda

IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
The Nutrition Innovation Lab will ensure that clear safety standards and practices/protocols are established for proper handling and disposal of contaminated water supplies and followed throughout the duration of the study.	Field: A standard operating manual for water sample collection and disposal. Decontamination with chlorine tablets and disposal similar to other plastic bags or taken to the health center	Field: Training and testing staff involved in water sample collection and testing. Site visits and checks by research managers and study team members	Set up of standard operating procedures at the start of the study with monitoring throughout. Responsible Party: Uganda: Annet Kawuma and Florence Kinyata and cognizant USAID AOR/AM, Egypt: Marwa Moaz and cognizant USAID AOR/AM	Training and assessment of staffs/enumerators were done in August 2014 for a period of 3 weeks and 1 week for pretest. Water sample collection was completed in June 2015. All enumerators were provided with SOP manual and implementation manual to guide them during the field data collection. Monitoring visits were made by Field supervisors (weekly) and research managers (monthly) and a progress note was submitted to the study Pls and the research team	N/A

IEE activity 9: Assessment of Malaria Prevalence in Households Benefitting from Malaria and Livestock Intervention - Uganda Birth Cohort Study

IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
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The Nutrition Innovation Lab will ensure that clear safety standards and practices/protocols are established and followed throughout the study for handling of blood samples and disposal of the rapid diagnostic kits used to detect malaria.	Field: A standard operating manual for using the rapid diagnostic kits and handling lancets	Field: Training and testing staff involved in using the rapid diagnostic kits and handling lancets and disposal of contaminated /used materials. Site visits and checks by research managers and study team members	Responsible Party: Uganda: Annet and Florence and cognizant USAID AOR/AM,	The staffs were trained in rapid diagnostic kits and handling lancets in August 2014. Monthly monitoring visits were made by research coordinators and progress reports were submitted until June, 2015	Training manuals included manual for using rapid diagnostic kits and its disposal. An implementation manual was prepared and distributed to all field enumerators. A local physician was hired for a week to train use of diagnostic kits and lancets disposal in 2014. Research coordinators used implementation manual as a checklist to monitor enumerators use of diagnostic tests in the field. A progress report was sent by enumerators every month.
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IEE activity 9: Assessment of Malaria Prevalence in Households Benefitting from Malaria and Livestock Intervention - Uganda Panel Study

IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
The Nutrition Innovation Lab will ensure that clear safety standards and practices/protocols are established and followed throughout the study for handling of blood samples and disposal of the rapid diagnostic kits used to detect malaria.	Field: A standard operating manual for using the rapid diagnostic kits and handling lancets	Field: Training and testing staff involved in using the rapid diagnostic kits and handling lancets and disposal of contaminated /used materials. Site visits and checks by research managers and study team members	Set up of standard operating procedures at the start of the study with monitoring throughout. Responsible Party: Uganda: Nassul Kabunga and cognizant USAID AOR/AM,	Supervisor training in Kampala: 5-11/11/2016 Enumerator training for northern region districts held at Lira: 28/11/2016-8/12/2016 Enumerator training for western region districts held at Mbarara: 26/11/2016-5/12/2016 Field visits by Nassul Kabunga: 05-14/12/2016; then 10-15/01/2017 Field visits by Jacinta Dusabe: 12-16/12/2016; then 24-28/01/2017	A total of 96 (37 females and 59 males) enumerators were training in Nov/December 2016. All materials used in collecting blood samples (including lancets, cotton wool, microcuvettes, etc) were being placed in provided safety boxes. These would later be safely incinerated at health facilities. Field staff were still observing safety precautions of wearing gloves while collecting blood samples. Records were taken appropriately, and results marked such that they match the household and individual IDs.

Country/Region: Nepal

IEE activity 4: Aflatoxin and Other Mycotoxin Assessment - Nepal

IEE Condition(s)	Mitigation Measure(s)	Monitoring Measures(s)	Timing and Responsible Parties	Monitoring Site Visit Date/Date of training (s) and other relevant dates	Major findings of site visit
Clear safety standards and practices/protocols will be established for proper blood sample collection and handling practices and followed throughout the duration of the study.	<p>Field: Each study involving aflatoxin or mycotoxin measurement will have a standard operating manual for blood collection and handling in the field. Consultant pediatrician and an experienced nurse from his team trained the field-based nurses on attaching pediatric urine bags, precautions, and disposal of biological wastes such as pipette tips, urine bags, and used diapers. Training was carried in May 20 to May 25, 2018.</p> <p>In addition, a lab technician from the team trained the nurses on pipetting of urine samples and proper disposal of used products (e.g. filter tips, diapers, bags) following the process.</p> <p>Some team members were trained on ASQ component starting July 2 to July. The environmental impact of ASQ assessment was found to be minima.</p>	<p>Field: Trained staff involved in blood and urine sample collection, processing and disposal of needles and other materials used for blood and urine collection were regularly monitored by research manager, research coordinator and study investigators.</p> <p>ASQ trained staff were monitored by research manager and research coordinator.</p>	Responsible Party: At the start of the study with monitoring through the study. Nepal: Johanna Andrews Chavez and Research Manager at Helen Keller International	<p>Training I: May 20th, 2018 to May 25, 2018.</p> <p>Consultant pediatrician and an experienced nurse trained the field based nurses and staff on urine sample collection process, precautionary measures and waste disposal process.</p> <p>Lab technician from the study team trained the field based nurses on pipetting of urine samples and proper disposal (of pipette tips, bags) following the pipetting of urine samples.</p> <p>Monitoring period I: May 27, 2018 to June 8.</p> <p>In this period, the field-based activities were closely monitored by research manager and research coordinator to ensure all blood and urine sample collection process was done as per standard protocol. Both ensured proper disposal of food and clinical waste as per the guidelines.</p> <p>Subsequent monitoring</p>	<p>Training I Findings: All the field nurses and field staff quickly learned standards and process involved in collecting urine samples as well as guidelines of bio-hazard waste disposal. (i.e. urine collection bags, diapers, pipettes.)</p> <p>Monitoring Period I Findings: It was found that all the nurses collecting blood samples were properly following the protocol for infant venous blood and urine sample collection. The nurses were properly disposing all clinical waste (such as needles, lancets, cotton swabs, urine bags, diapers, etc.) Eventually, the bio-waste was disposed in Nepalgunj Medical college.</p> <p>Subsequent monitoring visits, Findings: The field team were reminded regularly about following the safety standards and protocol. Minor issues during</p>

				<p>visits by field-based RM and RC: June 12, June 14, June 21, June 22, June 28, July 4, July 5, July 10, July 23, July 25, August 1, August 2, August 3, August 6, August 7, August 8 During these visits, both blood sample and urine sample collection processes were monitored. The field team was provided instructions and feedback based on the observations. The RC specifically monitored ASQ assessment activities.</p> <p>Study investigator visit 1: June 27 Monitoring of urine sample collection process</p> <p>Study investigator visit 2: August 6, August 7 Monitoring of urine sample collection process and ASQ assessment</p>	<p>monitoring visits (such as necessity to regularly clean field-based site) was improved. Procedures for waste management (especially managing food and clinical waste separately and properly) were streamlined to improve efficiency and effectiveness of the process. The ASQ staff cleaned the toys used in ASQ regularly.</p> <p>Study investigator visit 1 and 2, findings: A decision to use biodegradable paper cups instead of plastic cups during lunches to reduce environmental impact. The availability and feasibility of using paper plates was discussed and followed up. However due to lack of availability and time constraints, it could not be implemented.</p>
	<p>Lab: All Assessments being conducted will have a standard operating procedure. Strict quality assurance procedures will be established. The lab will adhere to standard bio hazard protocols for lab safety as prescribed by their parent institution.</p>	<p>Lab: Quality assurance testing is routinely conducted by the Labs of Dr. Wang. Adherence to bio-hazard protocols. Training and testing of staff involved in handling and analyzing samples</p>	<p>Responsible Party: Aflatoxin Assessment for Nepal: Dr. Jia Sheng Wang (UGA), Nutrition Innovation Lab partner</p>	<p>Quality assurance and lab safety inspection (research compliance) date: 12/07/2017, Training and testing of staffs: 1) Blood borne pathogens training: 01/16/2018 (updated), Biohazard waste handling: 9/6/2017, RTK Global Harmonized System training: 9/6/2017</p>	<p>Finding 1: Lab safety inspection: IBC protocol is up to date, lab specific biosafety plan available, passed biohazard waste disposal inspection, Appropriate PPE is worn during lab activities, passed chemical and radiation safety checklist</p>

Appendix 3: List of Publications FY2019

Nutrition Innovation Lab Publications FY2019

- I. Lauer J, Duggan C, Ausman L, Griffiths J, Webb P, Agaba E, Nshakira N, Tran H, Gewirtz A, Ghosh S. Biomarkers of maternal environmental enteric dysfunction are associated with shorter gestation and reduced length in newborn infants in Uganda. *American Journal of Clinical Nutrition*. 2018;108(4):889-96. PMID: 30247538 PMCID: PMC6186209 DOI: [10.1093/ajcn/nqy176](https://doi.org/10.1093/ajcn/nqy176)

Abstract

BACKGROUND:

Adverse birth outcomes, including preterm birth and stunting at birth, have long-term health implications. The relation between adverse birth outcomes and chronic, asymptomatic gastrointestinal inflammation (environmental enteric dysfunction-EED) is poorly understood.

OBJECTIVE:

We aimed to examine the relation between maternal EED and adverse birth outcomes in a sample of pregnant Ugandan women and their newborn infants.

DESIGN:

We conducted a prospective cohort study in Mukono, Uganda. A total of 258 pregnant women were enrolled at their first prenatal visit (~18 weeks of gestation). EED was measured by urinary lactulose:mannitol (L:M) ratio and serum concentrations of antibodies to the bacterial components flagellin and LPS. Covariates were obtained from survey data collected at 2 time points. Associations were assessed through the use of unadjusted and adjusted simple linear regression models.

RESULTS:

Complete birth outcome data were recorded for 220 infants within 48 h of delivery. Mean \pm SD gestational age was 39.7 ± 2.1 wk, and 7% were born preterm. Mean \pm SD length and length-for-age z score (LAZ) at birth were 48.1 ± 3.2 cm and -0.44 ± 1.07 , respectively. L:M ratio was not associated with any birth outcome. In adjusted models, higher concentrations of natural log-transformed anti-flagellin immunoglobulin G (IgG) and anti-LPS IgG were significantly associated with shorter length of gestation (β : -0.89 wk; 95% CI: $-1.77, -0.01$ wk, and β : -1.01 wk; 95% CI: $-1.87, -0.17$ wk, respectively) and with reduced length (β : -0.80 cm; 95% CI: $-1.55, -0.05$ cm, and β : -0.79 cm; 95% CI: $-1.54, -0.04$ cm, respectively) and LAZ at birth (β : -0.44 z score; 95% CI: $-0.83, -0.05$, and β : -0.40 z score; 95% CI: $-0.79, -0.01$, respectively).

CONCLUSION:

Maternal anti-flagellin and anti-LPS IgG concentrations in pregnancy, but not L:M ratio, were associated with shorter gestation and reduced infant length at birth. Further research on the relation between maternal EED and birth outcomes is warranted.

2. Harding L. K., Aguayo M. V., Webb P. Birthweight and feeding practices are associated with child growth outcomes in South Asia. *Maternal & Child Nutrition*. November, 29, 2018;14(S4):e12650. DOI: 10.1111/mcn.12650.

Abstract

Although there has been a focus on preventing stunting over the past decade, wasting has received less policy and programmatic attention. Recent national surveys from six South Asian countries were pooled to generate a dataset of 62,509 children aged 0 to 59 months to explore associations between low birthweight (LBW) and suboptimal infant and young child feeding (IYCF) practices with child wasting, severe wasting, and the co-occurrence of wasting and stunting. Logistic regression models accounted for the surveys' clustered designs and adjusted for a potential confounding factors. Children with reported LBW had significantly higher odds of being wasted (adjusted odds ratio [95% CI]: 1.60 [1.45, 1.76]) or severely wasted (1.57 [1.34, 1.83]), compared with non-LBW children. Similarly, children aged 0 to 23 months who were not breastfed within the first hour post-partum, those who were provided prelacteal feeds, and those aged 0 to 5 months who were not exclusively breastfed, were more likely to be wasted ($P < 0.05$ for all three feeding practices). In India, not achieving minimum diet diversity and minimum adequate diet were significantly associated with the co-occurrence of stunting and wasting. In other words, many key domains of concern to development agents who seek to address stunting are also of direct concern to those focused on wasting. The co-occurrence of wasting and stunting requires more integrated interventions. That is, programmes aimed at preventing LBW and poor IYCF to avert stunting should be linked more effectively with actions aimed at the management of wasting.

3. Thorne-Lyman A., K.C A., Manohar S., Shrestha B., Nonyane BAS., Neupane S., Bhandari S., Klemm RW., Webb P., West KP Jr. Nutritional resilience in Nepal following the earthquake of 2015. *PLoS ONE*. 2018. 13(11): e0205438. doi: 10.1371/journal.pone.0205438

Abstract

BACKGROUND:

The 2015 earthquake in Nepal caused massive damages and triggered relief activities to minimize human suffering. The post-earthquake nutrition and food security situation in the hardest hit areas remains uncertain.

METHODS:

Two national cross-sectional surveys were conducted in 2014 and 2016 among households (HH) with pre-school aged children or newly married women. Of the 21 village development committees (VDCs) included in this sample, 7 fell within "earthquake-affected" areas. This paper presents data from 982 HH, 1015 women, and 883 children from 2014 and 1056 HH, 1083 women, and 998 children from 2016 living in these areas, with longitudinal overlap of about 55%. Prevalence estimates and 95% confidence intervals

were calculated, and logistic regression was used to calculate p-values, both using robust estimates of standard errors to account for clustering.

RESULTS:

From 2014 to 2016, child wasting (weight-for-height z score <-2) fell from 4.5% (95% CI 3.3%– 6.1%) to 2.1% (1.4%– 3.1%) and food insecurity (assessed using the household food insecurity access scale) dropped from 17.6% (11.7%– 25.6%) to 12.4% (6.9%– 21.2%). Child stunting prevalence remained similar at both time-points. Improvements were also evident in dietary diversity and breastfeeding indicators.

CONCLUSIONS:

Nutrition and food security conditions remained comparable or improved one year after the earthquake despite evidence of structural and other damage. Livelihood resilience to shocks and/or effective nutrition, food or health interventions may have helped buffer the impact on nutrition, although this hypothesis requires further exploration

4. Thapa G., and Shively G. A dose-response model of road development and child nutrition in Nepal. *Research in Transportation Economics* 70: 112-24. November 19, 2018. doi.org/10.1016/j.retrec.2018.11.002.

Abstract

Transportation development accompanies economic development, both as a driver of growth and as an outcome of economy-wide investments made possible by growth. Evidence of the effects of roads and road quality on human well-being is limited. This paper studies the association between district-level transportation infrastructure and district-average child nutrition outcomes in Nepal. We combine two rounds of nationally representative data on child growth from the 2006 and 2011 Nepal Demographic and Health Surveys with district-level information on roads and road quality. We estimate a dose-response function for height-for-age and weight-for-height z-scores. Results suggest that roads and road quality matter for short- and long-term nutrition outcomes for children under five years of age. Using a spatial econometric model we also observe statistically significant geographic spillovers from roads, suggesting broad and beneficial health and nutrition payoffs from transportation development.

5. Moucheraud C., Chandyo R., Henjum S., Strand T., Ulak M., Fawzi W., Locks L., Webb P., Throne-Lyman A. Engagement in Agriculture Protects Against Food Insecurity and Malnutrition in Peri-Urban Nepal. *Current Developments in Nutrition*, Volume 3, Issue 1, 1 January 2019, nzy078, <https://doi.org/10.1093/cdn/nzy078>

Abstract

BACKGROUND:

Urbanization is occurring rapidly in many low- and middle-income countries, which may affect households' livelihoods, diet, and food security and nutritional outcomes.

OBJECTIVE:

The main objective of our study was to explore whether agricultural activity among a peri-urban population in Nepal was associated with better or worse food household security, household and maternal dietary diversity, and nutritional outcomes for children and women.

METHODS:

A cross-sectional survey was administered to 344 mother–child pairs in Bhaktapur district, Nepal, including data on household agricultural practices, livestock ownership, food security, dietary diversity and expenditures, anthropometric measurements of children (aged 5–6 y), maternal body mass index (BMI), and maternal anemia. Multivariable adjusted odds ratios (AORs) and unadjusted odds ratios were calculated using logistic regression.

RESULTS:

Our findings suggest that in this sample, cultivation of land was associated with lower odds of child stunting (AOR: 0.55; 95% CI: 0.33, 0.93) and household food insecurity (AOR: 0.33; 95% CI: 0.18, 0.63), but not low (or high) maternal BMI or anemia. Livestock ownership (mostly chickens) was associated with lower food insecurity (AOR: 0.34; 95% CI: 0.16, 0.73) but not with nutrition outcomes. Women in farming households were significantly more likely to eat green leafy vegetables than were women in nonfarming households, and children living in households that grew vegetables had a lower odds of stunting than children in households that cultivated land but did not grow vegetables (AOR: 0.49; 95% CI: 0.25, 0.98).

CONCLUSIONS:

Our study suggests that households involved in cultivation of land in peri-urban Bhaktapur had lower odds of children's stunting and of food insecurity than noncultivating households, and that vegetable consumption is higher among those households. Given Nepal's rapid urbanization rate, more attention is needed on the potential role of peri-urban agriculture in shaping diets and nutrition.

6. Lauer J., Duggan C., Ausman L., Griffiths J., Webb P., Bashaasha B., Agaba E., Turyashemerwa F., Ghosh S. Unsafe Drinking Water Is Associated with Environmental Enteric Dysfunction and Poor Growth Outcomes in Young Children in Rural Southwestern Uganda. *The American Journal of Tropical Medicine and Hygiene*, Volume 99, Issue 6, Dec 2018, p. 1606 – 1612
DOI: <https://doi.org/10.4269/ajtmh.18-0143>

Abstract

Environmental enteric dysfunction (EED), a subclinical disorder of the small intestine, and poor growth are associated with living in poor water, sanitation, and hygiene (WASH) conditions, but specific risk factors remain unclear. Nested within a birth cohort study, this study investigates relationships among water quality, EED, and growth in 385 children living in southwestern Uganda. Water quality was assessed using a portable water quality test when children were 6 months, and safe water was defined as lacking *Escherichia coli*

contamination. Environmental enteric dysfunction was assessed using the lactulose:mannitol (L:M) test at 12-16 months. Anthropometry and covariate data were extracted from the cohort study, and associations were assessed using linear and logistic regression models. Less than half of the households (43.8%) had safe water, and safe versus unsafe water did not correlate with improved versus unimproved water source. In adjusted linear regression models, children from households with safe water had significantly lower log-transformed (ln) L:M ratios (β : -0.22, 95% confidence interval (CI): -0.44, -0.00) and significantly higher length-for-age (β : 0.29, 95% CI: 0.00, 0.58) and weight-for-age (β : 0.20, 95% CI: 0.05, 0.34) Z-scores at 12-16 months. Furthermore, in adjusted linear regression models, ln L:M ratios at 12-16 months significantly decreased with increasing length-for-age Z-scores at birth, 6 months, and 9 months (β : -0.05, 95% CI: -0.10, -0.004; β : -0.06, 95% CI: -0.11, -0.006; and β : -0.05, 95% CI: -0.09, -0.005, respectively). Overall, our data suggest that programs seeking to improve nutrition should address poor WASH conditions simultaneously, particularly related to household drinking water quality.

7. Blakstad MM, Bellows AL, Mosha D, Canavan CR, Mlalama K, Kinabo J, Kruk ME, Masanja H, Fawzi WW. Neighbour home gardening predicts dietary diversity among rural Tanzanian women. *Public Health Nutr.* 2019 Jun;22(9):1646-1653. Epub 2019 Feb 12.

Abstract

OBJECTIVE:

The present study's aim was to assess the impact of a nutrition-sensitive intervention on dietary diversity and home gardening among non-participants residing within intervention communities.

DESIGN:

The study was a cross-sectional risk factor analysis using linear and logistic multivariate models.

SETTING:

In Tanzania, women and children often consume monotonous diets of poor nutritional value primarily because of physical or financial inaccessibility or low awareness of healthy foods.

PARTICIPANTS:

Participants were women of reproductive age (18–49 years) in rural Tanzania.

RESULTS:

Mean dietary diversity was low with women consuming three out of ten possible food groups. Only 23.4% of respondents achieved the recommended minimum dietary diversity of five or more food groups out of ten per day. Compared with those who did not, respondents who had a neighbour who grew crops in their home garden were 2.71 times more likely to achieve minimum dietary diversity (95% CI 1.60, 4.59; $P=0.0004$) and 1.91 times more likely to grow a home garden themselves (95% CI 1.10, 3.33; $P=0.02$). Other significant predictors of higher dietary diversity were respondent age, education and wealth, and number of crops grown.

CONCLUSIONS:

These results suggest that there are substantial positive externalities of home garden interventions beyond those attained by the people who own and grow the vegetables. Cost-effectiveness assessments of nutrition-sensitive agriculture, including home garden interventions, should factor in the effects on the community, and not just on the individual households receiving the intervention.

8. Bhandari S., Thorne-Lyman A., Shrestha B., Neupane S., Sanny Nonyane B., Manohar S., Klemm R., West K. Determinants of infant breastfeeding practices in Nepal: a national study. *International Breastfeeding Journal*. 3 April 2019, <https://doi.org/10.1186/s13006-019-0208-y>

Abstract

BACKGROUND:

Optimal breastfeeding practices, reflected by early initiation and feeding of colostrum, avoidance of prelacteal feeds, and continued exclusivity or predominance of breastfeeding, are critical for assuring proper infant nutrition, growth and development.

METHODS:

We used data from a nationally representative survey in 21 district sites across the Mountains, Hills and Terai (southern plains) of Nepal in 2013. Determinants of early initiation of breastfeeding, feeding of colostrum, prelacteal feeding and predominant breastfeeding were explored in 1015 infants < 12 months of age. Prelacteal feeds were defined as food/drink other than breast milk given to newborns in first 3 days. Predominant breastfeeding was defined as a child < 6 months of age is mainly breastfed, not fed solid/semi-solid foods, infant formula or non-human milk, in the past 7 days. Adjusted prevalence ratios (APR) and 95% confidence intervals (CI) were estimated, using log Poisson regression models with robust variance for clustering.

RESULTS:

The prevalence of breastfeeding within an hour of birth, colostrum feeding, prelacteal feeding and predominant breastfeeding was 41.8, 83.5, 32.7 and 57.2% respectively. Compared to infants not fed prelacteal feeds, infants given prelacteal feeds were 51% less likely to be breastfed within the first hour of birth (APR 0.49; 95% CI 0.36, 0.66) and 55% less likely to be predominantly breastfed (APR 0.45; 95% CI 0.32, 0.62). Infants reported to have received colostrum were more likely to have begun breastfeeding within an hour of birth (APR 1.26; 95% CI 1.04, 1.54) compared to those who did not receive colostrum. Infants born to mothers ≥ 20 years of age were less likely than adolescent mothers to initiate breastfeeding within 1 hour of birth. Infants in the Terai were 10% less likely to have received colostrum (APR 0.90; 95% CI 0.83, 0.97) and 2.72 times more likely to have received prelacteal feeds (APR 2.72; 95% CI 1.67, 4.45) than those in the Mountains.

CONCLUSIONS:

Most infants in Nepal receive colostrum but less than half initiate breastfeeding within an hour of birth and one-third are fed prelacteal feeds, which may negatively affect breastfeeding and health throughout early infancy.

9. Lauer J., McDonald C., Kisenge R., Aboud S., Fawzi W., L Enju., Tran H., Gewirtz A., Manji K., Duggan C. Markers of Systemic Inflammation and Environmental Enteric Dysfunction Are Not

Reduced by Zinc or Multivitamins in Tanzanian Infants: A Randomized, Placebo-Controlled Trial. The Journal of Pediatrics. April 2, 2019. <https://doi.org/10.1016/j.jpeds.2019.02.016>

Abstract

OBJECTIVE:

To examine whether daily zinc and/or multivitamin supplementation reduce biomarkers of environmental enteric dysfunction (EED), systemic inflammation, or markers of growth in a sample of infants from Dar es Salaam, Tanzania.

STUDY DESIGN:

Subgroup analysis of infants participating in a randomized, double-blind, placebo-controlled trial received daily oral supplementation of zinc, multivitamins, zinc + multivitamins, or placebo for 18 months starting at 6 weeks of age. EED (anti-flagellin and anti-lipopolysaccharide immunoglobulins), systemic inflammation (C-reactive protein and alpha-1-acid glycoprotein), and growth biomarkers (insulin-like growth factor-I and insulin-like growth factor binding protein-3) were measured via enzyme-linked immunosorbent assay in a subsample of 590 infants at 6 weeks and 6 months of age. EED biomarkers also were measured in 162 infants at 12 months of age.

RESULTS:

With the exception of anti-lipopolysaccharide IgG concentrations, which were significantly greater in infants who received multivitamins compared with those who did not (1.41 ± 0.61 vs 1.26 ± 0.65 , $P = .006$), and insulin-like growth factor binding protein-3 concentrations, which were significantly lower in children who received zinc compared with those who did not (981.13 ± 297.59 vs 1019.10 ± 333.01 , $P = .03$), at 6 months of age, we did not observe any significant treatment effects of zinc or multivitamins on EED, systemic inflammation, or growth biomarkers.

CONCLUSIONS:

Neither zinc nor multivitamin supplementation ameliorated markers of EED or systemic inflammation during infancy. Other interventions should be prioritized for future trials.

10. Smith, T. and G. Shively. "Individual, household, and community factors in child growth: a multilevel approach for Nepal." BMC Pediatrics. April 5, 2019. doi.org/10.1186/s12887-019-1469-8.

Abstract

BACKGROUND:

Childhood malnutrition and growth faltering is a serious concern in Nepal. Studies of child growth typically focus on child and mother characteristics as key factors, largely because Demographic and Health Surveys (DHS) collect data at these levels. To control for and measure the importance of higher-level factors this study supplements 2006 and 2011 DHS data for Nepal with data from coincident rounds of the Nepal Living Standards Surveys (NLSS). NLSS information is summarized at the district level and matched to children using district identifiers available in the DHS.

METHODS:

The sample consists of 7533 children aged 0 to 59 months with complete anthropometric measurements from the 2006 and 2011 NDHS. These growth metrics, specifically height-for-age and weight-for-height, are used in multilevel regression models, with different group designations as upper-level denominations and different observed characteristics as upper-level predictors.

RESULTS:

Characteristics of children and households explain most of the variance in height-for-age and weight-for-height, with statistically significant but relatively smaller overall contributions from community-level factors. Approximately 6% of total variance and 22% of explained variance in height-for-age z-scores occurs between districts. For weight-for-height, approximately 5% of total variance, and 35% of explained variance occurs between districts.

CONCLUSIONS:

The most important district-level factors for explaining variance in linear growth and weight gain are the percentage of the population belonging to marginalized groups and the distance to the nearest hospital. Traditional determinants of child growth maintain their statistical power in the hierarchical models, underscoring their overall importance for policy attention.

11. Lauer J., Duggan C., Ausman L., Griffiths J., Webb P., Wang JS., Xue K., Agaba E., Nshakira N., Ghosh S. Association between maternal aflatoxin exposure during pregnancy and adverse birth outcomes in Uganda. *Maternal and Child Nutrition*. April, 2019;15(2):e12701. PMID: 30242967 DOI: 10.1111/mcn.12701

Abstract

Aflatoxins are toxic metabolites of *Aspergillus* moulds and are widespread in the food supply, particularly in low- and middle-income countries. Both in utero and infant exposure to aflatoxin B1 (AFB1) have been linked to poor child growth and development. The objective of this prospective cohort study was to investigate the association between maternal aflatoxin exposure during pregnancy and adverse birth outcomes, primarily lower birth weight, in a sample of 220 mother-infant pairs in Mukono district, Uganda. Maternal aflatoxin exposure was assessed by measuring the serum concentration of AFB1 -lysine (AFB-Lys) adduct at 17.8 ± 3.5 (mean ± SD)-week gestation using high-performance liquid chromatography. Anthropometry and birth outcome characteristics were obtained within 48 hr of delivery. Associations between maternal aflatoxin exposure and birth outcomes were assessed using multivariable linear regression models adjusted for confounding factors. Median maternal AFB-Lys level was 5.83 pg/mg albumin (range: 0.71-95.60 pg/mg albumin, interquartile range: 3.53-9.62 pg/mg albumin). In adjusted linear regression models, elevations in maternal AFB-Lys levels were significantly associated with lower weight (adj-β: 0.07; 95% CI: -0.13, -0.003; p = 0.040), lower weight-for-age z-score (adj-β: -0.16; 95% CI: -0.30, -0.01; p = 0.037), smaller head circumference (adj-β: -0.26; 95% CI: -0.49, -0.02; p = 0.035), and lower head circumference-for-age z-score (adj-β: -0.23; 95% CI: -0.43, -0.03; p = 0.023) in infants at birth. Overall, our data suggest an association between maternal

aflatoxin exposure during pregnancy and adverse birth outcomes, particularly lower birth weight and smaller head circumference, but further research is warranted.

12. Kim J.J., Stites E., Webb P., Constanas M., Maxwell D.. The effects of male out-migration on household food security in rural Nepal. Food Security. May 30, 2019.
<https://doi.org/10.1007/s12571-019-00919-w>

Abstract

In Nepal, international migration is a highly gendered phenomenon. Compared to global figures, where women make up about half of the world's migrant population, 90% of Nepalese migrants are men. Many of these men migrate alone to earn wages abroad while their families stay behind. This level of male out-migration in Nepal occurs in a context characterized by widespread food insecurity. This paper examines the effects of male out-migration on household food security, especially on the women who stay behind, in the mountains of Far West Nepal. Our findings from in-depth interviews and focus group discussions suggest that male out-migration both alleviates and exacerbates households' experiences of insufficient quantity and inadequate quality of food, and uncertainty and worry about food. Migration can benefit households that stay behind through remittances which help cover basic expenses, and by facilitating access to loans and credit, and alleviating anxiety about having enough to eat. However, it comes at high costs. Men report undignified, unsafe, and difficult working conditions in India. Women bear additional childcare, fieldwork, and housework responsibilities. Limited male agricultural labor also hampers agricultural productivity and increases households' reliance on markets to meet basic needs. Drawing on gender- and caste-specific findings, our study highlights the importance of looking beyond the financial aspects of migration when examining its effects on food security.

13. Mezzano J., Namirembe G., Ausman L., Marino-Costello E., Shrestha R., Erhardt J., et al. Iron and Vitamin A Biomarkers in Mothers and Infants in Rural Uganda: Using the BRINDA Approach to Adjust for Inflammation (P10-108-19). Curr Dev Nutr. 2019;3(Suppl 1):nzz034.P10-108-19. Published 2019 Jun 13. doi:10.1093/cdn/nzz034.P10-108-19

Abstract

OBJECTIVES:

We aimed to assess prevalence of iron and vitamin A deficiencies in Ugandan mothers and infants using the BRINDA (Biomarkers Reflecting Inflammation and Nutritional Determinants of Anemia) adjustment and to ascertain any differences by prevalence of malaria.

METHODS:

From a prospective birth cohort (N = 5000) conducted in rural Uganda (2014–2016), samples from mothers (n = 1652, at birth) and infants (n = 695, 5–7 m/o) were analyzed for ferritin (FER), soluble transferrin receptor (sTFR), retinol binding protein (RBP), CRP, AGP, hemoglobin (Hb) and malaria. FER, sTFR and RBP were adjusted for inflammation using CRP and AGP. Depleted iron stores were defined as: FER <12 µg/L and <15 µg/L in children and mothers respectively; sTFR >8.3 mg/L for Fe-deficient erythropoiesis; RBP <1.05 µmol/L for vitamin A deficiency; and Hb <110 g/L for anemia. Prevalence estimates were stratified by malaria status.

RESULTS:

Adjustment for inflammation in mothers increased depleted iron stores (FER) from 7 to 12%, and decreased iron-deficient erythropoiesis (sTFR) from 27 to 22%. For children, adjustment increased depleted Fe stores from 17 to 40%, and iron-deficient erythropoiesis from 76 to 64%. Vitamin A deficiency in mothers was 9% and in infants decreased after adjustment (15% vs 4%). The prevalence of altitude adjusted anemia was 18% in mothers and 72% in infants. The prevalence of tissue iron deficiency (BIS <0 mg/kg) using adjusted sTFR and FER was 10% for mothers and 50% for infants compared to 8% and 34% using unadjusted markers respectively (Tables 1,2). Almost 14% of children (n = 75) were diagnosed with malaria. Malaria prevalence in mothers was low (5%), possibly due to the high (82%) prevalence of IPT prophylaxis reported during pregnancy. No significant differences were found in adjusted versus unadjusted estimates for Fe markers stratifying by malaria.

CONCLUSIONS:

Fe deficiency adjusted estimates varied by biomarker and were not correlated with malaria in line with BRINDA recommendations. For mothers and children, the prevalence of Fe deficiency (sTFR) and anemia (Hb) were similar, suggesting that a big part of anemia in Uganda could be due to Fe deficiency as opposed to other micronutrients.

14. Andrews-Trevino J., Webb P., Shively G., Rogers B., Baral K., Davis D., Paudel K., Pokharel A., Shrestha R., Wang J-S., Ghosh S. 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 Nepalese Infants, *The Journal of Nutrition* nxz122. June 14, 2019.
<https://doi.org/10.1093/jn/nxz122>

Abstract

BACKGROUND:

Exposure to aflatoxin has garnered increased attention as a possible contributor to adverse birth outcomes.

OBJECTIVE:

The objective of this study was to investigate the relation of maternal aflatoxin exposure with adverse birth outcomes such as birth weight, birth length, anthropometric z scores, low birth weight (LBW), small-for-gestational-age (SGA), stunting, and preterm birth (PTB).

METHODS:

This study used maternal and newborn data from the AflaCohort Study, an ongoing birth cohort study in Banke, Nepal (n = 1621). Data on aflatoxin B1 (AFB1)-lysine adducts in maternal serum were collected once during pregnancy (at mean \pm SD: 136 \pm 43 d of gestation). Maternal serum AFB1-lysine adduct concentration was measured via HPLC. Linear and logistic regression analyses were used to determine if maternal aflatoxin exposure was associated with 1) birth weight and length (primary outcomes) and 2) anthropometric z scores, LBW (weight <2.5 kg), SGA (weight <10th percentile for gestational age and sex), stunting at birth (length-for-age z score less than -2), or PTB (born <37 weeks of gestation) (secondary outcomes).

RESULTS:

The geometric mean of maternal serum AFB1-lysine adduct concentration was 1.37 pg/mg albumin (95% CI: 1.30, 1.44 pg/mg albumin). Twenty percent of infants were of LBW and 32% were SGA. Sixteen percent of infants were stunted at birth. In addition, 13% of infants were born preterm. In logistic multivariate regression models, mean maternal serum AFB1-lysine adduct concentrations were significantly associated with SGA (OR: 1.13; 95% CI: 1.00, 1.27; $P < 0.05$).

CONCLUSIONS:

Findings from this study suggest a small but significant association between serum AFB1-lysine adduct concentrations in pregnant women and SGA. Maternal aflatoxin exposure was not associated with other birth outcomes. These results highlight the need for future research on a threshold level of aflatoxin exposure needed to produce detectable adverse birth outcomes. This trial was registered at clinicaltrials.gov as NCT03312049.

15. Thorne-Lyman AL, Shrestha M, Fawzi WW, Pasqualino M, Strand TA, Kvestad I, Hysing M, Joshi N, Lohani M, Miller LC. Dietary diversity and child development in the far west of Nepal: A cohort study. *Nutrients*. 2019. 11(8), 1799

Abstract

Poverty adversely affects child development through multiple pathways in low- and middle-income countries. Relationships between diet and child development are poorly understood. In this study, we aimed to explore these associations in a longitudinal cohort of 305 children in rural Nepal (baseline mean age 14 months), evaluating dietary diversity and the consumption of specific food groups at three timepoints over 1.5 years. Child development was assessed using the Ages and Stages questionnaire-version 3 (ASQ-3). Associations between the number of days that children consumed minimum dietary diversity (MDD) ($\geq 4/8$ items) and specific food groups over time (range 0-3) and total and subscale ASQ scores at age 23-38 months were estimated using multiple linear and logistic regression, dichotomizing scores at the lowest quartile. After adjusting for confounders, each additional day of consuming MDD was associated with a 35% reduction in the odds of low total ASQ score [OR 0.65, 95% CI (0.46, 0.92)]. The consumption of animal source foods [OR 0.64, (0.46, 0.89)], and vegetables/fruits [OR 0.60, (0.41, 0.90)], but not processed foods [OR 0.99, (0.62, 1.59)] was associated with lower odds of low total development. Vegetables, fruits and animal source foods may be important for child development in this setting.

16. Kadjo, D. Ricker J,-Gilbert, Tahirou A, and **Shively G**. Food Safety and Adverse Selection in Benin's Rural Maize Markets. *Journal of Agricultural Economics*. July 29, 2019. doi: 10.1111/1477-9552.12350.

Abstract

Without enforced standards or reliable third-party verification, food safety threats such as pesticide residues and aflatoxin contamination are generally unobservable or only partially observable to both buyers and sellers, especially of staple foods in rural maize markets in

sub-Saharan Africa. As a result, sellers have more information about food quality than do buyers. Such information asymmetries can impede market development and undermine human health. We study farm household behaviour in the context of imperfect food safety information. We pool observations obtained from 707 food storage containers maintained by 309 farm households in Benin, surveyed following the maize harvests of 2011/2012 and 2013/2014. Our results indicate that when a household perceives a food safety risk associated with application of insecticides, on average it is 33 percentage points less likely to apply insecticides to maize it intends to consume than it is to maize it intends to sell. These individuals are also more likely to sell maize than households without food safety concerns. Results highlight the potential value of improved storage technologies and quality control to promote market transactions and reduce hidden health risks.

17. Thorne-Lyman AL, Shaikh S, Mehra S, Wu LSF, Ali H, Alland K, Schultze KJ, Mitra M, Hur J, Christian P, Labrique AB, West KP Jr. Dietary patterns of >30,000 adolescents 9-15 years of age in rural Bangladesh. *Ann N.Y. Acad. Sci.* 2019. doi: 10.1111/nyas.14207

Abstract

Little is known of the usual food intakes of rural adolescents in South Asia. This study describes dietary patterns, based on >91,000 7-day food frequencies among 30,702 girls and boys, aged 9–15 years in rural northwest Bangladesh. Three intake assessments per child, taken across a calendar year, were averaged to represent individual annual intake patterns for 22 food groups. Latent class analysis was used to assign individuals to dietary patterns based on class membership probabilities. The following five dietary patterns (class membership probabilities) were identified: (1) “least diverse” (0.20); (2) “traditional” (0.28); (3) “low vegetable/low fish” (0.23), (4) “moderately high meat” (0.20); and (5) “most diverse” (0.09). The least diverse pattern had the lowest median consumption of most foods and traditional had a relatively higher intake of most vegetables and fish. The most diverse pattern consumed both healthy and processed foods much more often than other patterns. The two most diverse patterns (4 and 5) were associated with higher socioeconomic status, body mass index, height-for-age Z-score, and male gender, and the least diverse pattern showed inverse associations with these characteristics. The most diverse pattern may represent an early wave of the nutrition transition in rural Bangladesh.

18. Miller, L., Neupane, S., Joshi, N., Lohani, M., Rogers, B., Neupane, S., Ghosh, S., and Webb, P. Multisectoral community development in Nepal has greater effects on child growth and diet than nutrition education alone. *Public Health Nutrition*, 1-16. doi:10.1017/S136898001900260X. September 23, 2019.

Abstract

OBJECTIVE:

To compare the impact on child diet and growth of a multisectoral community intervention v. nutrition education and livestock management training alone.

DESIGN:

Longitudinal community-based randomized trial involving three groups of villages assigned to receive: (i) Full Package community development activities, delivered via women's groups; (ii) livestock training and nutrition education alone (Partial Package); or (iii) no intervention (Control). Household surveys, child growth monitoring, child and household diet quality measures (diet diversity (DD), animal-source food (ASF) consumption) were collected at five visits over 36 months. Mixed-effect linear regression and Poisson models used survey round, treatment group and group-by-round interaction to predict outcomes of interest, adjusted for household- and child-specific characteristics.

SETTING:

Banke, Nepal.

PARTICIPANTS:

Households (n 974) with children aged 1–60 months (n 1333).

RESULTS:

Children in Full Package households had better endline anthropometry (weight-for-age, weight-for-height, mid-upper-arm-circumference Z-scores), DD, and more consumption of ASF, after adjusting for household- and child-specific characteristics. By endline, compared with Partial Package or Control groups, Full Package households demonstrated preferential child feeding practices and had significantly more improvement in household wealth and hygiene habits.

CONCLUSIONS:

In this longitudinal study, a comprehensive multisectoral intervention was more successful in improving key growth indicators as well as diet quality in young children. Provision of training in livestock management and nutrition education alone had limited effect on these outcomes. Although more time-consuming and costly to administer, incorporating nutrition training with community social capital development was associated with better child growth and nutrition outcomes than isolated training programmes alone.

19. Hicks C., Cohen P., Graham N., Nash K., Allison E., D'Lima C., Mills D., Roscher M., Thilsted S., Thorne-Lyman A., MacNeil A. Harnessing global fisheries to tackle micronutrient deficiencies. *Nature*, September 25, 2019. <https://doi.org/10.1038/s41586-019-1592-6>

Abstract

Micronutrient deficiencies account for an estimated one million premature deaths annually, and for some nations can reduce gross domestic product^{1,2} by up to 11%, highlighting the need for food policies that focus on improving nutrition rather than simply increasing the volume of food produced³. People gain nutrients from a varied diet, although fish—which are a rich source of bioavailable micronutrients that are essential to human health⁴—are often overlooked. A lack of understanding of the nutrient composition of most fish⁵ and how nutrient yields vary among fisheries has hindered the policy shifts that are needed to effectively harness the potential of fisheries for food and nutrition security⁶. Here, using the concentration of 7 nutrients in more than 350 species of marine fish, we estimate how environmental and ecological traits predict nutrient content of marine finfish species. We use this predictive model to quantify the global spatial patterns of the concentrations of nutrients in marine fisheries and compare nutrient yields to the prevalence of micronutrient deficiencies in human populations. We find that species from tropical

thermal regimes contain higher concentrations of calcium, iron and zinc; smaller species contain higher concentrations of calcium, iron and omega-3 fatty acids; and species from cold thermal regimes or those with a pelagic feeding pathway contain higher concentrations of omega-3 fatty acids. There is no relationship between nutrient concentrations and total fishery yield, highlighting that the nutrient quality of a fishery is determined by the species composition. For a number of countries in which nutrient intakes are inadequate, nutrients available in marine finfish catches exceed the dietary requirements for populations that live within 100 km of the coast, and a fraction of current landings could be particularly impactful for children under 5 years of age. Our analyses suggest that fish-based food strategies have the potential to substantially contribute to global food and nutrition security.

20. Varijakshapanicker P, Mckune S, Miller LC, Hendrickx S, Balehegn M, Dahl GE, Adesogan AT. Sustainable livestock systems to improve human health, nutrition, and economic status. *Animal Frontiers* October 2019, Vol. 9, No. 4doi: 10.1093/af/vfz041.

Implications:

Sustainable livestock systems contribute to food security, economic and environmental stewardship, and sociocultural needs and are vital for achieving most of the United Nation's Sustainable Development Goals.

Livestock production contributes to sustainability through use of uncultivable land for food production, conversion of energy and protein sources that cannot be used by humans into highly nutritious animal-sourced food and reduction of environmental pollution with agro-industrial by-products, while generating income and supporting livelihoods of millions of people all over the world.

Some livestock systems are particularly effective at carbon sequestration and hence reducing greenhouse gas emissions that contribute to global warming.

Livestock production offers the greatest potential to reduce greenhouse gas emissions from agriculture and animal scientists have devised several effective strategies that can reduce such emissions from livestock systems by up to 30%.

Most of the current discourse on sustainability focuses on one albeit important factor—the environment. Equally important factors are the need to ensure food and nutritional security for the growing global population in a culturally acceptable manner that ensures its accessibility, affordability, and safety.

While livestock systems generally contribute to sustainability, poorly managed livestock systems may have adverse effects on the environment and human and animal health and welfare.

Non peer reviewed

21. 6th Annual Scientific Symposium in Nepal, 'Food, Diets & Nutrition: 25 years of Progress and a Vision for Nepal', 2018
https://www.nutritioninnovationlab.org/sites/default/files/inlinefiles/2018%20Nepal%20Symposium%20Final%20Report_3.13.19.pdf

In press

1. Lauer J, Duggan C. Environmental Enteric Dysfunction. Encyclopedia of Gastroenterology 2nd Edition. In press. (Encyclopedia Chapter)
2. Lauer J, Duggan C. 50 Years Ago in the Journal of Pediatrics: Malnutrition and Brain Development. In press at The Journal of Pediatrics.

Submitted/Under review

- 1 Agrawal P, Manohar S, Thorne-Lyman AL, KC A, Shrestha B, Klemm RD, West KP Jr. Prevalence of Damaged and Missing Teeth among Women in Southern Rural Nepal as Assessed by a Survey-based Approach. *Submitted and under review Plos One*
- 2 Debela, B., Shively G, and Holden S. "Food for Work and Diet Diversity in Ethiopia." *Under review at Review of Development Economics*.
- 3 Omiat, G. and Shively G. "Rainfall and Child Growth in Uganda." *Under review at Economics and Human Biology*.
- 4 Arega, M. and Shively G. Food Aid, Cash Transfers and Producer Prices in Ethiopia. *Under review at African Journal of Agricultural and Resource Economics*.
- 5 Shively, G. and A. Evans. Dietary Diversity in Nepal: A Latent Class Approach. *Under review at Public Health Nutrition*.
- 6 Shively, G., T. Smith and M. Paskey. Altitude and Child Growth in Nepal. *Under review at Mountain Research and Development*.
- 7 Darko F, Ricker-Gilbert J, Kilic T, Shively G. Profitability of Fertilizer Use in SSA: Evidence from Malawi. *Under review at Journal of African Economies*.
- 8 Josephson, A. and G. Shively. "Unanticipated Events, Perceptions, and Household Labor Allocation in Zimbabwe." *Under review at World Development*.
- 9 Andrews-Trevino, J., S. Ghosh, G. Shively, B. Rogers, K. Baral, D. Davis, A. Pokharel, R. Shrestha, J.-S. Wang, and P. Webb "Aflatoxins in the blood of pregnant women, their food sources, and agricultural practices in rural Nepal." *Under review at Environmental Research*.
- 10 Andrews-Trevino JY, Webb P, Shively G, Rogers B, Baral K, Davis D, Paudel K, Pokharel A, Shrestha R, Xue KS, Wang JS, Ghosh S. Dietary determinants of aflatoxin BI-lysine adducts in pregnant women consuming a rice-dominated diet in Nepal. *Submitted to European Journal of Clinical Nutrition*.
- 11 Namirembe G., Shrestha R., Houser R., Ghosh S., Baral K., Davis D., Webb P. Measuring Governance: Developing a novel metric for assessing the translation of policies into action in Nepal. *Submitted to BMC Nutrition*, July 2019.
- 12 Broadus-Shea ET, Manohar S, Thorne-Lyman AL, Bhandari S, Nonyane BAS, Winch PJ, West KP Jr. Small-scale livestock production in Nepal is directly associated with children's increased intakes of eggs and dairy, but not meat. *Under review at Journal of Nutrition*.
- 13 KC A, Thorne-Lyman AL, Manohar S, Shrestha B, Klemm R, Adhikari RK, Webb P, West Jr. KP. Preschool child nutritional status in Nepal in 2016 and comparative trends. *Under review at Food and Nutrition Bulletin*

- I4 Miller L, Joshi N, Shrestha M, Neupane S, Neupane S, Lohani M, Thorne-Lyman AL, Both dietary diversity and consumption of animal source foods over time protect young rural Nepali children from poor development. *Under review at Maternal and Child Nutrition*
- I5 Thorne-Lyman AL, Parajuli KR, Paudyal N, Chitekwe S, Shrestha R, Manandhar DL, West Jr KP. To see, hear and live: 25 years of the vitamin A program in Nepal. *Under review at Maternal and Child Nutrition*